UNITED STATES SPACE FORCE

FINDING OF NO SIGNIFICANT IMPACT

Falcon 9 Launch Cadence Increase at Vandenberg Space Force Base, California

CEQ Unique Identification Number: EAXX-007-57-USF-1724161195

Pursuant to provisions of the National Environmental Policy Act (NEPA), Title 42 United States Code Section 4321 et seq., implemented by Council on Environmental Quality (CEQ) regulations at Title 40, Code of Federal Regulations (CFR) Parts 1500–1508, and 32 CFR Part 989, Environmental Impact Analysis Process, the Department of the Air Force (DAF), as the Lead Agency, prepared the attached Final Environmental Assessment (EA) to address the potential environmental impacts on the human environment associated with proposed Falcon 9 Launch Cadence Increase at Vandenberg Space Force Base (VSFB). The current launch capacity is insufficient to meet critical DOD and commercial launch missions. The EA supports the proposal to provide greater mission capability to the Department of Defense (DOD), National Aeronautics and Space Administration, and commercial customers by increasing Falcon 9's flight opportunities in furtherance of U.S. policy, as discussed in the EA, page 1-2, § 1.2.

This FONSI incorporates by reference and attaches hereto the *Final Environmental Assessment (EA), Falcon 9 Cadence Increase at Vandenberg Space Force Base (VSFB), California*. The EA considered the potential environmental impacts of Alternative 1 (Proposed Action) Increase Launch Cadence (EA, page 2-1, § 2.1), Alternative 2 (a modified version of Alternative 1), and the No Action Alternative, and identified mitigations to be implemented prior to taking an impact-inducing action (EA Appendix L).

This FONSI also serves as the Alternative 2 RECORD OF CONFORMITY ANALYSIS (ROCA) for verifying General Conformity Rule (GCR; 40 CFR Part 51, Subpart W, as adopted by reference in South Coast Air Quality Management District (SCAQMD) Rule 1901, September 1994) compliance.

DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

Alternative 1 (Proposed Action), Increase Launch Cadence

The Proposed Action (Alternative 1) (EA, page 2-1, § 2.1) is to increase the Falcon 9 annual launch cadence from 36 to 50 launches per year at Space Launch Complex 4 (SLC-4) on VSFB, increase Falcon 9 first stage and fairing recovery activities, and expand the recovery area in the Pacific Ocean. Up to 12 boosters per year would continue to land at SLC-4.

The Proposed Action, Alternative 1, would result in Nitrogen Oxides (NOx, an ozone precursor) emissions during project transport activities, site preparation, mobilization activities, and static fire and launch events. Generally, the emissions are relatively insignificant outside the Los Angeles-South Coast Air Basin. The Proposed Action is the only alternative expected to result in an exceedance of Ozone (NOx as a precursor) General Conformity Rule (GCR) *de minimis* threshold value. Therefore, the DAF cannot determine if the Proposed Action will have less than significant impacts on air quality until it completes the GCR Determination. A GCR Determination must be completed before Alternative 1 could proceed. DAF is conducting a GCR Determination.

Alternative 2 (Modified Proposed Action) (EA, page 2-6, § 2.4), Increase Launch Cadence While Maintaining Operations In Compliance With GCR Requirements

Alternative 2 is an alternative that modifies the Proposed Action's (Alternative 1) operations within the SCAQMD to keep the annual net change in emissions below the 10 tons per year (tpy) Clean Air Act (CAA) GCR *de minimis* value for NOx. This would be accomplished through fewer operating hours and/or different boat routes to reduce emissions within nonattainment areas. DAF determined that emissions of NOx from operations at the intensity of the Proposed Action would exceed the 10 tpy allowable limit (*de minimis* value) within the Los Angeles-South Coast Air Basin Ozone Extreme Nonattainment Area which falls within SCAQMD. A nonattainment area is a geographical area that exceeds one or more National Ambient Air Quality Standards (NAAQS). To remedy this situation, activities will be restricted within the Los Angeles-South Coast Air Basin Ozone Extreme Nonattainment Area to remain at *de minimis* levels (i.e., less than 10 tpy). DAF calculated the reasonably foreseeable scenario of restricted operations to demonstrate NOx emissions associated with this action's operations can be maintained below 10 tpy *de minimis* value for the near future. To ensure activities are maintained below the *de minimis* value, SpaceX will calculate and keep a weekly running total of NOx emissions associated with operations and will halt all operations within SCAQMD prior to exceeding 10 tpy of NOx emissions annually.

As a result of the modified operations, Alternative 2 poses an insignificant impact on air quality and therefore GCR is not applicable.

No Action Alternative

The No Action alternative provides baseline conditions for each resource area for comparing the potential environmental effects of the action alternatives. As analyzed the No Action Alternative (EA, page 2-7, § 2.4.2) would not increase the annual cadence for Falcon 9 operations from SLC-4 on VSFB, increase Falcon 9 first stage and fairing recovery activities, or expand the recovery area and rocket launch mission would continue at current levels.

MITIGATION

The EA considered the environmental consequences of the proposed action (EA page 3-1, Chapter 3) and results of required consultations with the relevant agencies (EA page 3-25, § 3.3.1 and Appendices A through D and L). The consultations resulted in prescribed mitigation to be applied to support making a finding of no significant impact. In addition, mitigation is required for emissions within the Los Angeles-South Coast Air Basin Extreme Ozone Nonattainment Area under the authority of the SCAQMD. For identified impacts, the following measures are being taken. SLD 30 is responsible for:

- Ensuring compliance with the actions required by USFWS's Biological Opinion to monitor and mitigate potential adverse effects to listed species (EA, page 3-29, § 3.3.2 and Appendix A).
- Ensuring compliance with the actions required by NMFS Letter of Authorization (EA page 3-40, § 3.4.2 and Appendix B).
- Carrying out the actions agreed to during negotiations with the California Coastal Commission during Coastal Zone Management Act (CZMA) federal consistency proceedings (EA page 3-51, § 3.7.2 and Appendix D).

- Limit operation activities that generate NOx emissions within the Los Angeles-South Coast Air Basin Extreme Ozone Nonattainment Area to less than 10 tpy (GCR de minimis level for NOx) pending the completion of the GCR Determination required by 42 USC 7506(c) and SCAQMD Rule 1901 (EA page 3-7, § 3.1.2.1.3). In part, SLD 30 will receive a weekly running tally of net change in NOx emissions within the Los Angeles-South Coast Air Basin Extreme Ozone Nonattainment Area associated with harbor operations of this Action to demonstrate compliance with the GCR de minimis level.

To track mitigations, SLD-30 will develop a Mitigation Plan that identifies oversight and execution of specific mitigations. SLD-30 will not implement any impact-inducing action before the applicable mitigation measure described in the EA and FONSI are put in place.

FINDING OF NO SIGNIFICANT IMPACT

Based on my review of the facts and analyses contained in the attached EA, I conclude that implementing the Modified Proposed Action (Alternative 2) and the associated mitigations as described in the EA, its supporting Appendices, and as will be defined more specifically in the Mitigation Plan, will not have a significant impact on the quality of the human environment. Additionally, Alternative 2 will result in *de minimis* emissions per the GCR (40 CFR 93.153(c)(1)). Therefore, further analysis with a GCR Determination is not required and this FONSI is appropriate, and no Environmental Impact Statement is required.

MORIARTY.ROBERT.E.1013267584 Digitally signed by MORIARTY.ROBERT.E.1013267584 Date: 2024.11.01 18:20:28 -04'00'

1 Nov 24

ROBERT E. MORIARTY, P.E., SES — Date
Deputy Assistant Secretary of the Air Force (Installations)

Attachment:
Final Environmental Assessment Falcon 9 Cadence Increase at Vandenberg Space Force Base, California

PRIVACY ADVISORY

This Environmental Assessment (EA) is provided for public comment in accordance with the National Environmental Policy Act (NEPA), the President's Council on Environmental Quality NEPA Regulations (40 Code of Federal Regulations [CFR] Parts 1500-1508) and 32 CFR Part 989, Environmental Impact Analysis Process (EIAP).

The EIAP provides an opportunity for public input on Department of the Air Force (DAF) decision making, allows the public to offer input on alternative ways for the DAF to accomplish what it is proposing, and solicits comments on the DAF's analysis of environmental effects.

Public commenting allows the DAF to make better, informed decisions. Letters or other written or oral comments provided may be published in the EA. As required by law, comments provided will be addressed in the EA and made available to the public. Providing personal information is voluntary. Any personal information provided will be used only to identify your desire to make a statement during the public comment portion of any public meetings or hearings or to fulfill requests for copies of the EA or associated documents. Private addresses will be compiled to develop a mailing list for those requesting copies of EA; however, only the names of the individuals making comments and specific comments will be disclosed. Personal home addresses and phone numbers will not be published in the EA.

Compliance with Section 508 of the Rehabilitation Act

To the extent possible, this document is compliant with Section 508 of the Rehabilitation Act. This allows assistive technology to be used to obtain the available information from the document. Due to the nature of graphics, figures, tables, and images occurring in the document, accessibility is limited to a descriptive title for each item.

Compliance with Revised CEQ Regulations

This EA has been verified to be compliant with the 75-page limit, not including appendices, required by 40 CFR 1501.5(f). As defined by 40 CFR 1508.1(v) a "page" means 500 words and does not include maps, diagrams, tables, or other means of graphically displaying quantitative or geospatial data.

COVER SHEET

Designation:	Final Environmental Assessment
Unique Identifier:	EAXX-007-57-USF-1724161195
Title of Proposed Action:	Falcon 9 Cadence Increase
Project Location:	Vandenberg Space Force Base, Santa Barbara County, California
Lead Agency for the EA:	Department of the Air Force (DAF)
Cooperating Agency:	Federal Aviation Administration (FAA), U.S. Coast Guard (USCG)
Affected Region:	Central/Southern California
Action Proponent:	DAF
Point of Contact:	Beatrice Kephart, Chief, Installation Management Flight Space Launch Delta 30 1028 Iceland Avenue, Building 11146 Vandenberg Space Force Base, California 93437
Date:	November 2024

The Department of the Air Force (DAF) has prepared this Final Environmental Assessment (EA) in accordance with the National Environmental Policy Act, as implemented by the Council on Environmental Quality Regulations and DAF regulations for implementing the National Environmental Policy Act. The Proposed Action includes increasing Falcon 9's annual flight capacity from 36 to 50 launches annually at Vandenberg Space Force Base. This action would include an expansion of the downrange recovery area in the Pacific Ocean and an increase in associated recovery operations. A permanent increase of approximately 400 additional personnel would occur over time.

This Final EA evaluates the potential environmental impacts associated with the Proposed Action, Alternative 2 (Modified Proposed Action), and the No Action Alternative to the following resource areas: air quality/climate, noise, biological resources, water resources, coastal resources, Department of Transportation Act section 4(f) resources, utilities, socioeconomics, transportation, human health and safety, hazardous materials and waste management, solid waste management, land use and aesthetics, visual effects, light emissions, and visual resources/character, geological resources, environmental justice and protection of children, farmlands, natural resources, and wild and scenic rivers.

Final

Environmental Assessment

Falcon 9 Cadence Increase at

Vandenberg Space Force Base, California

November 2024

Space Launch Delta 30, Installation Management Flight Environmental Assets
1028 Iceland Avenue, Building 11146
Vandenberg Space Force Base, California 93437

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ACRONYMS AND ABBREVIATIONS

2 ROPS/DON	2nd Range Operations Squadron
AB	Assembly Bill
ac	acre(s)
ACAM	Air Conformity Applicability
ac-ft	acre-feet
AFMAN	Air Force Manual
AFCEC	Air Force Civil Engineer Center
AFI	Air Force Instruction
AFOSH	Air Force Occupational Safety and Health
AOC	Area of Concern
AOI	Area of Interest
APE	Area of Potential Effects
AQMP	Air Quality Management Plan
BCC	Federal Bird Species of Conservation Concern
BGEPA	Bald and Golden Eagle Protection Act
BO	Biological Opinion
CalEEMod	California Emissions Estimator Model
CCC	California Coastal Commission
CCR	California Code of Regulations
CCZ	California Coastal Zone
CD	Consistency Determination
CDFW	California Department of Fish and Wildlife
CDNL	C-weighted DNL
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CHNMS	Chumash Heritage National Marine Sanctuary
CINMS	Channel Islands National Marine Sanctuary
CNDDB	California Natural Diversity Database
CNEL	Community Noise Equivalent Level
CO	carbon monoxide
CO_2	carbon dioxide
CO_{2e}	carbon dioxide equivalent
CRLF	California red-legged frog
CZMA	Coastal Zone Management Act
DAF	Department of the Air Force
dB	decibels
dBA	A-weighted decibels
dBC	C-weighted decibels
dB re 20 μPa	decibels related to 20 micropascals
dB re 20 μPa^2sec	decibels related to 20 micropascals squared seconds
DNL	Day-Night Average Sound Level
DOD	Department of Defense
DODI	Department of Defense Instruction
DOT	Department of Transportation
DPS	Distinct Population Segment
EA	Environmental Assessment
EIS	Environmental Impact Statement
EMS	Environmental Management System
EO	Executive Order
EPM	Environmental Protection Measure
ERP	Environmental Restoration Program
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FAA	Federal Aviation Administration
FE	federally endangered
FONSI	Finding of No Significant Impact
FT	federally threatened
ft	foot/feet
ft^2	square feet
FWHA	Federal Highway Administration
GAO	Government Accountability Office
GHG	greenhouse gas
HMMP	Hazardous Materials Management Process
HWMP	Hazardous Waste Management Plan
Hwy	highway
Hz	hertz
IAW	in accordance with
ISWMP	Integrated Solid Waste Management Plan
km	kilometer(s)
kW-hr	kilowatt-hour
L_{max}	maximum sound pressure level
L_{eq}	equivalent sound level
L_{peak}	highest instantaneous sound level
lb(s)	pound(s)

LC	Launch Complex
LOA	Letter of Authorization
LOC	Letter of Concurrence
mi	mile(s)
MBTA	Migratory Bird Treaty Act
MMPA	Marine Mammal Protection Act
MMRP	Military Munitions Response Program
MOA	Memorandum of Agreement
N_2O	Nitrous Oxide
NAAQS	National Ambient Air Quality Standards
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NCI	Northern Channel Islands
ND	negative determination
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
nm	nautical mile(s)
NMFS	National Marine Fisheries Service
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
NOA	Notice of Availability
NOAA	National Oceanic and Atmospheric Administration
NOTAM	Notice to Air Missions
NOTMAR	notice to mariners
NRHP	National Register of Historic Places
O_3	ozone
OSHA	Occupational Safety and Health Administration
P	proposed for listing under the ESA
P2	pollution prevention
PHS	Pacific harbor seal
$PM_{2.5}$	particulate matter less than 2.5 microns (fine particulate matter)
PM_{10}	particulate matter less than 10 microns
POC	point of contact
psf	pound(s) per square foot
RCRA	Resource Conservation and Recovery Act
RGF	Regional Growth Forecast
RHNA	Regional Housing Needs Allocation
ROI	region of influence
RORO	roll-on-roll-off
RWQCB	Regional Water Quality Control Board
SBCAG	Santa Barbara County Association of Governments
SCAB	South Coast Air Basin
SCAQMD	South Coast Air Quality Management District
SCCAB	South-Central Coast Air Basin
SC-GHG	social cost of greenhouse gases
SE	state endangered species
SEA	Supplemental Environmental Assessment
SHPO	State Historic Preservation Office
SIP	State Implementation Plan
SLC	Space Launch Complex
SLD 30	Space Launch Delta 30
SLD 30/SEL	Space Launch Delta 30, Launch Safety
SMI	San Miguel Island
SO_2	sulfur dioxide
SOx	sulfur oxides
SpaceX	Space Exploration Technologies Corporation
SR	State Route
SSC	California Species of Special Concern
SYBCI	Santa Ynez Band of Chumash Indians
tpd	tons per day
tpy	tons per year
UPRR	Union Pacific Railroad
U.S.	United States
USC	United States Code
USACE	U.S. Army Corps of Engineers
USAF	U.S. Air Force
USCG	U.S. Coast Guard
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USSF	United States Space Force
VCAPCD	Ventura County Air Pollution Control District

VSFB	Vandenberg Space Force Base	WOTS	Waters of the State
VSMR	Vandenberg State Marine Reserve	WOTUS	Waters of the United States
VOC	volatile organic compounds		

1 PURPOSE OF AND NEED FOR THE PROPOSED ACTION

1.1 Introduction and Background

The Department of Air Force (DAF) Space Launch Delta 30 (SLD 30) has prepared this Environmental Assessment (EA) to evaluate an increase in Falcon 9 annual launch cadence from 36 to 50 launches per year at Space Launch Complex 4 (SLC-4) on Vandenberg Space Force Base (VSFB), an increase in Falcon 9 first stage and fairing recovery activities, and an expanded recovery area in the Pacific Ocean. This EA also evaluates the potential environmental impacts associated with the Federal Aviation Administration's (FAA's) licensing determinations to continue conducting Falcon launch operations at VSFB and FAA's approval of related airspace closures. Space Exploration Technologies Corporation (SpaceX) currently launches United States (U.S.) Government and commercial payloads using the Falcon 9 from SLC-4. SpaceX supports, and is under contract for, the full spectrum of U.S. Government space mission requirements, including spacecraft launches for the National Aeronautics and Space Administration (NASA) and the U.S. Department of Defense (DOD). The current launch capacity is insufficient to meet critical DOD and key commercial launch missions.

This EA was prepared in accordance with the National Environmental Policy Act (NEPA) of 1969 as amended (42 United States Code [USC] Section 4321, et seq.), the Council on Environmental Quality's (CEQ) regulations for implementing NEPA (40 Code of Federal Regulations [CFR] Parts 1500-1508), the DAF's Environmental Impact Analysis Process (32 CFR Part 989), and FAA Order 1050.1F, *Environmental Impacts: Policies and Procedures*. The DAF is the lead agency for the preparation and coordination of the EA; the FAA and United States Coast Guard (USCG) are cooperating agencies.

As 40 CFR Section 1501.12 indicates, agencies shall incorporate relevant material into environmental documents by reference when the effect is to cut down on bulk without impeding agency and public review of the action, including the documents incorporated by reference therein:

- *Final Draft Environmental Assessment Falcon 9 and Falcon 9 Heavy Launch Vehicle Programs from Space Launch Complex 4 East, Vandenberg Air Force Base, California* (2011 EA; DAF 2011)[1]
- Final Environmental Assessment Boost-Back and Landing of the Falcon 9 Full Thrust First Stage at SLC-4 West Vandenberg Air Force Base, California and Offshore Landing Contingency Option (2016 EA; DAF 2016)[2]
- *Final Supplemental Environmental Assessment Launch, Boost-Back, and Landing of the Falcon 9 at Vandenberg Air Force Base, California and Offshore Landing Contingency Options* (2018 SEA; DAF 2018)[3]

[1] https://www.vandenberg.spaceforce.mil/Portals/18/documents/Environmental/EIAP-2011-03-1_EA_Falcon9-SLC-4E.pdf?ver=ltWVg_TKsa8haZ0zvhdM6A%3d%3d

[2] https://www.vandenberg.spaceforce.mil/Portals/18/documents/Environmental/EIAP-2016-04-1_EA_Falcon9_Boost-back.pdf?ver=ICyyMrxyiTGXagCmf29TXA%3d%3d

[3] https://www.vandenberg.spaceforce.mil/Portals/18/documents/Environmental/EIAP-2018-01-31_SEA_Falcon9_Launch-Boost-back.pdf?ver=kTLZUufAucxBEFEzzsQlAw%3d%3d

- *Final Supplemental Environmental Assessment Falcon 9 Cadence Increase at Vandenberg Space Force Base, California and Offshore landing Locations* (2023 SEA; DAF 2023)[4]
- *Environmental Assessment for Launch of NASA Routine Payloads on Expendable Launch Vehicles* (NASA 2011)[5]

These documents were reviewed to identify any changes in existing conditions or expected effects that have occurred since their publication. Any changes that were identified are incorporated into this EA.

In a forthcoming Environmental Impact Statement (EIS), the DAF will analyze a proposal to modify SLC-6 at VSFB to launch Falcon 9 and Falcon Heavy and increase cumulative launch cadence of Falcon 9 and Falcon Heavy on VSFB to 100 launches per year. The current Proposed Action will be included in the upcoming EIS as a past action in the cumulative impacts analysis.

1.2 Purpose and Need for the Proposed Action

The purpose of the Proposed Action is to provide greater mission capability to the DOD, NASA, and commercial customers by increasing Falcon 9's flight capacity. This is in furtherance of U.S. policy to ensure capabilities necessary to launch and insert necessary national security payloads into space (10 USC Section 2273, "Policy regarding assured access to space: national security payloads").

The need for the Proposed Action is to ensure United States Space Force (USSF) Assured Access to Space without compromising current launch capabilities and fulfill (in part) the U.S. Congress's grant of authority to the Secretary of Defense, pursuant to 10 USC Section 2276(a), "Commercial space launch cooperation," that the Secretary of Defense is permitted to take action to:

- Maximize the use of the capacity of the space transportation infrastructure by the DOD by the private section in the U.S.
- Maximize the effectiveness and efficiency of the space transportation infrastructure of the DOD.
- Reduce the cost of services provided by the DOD related to space transportation infrastructure and launch support facilities and space recovery support facilities.
- Encourage commercial space activities by enabling investment by covered entities in the space transportation infrastructure of the DOD.
- Foster cooperation between the DOD and covered entities.[6]

Satisfaction of these needs benefit the government and public interests and reduces operational costs. Public interests largely intersect with the government interests identified, including greater mission capability for space exploration and advancing reliable and affordable access to space which in turn advances the scientific and national security benefits of the U.S. space program as a whole. Demand for launch services has continued to increase over the past 20 years, and the space industry's growth projections indicate this will continue into the foreseeable future. SpaceX's Proposed Action would continue the U.S. goal of encouraging activities by the private sector to strengthen and expand U.S. space

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[4] https://www.vandenberg.spaceforce.mil/Portals/18/documents/Environmental/EIAP-2023-05-1_SEA_SpaceX_Falcon9CadenceIncrease.pdf?ver=gsIu4FWj4nqnZsbyzmodpA%3d%3d

[5] https://www.vandenberg.spaceforce.mil/Portals/18/documents/Environmental/EIAP-2011-11_EA_ProgrammaticNASARoutinePayloads_ExpendableLaunchVehicles.pdf?ver=0YCTsNGDrYeI9uWSMoHVNQ%3d%3d

[6] The term "covered entity" means a non-Federal entity that is organized under the laws of the United States or of any jurisdiction within the United States and is engaged in commercial space activities.

transportation infrastructure, thus furthering national security, defense, and space transportation policy objectives[7].

1.3 Lead and Cooperating Agency Actions

Pursuant to agreements between the DAF and the FAA, the DAF is the lead agency for preparing and coordinating this EA (40 CFR Section 1501.7) because the proposed action will be from and on a DAF installation. The FAA and the USCG are cooperating agencies (40 CFR Section 1501.8). Pursuant to 10 USC Section 2276, *Commercial Space Launch Cooperation*, DOD Instruction 3100.12, *Space Support,* and DOD Instruction 3230.3, *DOD Support for Commercial Space Launch Activities,* the USSF, under the DAF, is responsible for implementing support to commercial launch and reentry activity. In addition, as the federal department with the sole administrative authority over this U.S. owned property for the purposes of national defense, the DAF has authority over space-related operations, to include ground-based operations on VSFB. After the public and consulting parties review the EA, if the DAF, as lead agency, determines that the Proposed Action would not individually or cumulatively result in significant impacts on the human or natural environment, the DAF would issue a Finding of No Significant Impact (FONSI). Alternatively, if the DAF determines at any point in the NEPA process that the Proposed Action may, individually or cumulatively, result in significant impacts, it would either issue a Notice of Intent to prepare an Environmental Impact Statement, or issue a decision to select the No Action Alternative for this proposal.

The FAA is a cooperating agency because it is the organization within the Department of Transportation (DOT) with the responsibility of licensing certain commercial space launch operations in the U.S. and approves related airspace closures. The Commercial Space Launch Act of 1984, as amended, and 51 USC Sections 50901-50923, authorizes the Secretary of Transportation to oversee, license, and regulate certain commercial launch and reentry activities, and the operation of launch and reentry sites within the U.S. Section 50905 directs the Secretary of Transportation to exercise this responsibility consistent with public health and safety, safety of property, and the national security and foreign policy interests of the U.S. In addition, Section 50903 states that the Secretary of Transportation shall encourage, facilitate, and promote commercial space launches and reentries by the private sector. As codified at 49 CFR Section 1.83(b), the Secretary of Transportation delegated authority to carry out these functions to the FAA administrator. The FAA is also responsible for creating airspace closure areas in accordance with FAA Order JO 7400.2P, *Procedures for Handling Airspace Matters,* to ensure public safety.

The FAA's Proposed Action is to issue certain licenses along with potential renewals and modifications to licenses within the scope of operations analyzed in this EA to SpaceX that would allow SpaceX to continue to launch and land Falcon at VSFB. In addition, the FAA must also approve related airspace closures for launch and landing operations. If, after reviewing this EA, the FAA determines the Proposed Action would not individually or cumulatively result in significant impacts on the human environment, the FAA would adopt this EA and issue its own decision document to support issuing a launch and reentry license to SpaceX and approving related airspace closures. The FAA would draw its own conclusions from the analysis presented in this EA and assume responsibility for its environmental decisions and any related mitigation measures. For the FAA to use this analysis to support its determination, the EA must meet the

[7] *See* DOD, *2022 National Defense Strategy* at 19-20, available at https://media.defense.gov/2022/Oct/27/2003103845/-1/-1/1/2022-NATIONAL-DEFENSE-STRATEGY-NPR-MDR.PDF

requirements of FAA Order 1050.1F, *Environmental Impacts: Policies and Procedures*, which contains the FAA's policies and procedures for compliance with NEPA. Successfully completing the environmental review process does not guarantee that the FAA would issue SpaceX's commercial launch and reentry license or approve related airspace closures.

The USCG is a cooperating agency because of its regulatory authority over waters subject to jurisdiction of the U.S. pursuant to the Ports and Waterways Safety Act, 46 USC Section 700, and regulatory authority of U.S. and foreign flag vessels as outlined in Titles 33 and 46 of the CFR. The USCG also reviews and advises SLD 30 on all launch and reentry site evaluation risk assessments with focus on vessel navigation safety. The USCG also supports SLD 30 with early warning communication to the maritime industry with notice to mariners (NOTMAR) as outlined in 33 CFR subpart 72.01. SLD 30 and USCG District Eleven have entered into a Memorandum of Agreement (MOA) to assist with maritime safety and space operational review that have a maritime nexus. USCG District Eleven utilizes authorities authorized in the Ports and Waterways Safety Act and the CFR to evaluate SpaceX and SLD 30 navigation risk assessments with launch and reentry activities associated with commercial and recreational vessels on the high seas off the California Coast. The USCG evaluates every launch and reentry activity for risk to waterway users and the environment under this process.

1.4 Intergovernmental Coordination, Public, and Agency Participation

1.4.1 Public Notification and Review

Following the publication of a Notice of Availability (NOA) in several local newspapers, the DAF made the Draft EA and FONSI available for public review and comment for 30 days. The DAF also posted the Draft EA on the SLD 30 website[8] and distributed the Draft EA and FONSI per the current VSFB NEPA Distribution List (Appendix K), including the State Clearinghouse.

DAF received 17 public comments during the 30-day public comment period as well as several comments from state and federal government agencies. In response to public comments, DAF revised the Draft EA, as appropriate, and prepared this Final EA. The Final EA reflects DAF's consideration of comments, and DAF has provided responses to comments in Appendix K.

1.4.2 Government to Government Consultation

Executive Order (EO) 13175, "Consultation and Coordination with Indian Tribal Governments" directs federal agencies to coordinate and consult with Native American tribal governments whose interests might be directly and substantially affected by activities on federally administered lands. There is no National Historic Preservation Act (NHPA) Section 106 trigger for this project, and therefore, the federally recognized Santa Ynez Band of Chumash Indians (SYBCI) was not consulted under Section 106. However, this Draft EA was submitted to the SYBCI for review following EO 13175. No response was received.

1.4.3 Interagency Coordination

During the development of this EA, DAF coordinated with various local, state, and federal agencies regarding the Proposed Action and will continue to coordinate with these agencies as required.

[8] https://www.vandenberg.spaceforce.mil/About-Us/Environmental/EAS/

In accordance with (IAW) Section 7 of the Endangered Species Act (ESA), DAF has engaged with the United States Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS). A Biological Assessment was submitted to USFWS in support of Section 7 consultation (Appendix A). The resultant Biological Opinion (BO; USFWS 2024; Appendix A) assessed the effects of 16 additional launches between 1 October and 31 December 2024 (thus reaching a cadence of 50 launches in calendar year 2024) on endangered and threatened species due to the Proposed Action. NMFS issued a Section 7 Letter of Concurrence (LOC) on 17 April 2024 (Appendix B). DAF also engaged with NMFS in accordance with the Marine Mammal Protection Act (MMPA) and was issued a renewed Letter of Authorization (LOA) in April 2024 (Appendix B). DAF provided an assessment to NMFS in August 2024 determining the Proposed Action falls within the take numbers covered under the current LOA and are adequate to cover shifting impacts from portions of the Northern Channel Islands (NCI) to two mainland haulouts.

Pursuant to the Coastal Zone Management Act (CZMA), DAF has engaged extensively with the California Coastal Commission (CCC) and submitted a Federal Consistency Determination (CD) for the proposed action on 9 July 2024. (Appendix D). On 27 September 2024 the CCC staff published its report, recommending the full Commission vote to concur with the DAF CD. On 10 October 2024, the CCC voted 6-4 to object to the DAF's CD. Under the CZMA and its implementing regulations, the DAF may proceed with the proposed action over a CCC objection if it finds the Proposed Action is fully consistent with the enforceable policies of California's approved coastal management plan. See 15 CFR § 930.43(d)(1)-(2).

IAW the Department of Transportation (DOT) Act of 1966, now codified at 49 USC Section 303, DAF coordinated with the FAA regarding compliance with Section 4(f), which protects publicly owned parks, recreational lands, wildlife refuges, and historic sites.

2 DESCRIPTION OF THE PROPOSED ACTION AND ALTERNATIVES

2.1 Alternative 1 (Proposed Action), Increase Launch Cadence

The Proposed Action is to increase the annual Falcon 9 launch cadence at SLC-4 on VSFB from 36 to 50 to support future U.S. Government and commercial launch service needs. VSFB occupies approximately 99,100 acres (ac) of central Santa Barbara County, California, and is approximately halfway between San Diego and San Francisco (Figure 2.1 -1). SLC-4 is located on South Base, approximately 4.0 miles (mi) south of the Santa Ynez River and 0.9 mi east of the Pacific Ocean. SLC-4E is the existing launch facility for the Falcon 9 program and SLC-4W is the existing landing facility for the Falcon 9 program.

2.1.1 Launch Vehicle

SpaceX would continue to launch Falcon 9 from SLC-4. Falcon 9 is approximately 229 feet (ft) tall and produces approximately 1.7 million pounds (lbs) of thrust at liftoff. A discussion of Falcon 9 can be found in Section 2.3 of the 2016 EA and Section 2.2 of the 2018 SEA.

2.1.2 Launch

SpaceX would conduct launch operations in the same way as described in Section 2.2 of the 2018 SEA and previous environmental documents. One to 3 days before each launch, an engine static fire test, which lasts a few seconds, may be performed. The need to conduct a static fire test depends on the mission, but there would be no more than 30 static fire events per year. Typically, 5 weather balloons are released prior to each launch to measure wind speed. The data are used to create wind profiles that help determine if it is safe to launch and land the vehicle. A radiosonde, the size of a half-gallon milk carton, is attached to the weather balloon to measure and transmit atmospheric data to the launch operator. The latex balloon rises to approximately 20-30 kilometers (km) above Earth's surface and bursts. The radiosonde and shredded balloon pieces fall back to Earth and are not recovered. The radiosonde does not have a parachute and is expected to sink to the ocean floor. Launch operations would occur day or night, at any time during the year.

2.1.2.1 Launch Safety

SpaceX, the DAF, the FAA, and the USCG implement numerous protocols and procedures to assess, avoid, mitigate, and minimize potential risks to public safety and the environment during space launch, which are discussed throughout this EA. The Falcon 9 launch vehicle is proven as one of the most reliable space launch vehicles ever developed, with over a 99% launch success rate since June 2010. Due to the Falcon 9 vehicle success rate, launch failure would be an extremely low probability and would represent an off-nominal, worst-case scenario and is not assessed in detail for these reasons. SpaceX implements an Operations Safety Plan at SLC-4, and in the event of a launch failure, SpaceX would activate an Emergency Action Plan. Accordingly, the potential impacts on the environment resulting from a launch failure are not expected to be significant.

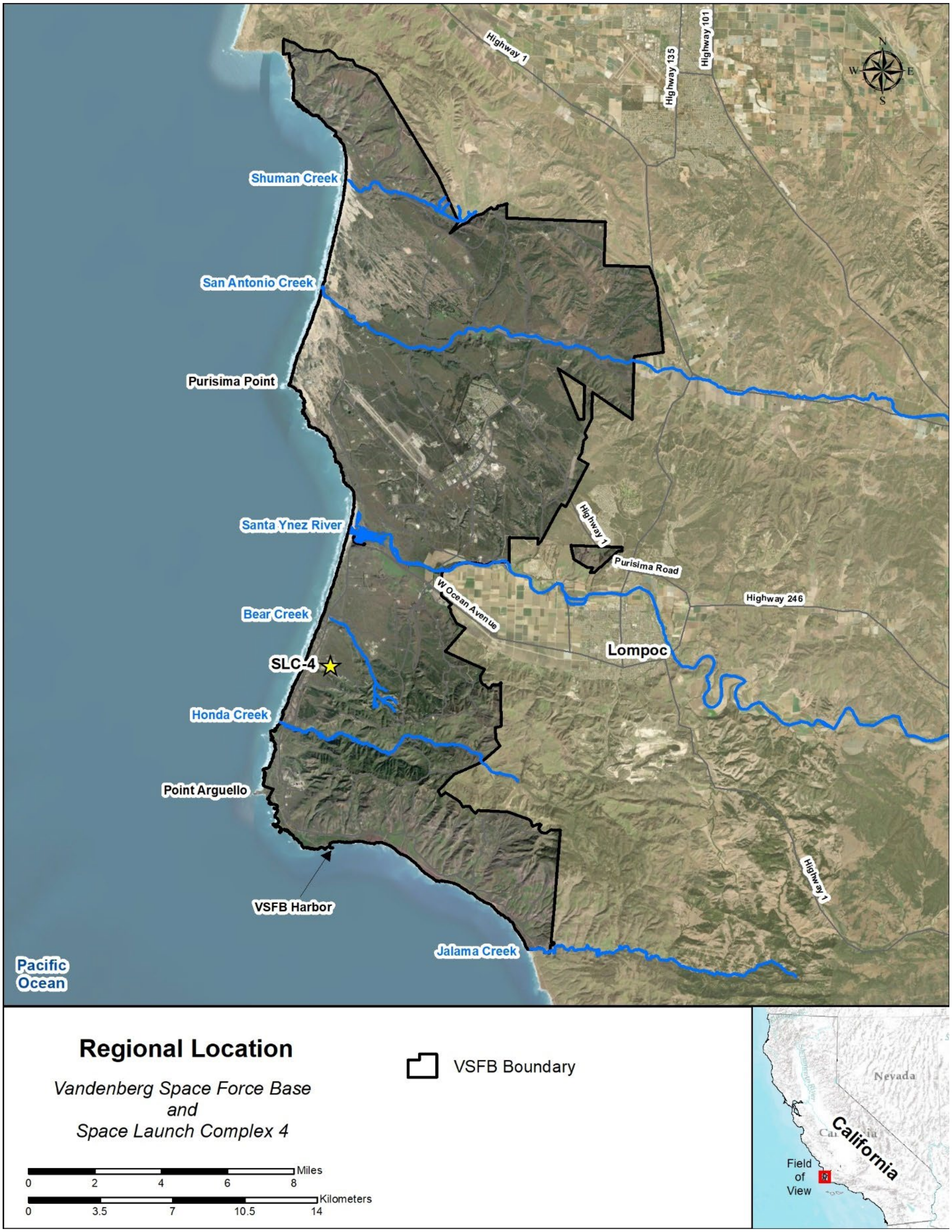

Figure 2.1-1. Project Location Map

2.1.2.1.1 Shipping Lanes

The Proposed Action does not include altering the dimensions of shipping lanes. USCG District Eleven was granted specific regulatory authority to restrict vessel movement, implement safety and warning zones, and provide early warning advisement, but all responsibility to limit risk to navigation safety is solely on SpaceX. USCG District Eleven will advise SpaceX and SLD 30 when the risk exceeds acceptable levels and the primary applicant will be responsible for minimizing the risk with alternate strategies before formal publications. Federal government agencies, including the USCG, are responsible for ensuring maritime safety as required by applicable statutes and regulations, such as the Ports and Waterways Safety Act, 46 USC Sections 70001–70054 and implementing regulations, 33 CFR Part 1 (*General Provisions*), 14 CFR Part 450 (*Launch and Reentry License Requirements*), and 40 CFR Section 229.3 (*Transportation and Disposal of Vessels*). To comply with the necessary notification requirements, SpaceX would notify USCG of any upcoming launch operations to ensure safe launches over the high seas and navigable waters of the U.S. (WOTUS), consistent with current procedures. The USCG would be responsible for issuing NOTMARs that provide hazard area locations before each mission event with ocean impacts. A NOTMAR provides notice of temporary changes in conditions or hazards in navigable waterways with maritime traffic to assist in mitigating risks for dangers associated with waterway users. This tool provides an established and reliable line of communication with the maritime public. The NOTMAR would include the operations dates and times and coordinates of the hazardous operation area.

2.1.2.1.2 Airspace

The Proposed Action does not include altering the dimensions (shape and altitude) of the airspace. All launch and reentry operations would be infrequent and of short duration and comply with the necessary notification requirements, including issuing Notice to Air Missions (NOTAMs), as defined in agreements required for an FAA issued launch license. Advance notice via NOTAMs and identifying Aircraft Hazard Areas assist general aviation pilots to schedule around any temporary disruption of flight activities in the operation area. A NOTAM provides notice of unanticipated or temporary changes to components of, or hazards in, the National Airspace System (NAS; FAA Order JO 7930.2S, Notices to Air Missions). The FAA issues a NOTAM at least 24 hours before a launch or reentry activity in the airspace to notify pilots and other interested parties of temporary conditions. SpaceX regularly provides FAA with updates and schedule changes to their notional three-month launch schedule to minimize interruption to air traffic. FAA's licensing requirements, the process for closures of the National Air Space System, and SLD 30 Range Safety actions during launch operations are described in Section 2.2.1 of the 2023 SEA.

2.1.2.2 Launch Frequency

The DAF proposes to increase the Falcon 9 SLC-4 launch cadence at VSFB from 36 to 50 launches per year. SpaceX has continued to improve its turn-around time between launches, which has provided more opportunity for launches at SLC-4. Increasing launch cadence would help meet the need for critical DOD, National Security, and key commercial launch missions, as described in Section 1.2.

2.1.2.3 Trajectories

Trajectories (i.e., the flight path of rockets) from SLC-4 would remain within the previously analyzed azimuth range of 140 to 325 degrees. Each trajectory would be provided in SpaceX's Flight Safety Data Package and submitted to the FAA before the launch.

2.1.2.4 Landing

SpaceX would land first stage boosters at VSFB or downrange on a droneship as described in Section 2.3.2 of the 2016 EA and Section 2.2.3 of the 2023 SEA. Following each launch, SpaceX would perform a landing of the first stage, either downrange on a droneship or at SLC-4. Mission objectives may occasionally require expending the first stage booster in the Pacific Ocean, as described in Section 2.1.1 of the 2011 EA. If expended, the first stage would break up upon atmospheric re-entry and there would be no residual propellant or explosion upon impact with the Pacific Ocean. The first stage remnants are not buoyant and would sink to the bottom of the ocean. SpaceX would continue to land up to 12 boosters per year at SLC-4. Fairing recovery and jettisoning the Merlin Vacuum Engine skirt ring would occur as described in Section 2.2.1.4 and 2.2.2 of the 2023 SEA. SpaceX is proposing to expand its downrange recovery area by approximately 900 mi west and approximately 1,000 mi south (Figure 2.1-2) to account for potential missions with an expended first-stage booster. The droneship would then transport the booster to the Port of Long Beach as described in Section 2.2.3 of the 2023 SEA.

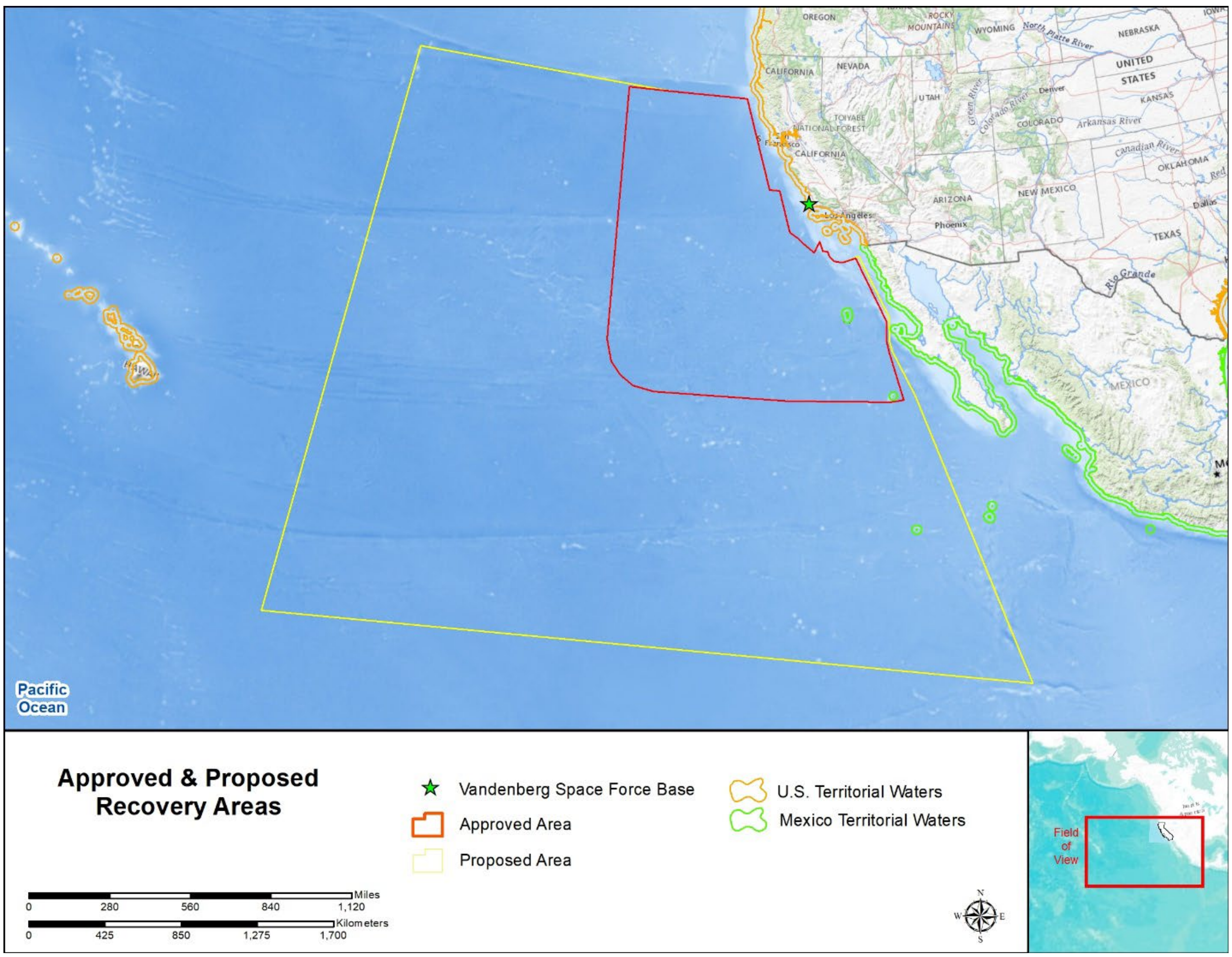

Figure 2.1-2. Proposed Recovery Area

2.1.2.5 Payloads

Payloads and their associated materials/fuels/volumes are mission-dependent but would be similar to current U.S. Government and commercial payloads as described in the 2011 *Environmental Assessment* *for Launch of NASA Routine Payloads* (NASA 2011), for which the DAF was a cooperating agency. As discussed in Section 2.2.6 of the 2023 SEA, Falcon launches from SLC-4 would continue to have similar payloads. Novel payloads such as reentry capsules would undergo a separate review under NEPA and require their own FAA Vehicle Operator License.

2.1.3 Personnel and Ground Operations

Operations would be similar to those described in Section 2.2.6 of the 2023 SEA at SLC-4. To support a cadence increase, SpaceX anticipates adding up to 400 additional personnel to VSFB operations over time, for a total of 700 staff.

The existing SpaceX facilities are adequate to support the staff increase. Ground transportation support during launch campaigns would continue to be minimal. SpaceX would continue to utilize specialized trucks to transport boosters between existing SpaceX facilities, including facilities in Hawthorne, California, Building 398, and at SLC-4 on VSFB. The first stage, second stage, interstage, and payload are each transported by 18-wheel trucks. Fuel and helium are also delivered by 18-wheel trucks on a weekly basis. Personal vehicles would be used by employees to commute locally on and off site. Payload integration and pre-launch protocols associated with the Proposed Action would remain unchanged. However, these operations would increase in frequency to support 50 launches per year.

2.1.4 Utilities

SpaceX would utilize approximately 70,000 gallons of water per launch at SLC-4, as described in Section 2.2.1.3 of the 2023 SEA. Landing operations at SLC-4 previously utilized approximately 40,000 gallons per landing, but no longer require the use of water for operations. At maximum cadence, the Proposed Action would use up to 18.6 acre-feet (ac-ft) of water per year, including increased water use for personnel and operations. Existing utilities at SLC-4, such as power, communications, and fluids systems are adequate to support the proposed increase in cadence. Generators would continue to be utilized at SLC-4 to support operations and for emergency power. Increased personnel at SLC-4 are not expected to result in septic systems exceeding capacity. The septic system at Building 398 has planned improvements independent of the Proposed Action, thus would be able to support increased personnel use.

2.1.5 Vehicle Refurbishment

SpaceX would continue to process vehicles at existing SpaceX facilities such as Building 398. Operations include refurbishing the recovered first stage and fairing for reuse in future missions. Up to 50 boosters and 50 fairings would be refurbished each year. Solvents such as isopropyl alcohol, isopar, and Simple Green would be used during these operations, as well as for launch pad operations, facility maintenance, and vehicle system(s) flushing during refurbishment. System flushing includes the purging of residual waste from the vehicle to maintain system health and avoid contamination. Remaining hazardous waste is contained in drums and disposed of or recycled in accordance with applicable federal, state, and local regulations.

2.1.6 Harbor Operations

SpaceX would continue to transport first stage boosters and fairings from the Port of Long Beach to the VSFB harbor via a "roll-on-roll-off" (RORO) barge, as described in Section 2.2.5 of the 2023 SEA. The Proposed Action would include increasing from 36 to up to 50 operation events per year. Each harbor operation lasts for approximately four hours, or one tide window. Harbor operations could occur at any time of day, as they are dependent on the tides. The Proposed Action does not include additional dredging outside the quantity and depth specified by SLD 30's existing permit from the United States Army Corps of Engineers (USACE).

2.2 Alternative 2 (Modified Proposed Action), Increase Launch Cadence While Maintaining Operations in Compliance with GCR Requirements

Alternative 2 is an alternative that modifies the Proposed Action's (Alternative 1) operations, as described in Section 2.1.6, within the SCAQMD to keep the annual net change in emissions below the 10 tons per year (tpy) Clean Air Act (CAA) General Conformity Rule (GCR) *de minimis* value for Nitrogen Oxides (NOx, an ozone precursor). This would be accomplished through fewer operating hours and/or different boat routes to reduce emissions within nonattainment areas. DAF determined that emissions of NOx from operations at the intensity of the Proposed Action would exceed the 10 tpy allowable limit (*de minimis* value) within the Los Angeles-South Coast Air Basin Ozone Extreme Nonattainment Area which falls within SCAQMD. A nonattainment area is a geographical area that exceeds one or more National Ambient Air Quality Standards (NAAQS). To remedy this situation, activities would be restricted within the Los Angeles-South Coast Air Basin Ozone Extreme Nonattainment Area to remain at *de minimis* levels (i.e., less than 10 tpy). DAF calculated the reasonably foreseeable scenario of restricted operations to demonstrate NOx emissions associated with this action's operations can be maintained below 10 tpy *de minimis* value for the near future. To ensure activities are maintained below the *de minimis* value, SpaceX would calculate and keep a weekly running total of NOx emissions associated with operations, to be made available to the DAF, and would halt all operations within SCAQMD prior to exceeding 10 tpy of NOx emissions annually.

Should SpaceX require additional operations that could result in exceeding the 10 tpy *de minimis* value for NOx, SpaceX needs to reassess the operations consistent with the GCR requirements, as identified in GCR; 40 CFR Part 51, Subpart W that are applicable to the Los Angeles-South Coast Air Basin Ozone Nonattainment Area at the time of reassessment, if required.

2.3 Alternative Screening Criteria

IAW 32 CFR Section 989.8, SLD 30 and SpaceX evaluated alternative sites to increase Falcon annual launch cadence for reasonableness using the following selection criteria:

- **Criterion 1:** Ability to launch payloads to polar and geostationary orbits.
- **Criterion 2:** Require minimal construction to meet near-term manifest needs.

2.4 Alternatives to the Proposed Action Carried Forward for Analysis

The DAF carried Alternative 1, the Proposed Action, Alternative 2, Increase Launch Cadence While Maintaining Harbor Operations in Compliance with GCR Requirements and the No Action Alternative forward for analysis.

2.4.1 Alternative 2 (Modified Alternative 1), Increase Launch Cadence While Maintaining Harbor Operations in Compliance with GCR Requirements

Alternative 2 entails modifying the Proposed Action's (Alternative 1) harbor operations to keep the annual net change in emissions below the 10 tpy GCR *de minimis* value for nitrogen oxides (NOx, an ozone precursor). This would be accomplished through fewer operating hours and/or different boat routes to reduce emissions within nonattainment areas. This Alternative maintains the ability to launch payloads to polar and geostationary orbits. Alternative 2 would reduce the efficiency of recovery operations, requiring additional time to return first-stage boosters and fairings to VSFB for refurbishment.

2.4.2 No Action Alternative

Under the No Action Alternative, SpaceX would not increase the annual cadence for Falcon 9 operations from VSFB, increase Falcon 9 first stage and fairing recovery activities, or expand the recovery area, and rocket launch mission would continue at current levels. SpaceX would not meet the DOD requirements for Assured Access to Space nor fully meet the National Space Transportation Policy goals of providing low-cost reliable access to and from space. The National Space Transportation Policy goals would be negatively affected, as would the more short-term need to meet the increase in current and future manifest demands. DOD's statutory authority to contract with and rely on commercial space operations and the intent of the 2020 National Space Policy would be impaired.

Under the No Action Alternative, there would be no new impacts on the environmental impact categories analyzed in this EA. The No Action Alternative is the environmentally preferable alternative. However, the No Action Alternative does not meet the Purpose and Need. The No Action Alternative provides the basis for comparing the environmental consequences of the Proposed Action.

2.5 Alternatives Considered but Eliminated from Further Analysis

CEQ Regulations for Implementing the Procedural Provisions of NEPA (40 CFR Parts 1500–1508) require federal agencies to use the NEPA process to identify and assess the reasonable alternatives to the Proposed Action that would foster informed decision making.

2.5.1 Kennedy Space Center/Cape Canaveral Space Force Station

SpaceX evaluated its existing leased facilities at Cape Canaveral Space Force Station (SLC-40) and Kennedy Space Center Launch Complex [LC]-39A for reasonableness. SpaceX currently launches Falcon 9 from SLC-40 and LC-39A including crew missions. SLC-40 and LC-39A were dismissed from consideration as they predominantly support a different range of trajectories. For example, polar trajectories or those with an inclination greater than 53 degrees cannot be launched from LC-39A or SLC-40 without substantial impacts to vehicle performance, to the point that certain payloads cannot be launched. Accordingly, these sites do not meet screening criterion #1.

2.5.2 Non-SpaceX VSFB Facilities

SpaceX evaluated existing facilities at VSFB for reasonableness. Non-SpaceX sites at VSFB would not be able to readily provide infrastructure requirements without substantial construction activities, which would result in additional impacts and would not support the near-term launch manifest needs, thus do not meet screening criterion #2.

2.6 Permits, Licensees, and Other Authorizations

The Proposed Action would require a modification of SpaceX's existing FAA launch license (LLO-18-111). An air permit would also be required from the Santa Barbara County Air Pollution Control District.

3 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

The resources listed in Table 3.0-1 were considered but eliminated from detailed analysis in this EA because the resource would not be affected or there would be no change from what was analyzed in the 2023 SEA.

Table 3.0-1. Resources not analyzed

Resource	Reason not Analyzed
Land Use and Aesthetics	The activities under the Proposed Action are consistent with those already conducted at VSFB. SLC-4 would be used for the proposed expansion of SpaceX activities. The proposed activities would be similar to launch activities that have been performed at this site and nearby launch sites on VSFB. The proposed increase in launch cadence would be consistent with existing land use at the project site, would not result in a change to land use or be incompatible with adjacent land uses, such as agricultural land, and would not alter the existing industrial character of the area. Views along the coastline would not change and no alterations to the visual landscape would occur. Therefore, this resource was considered but eliminated from detailed analysis in this EA.
Visual Effects, Light Emissions, and Visual Resources/Visual Character	The Proposed Action would not change the existing or planned use of VSFB. Launch and landing would occur from existing sites at SLC-4 on VSFB. The Proposed Action would conform to the existing designated land uses. With regards to human impacts, the additional proposed launch activities would not differ visually from those activities already occurring at VSFB. Rockets may be visible to people in the sky more often and there could be greater instances of nighttime lighting, but the visual sensitivity of VSFB is low because it is a federal launch range. Therefore, this resource was considered but eliminated from detailed analysis in this EA.
Geological Resources	The Proposed Action does not include any construction or new ground disturbing activities that weren't already considered in prior EAs and SEAs; therefore, this resource was considered but eliminated from detailed analysis in this EA.
Environmental Justice and Protection of Children	Under the Proposed Action launches and landings would occur on VSFB and primarily over open ocean away from populated areas. VSFB controls public access to the Base and therefore no public member would be present near the launch site during launch operations. Launch and landing would not occur near any schools or childcare facilities. Therefore, launch and landing under the Proposed Action does not have the potential for disproportionately high and adverse effects on minority or low-income populations or a disproportionate health or safety risk to children. Noise

Resource	Reason not Analyzed
	created during launch and landing activities would impact various communities in Santa Barbara, Ventura, and Los Angeles Counties (see Section 3.2), but would not disproportionately impact any communities with Environmental Justice concerns. Therefore, this resource was considered but eliminated from detailed analysis in this EA.
Farmlands	The Proposed Action would not convert prime agricultural land to other uses or result in a decrease in the land's productivity. Therefore, this resource was considered but eliminated from detailed analysis in this EA.
Natural Resources	The Proposed Action would minimally affect supplies of energy, water, and would not affect asphalt, aggregate, and wood, and other natural resources in the region because the project either requires none to relatively small amounts of these resources or there are abundant suppliers available in the region. Therefore, the potential impacts to natural resources are considered but eliminated from detailed analysis in this EA.
Wild and Scenic Rivers	There are no rivers protected under the California Wild and Scenic Rivers Act within the affected environment. Therefore, this resource was considered eliminated from detailed analysis in this EA.

3.1 Air Quality and Climate

3.1.1 Affected Environment

The approach to analysis under the Clean Air Act of 1970 (42 USC Part 7401 et seq.), as amended, and General Conformity Analysis (40 CFR Part 93) under NEPA are discussed in Appendix E. The region of influence (ROI) for air quality includes the Study Area and adjoining land several mi inland, which may be downwind from emission sources associated with the Proposed Action, and includes Santa Barbara, Ventura, and Los Angeles Counties. For GCR purposes, each nonattainment or maintenance area that the action (or portions of the action) will occur within is considered a separate ROI and each must have a separate General Conformity evaluation (40 CFR 93.150(e)). None of the Air Districts where any of these proposed actions may occur has adopted the 2010 revisions to 40 CFR Part 93. Consequently, the applicable conformity rules are found at South Coast Air Quality Management District (SCAQMD) Rule 1901; Santa Barbara County Air Pollution Air Pollution Control District (SBAPCD) Rule 702; and Ventura County Air Pollution Control District (VCAPCD) Rule 220. A "nonattainment area" is a geographical area designated by USEPA as exceeding the NAAQS for one or more criteria pollutants. Maintenance areas are former nonattainment areas.

3.1.1.1 Climate of the Study Area

The climate of the Pacific Ocean and adjacent land areas is influenced by surface water temperatures, water currents, and wind. Offshore climates are moderate and seldom have extreme seasonal variations because the ocean is slow to change temperature. Ocean currents influence climate by moving warm and cold water between regions. Adjacent land areas are affected by the wind that is cooled or warmed when blowing over these currents. The wind also moves evaporated moisture from the ocean to adjacent land areas and is a major source of rainfall.

The climate of coastal Southern California and adjacent offshore Pacific Ocean waters consists of warm, dry summers and cool, typically wet winters (although the region has been subject to regular severe drought), mainly influenced by a semi-permanent high-pressure system (the Pacific High) in the eastern Pacific Ocean. This Pacific High maintains clear skies in Southern California for much of the year. When the Pacific High moves south during the winter, this pattern changes and low-pressure centers migrate into the region, bringing precipitation, falling mainly as rain in October-April. The predominant regional wind directions are westerly and west-southwesterly during all four seasons. Surface winds are typically from the north and west (onshore) during the day and from the east (offshore) at night (Dudek 2024).

3.1.1.2 Existing Air Quality

Offshore air quality is generally better than adjacent onshore areas because there are few or no large sources of criteria air pollutants offshore. Much of the air pollutants in offshore areas are transported there from adjacent land areas by low-level offshore winds, so concentrations of criteria air pollutants generally decrease with increasing distance from land. No criteria air pollutant monitoring stations are located in offshore areas, so air quality in the Study Area must be inferred from adjacent land areas where air pollutant concentrations are monitored.

The Proposed Action includes activities in the South Central Coast and the South Coast Air Basins (SCAB). Coastal waters within 3 nautical miles (nm) of the shore are under the same air quality jurisdiction as the contiguous land areas of the South-Central Coast Air Basin (SCCAB). VSFB is located within the SCCAB, which includes San Luis Obispo, Santa Barbara, and Ventura counties. The Santa Barbara County Air Pollution Control District (SBCAPCD) has jurisdiction over Santa Barbara County and the Ventura County Air Pollution Control District (VCAPCD) has jurisdiction over Ventura County. The Proposed Action would also include vessel travel to and from the Port of Long Beach in Los Angeles County. Los Angeles County is located within the SCAB and the South Coast Air Quality Management District (SCAQMD).

Santa Barbara County is in attainment for all NAAQSs. Most of Ventura County is in serious nonattainment for eight-hour ozone (O_3) NAAQS including the area where the action will take place. Los Angeles County, where portions of the action will take place, is in extreme nonattainment for the eight-hour- ozone (O_3) NAAQS, maintenance for carbon monoxide, nonattainment for lead, nonattainment for particulate matter 2.5, and maintenance for particulate matter 10. Within attainment areas, SpaceX is required to ensure air quality does not significantly deteriorate due to air emissions associated with the Proposed Action. The Proposed Action is required to demonstrate conformity with the approved State Implementation Plan (SIP) if the net emissions equal or exceed the *de minimis* emission levels in nonattainment and maintenance areas.

3.1.1.2.1 Criteria Air Pollutants

Air pollutants emitted more than 3,000 ft above ground level are considered to be above the atmospheric inversion layer and, therefore, do not affect ground-level air quality (U.S. Environmental Protection Agency [USEPA] 1992). Emissions released above this altitude distance are often too highly dispersed within the atmosphere to impact pollutant concentrations over land and the surface of the water in the lower atmosphere, measured at ground-level monitoring stations, upon which federal, state, and local regulatory decisions are based. However, since all of the sources of pollutants are mobile, and it is difficult to determine where exactly emissions would be released within the Study Area, all emissions occurring under 3,000 ft are considered when comparing against the *de minimis* thresholds. Table 3.1-1 shows annual emissions from SpaceX activities (including launch and landing activities; static firing; booster and fairing recoveries; work transits; vendor deliveries; and generator use) from 36 launch events.

Table 3.1-1. Estimated annual criteria pollutant emissions under the current environmental baseline conditions[1]

Criteria Pollutants	Annual Emissions (tons per year)				
	CO	NO_x	VOC	SO_x	PM_{10}
Emissions (0–3 nm)	7.7511	13.8268	9.1476	0.1158	0.4000
Emissions (3–12 nm)	0.5065	2.5509	0.2132	0.1312	0.0643
TOTAL	**8.2576**	**16.3777**	**9.3608**	**0.247**	**0.4643**

[1]Table includes criteria pollutant precursors (e.g., volatile organic compounds [VOCs]). Individual values may not add exactly to total values due to rounding.

Notes: CO = carbon monoxide, NO_X = nitrogen oxides, NO_2 = nitrogen dioxide, PM_{10} = particulate matter ≤ 10 microns in diameter, SO_2 = sulfur dioxide, SO_X = sulfur oxides, VOC = volatile organic compound, nm = nautical miles

3.1.1.2.2 Climate

Current activities in the Study Area involve mobile sources using fossil fuel combustion. Greenhouse gas (GHG) emissions can persist in the atmosphere from 12 years for methane to up to 200 years for carbon dioxide. Emissions generated by specific activities contribute incrementally in combination with past and future emissions from all other sources to global warming that produces the adverse effects of climate change. Table 3.1-2 shows the current environmental GHG emissions baseline produced under SpaceX activities (including launch and landing activities; static firing; booster and fairing recoveries; work transits; vendor deliveries; and generator use) from 36 launch events and compares them against total national GHG emissions.

Table 3.1-2. Estimated annual greenhouse gas emissions under the current environmental baseline conditions

Emissions of CO_2e (Metric Tons per Year)	
Current Environmental Baseline GHG Emissions	23,565
National GHG Emissions	5,981,400,000
Percent of National Emissions	0.000394%
California GHG Emissions	369,200,000
Percent of California Emissions	0.006383%

Notes: CO_2e = carbon dioxide equivalent

3.1.2 Environmental Consequences

Air quality impacts would be significant if the action would cause pollutant concentrations to exceed one or more of the NAAQs, as established by the USEPA under the Clean Air Act, for any of the time periods analyzed in this EA, or to increase the frequency or severity of any such existing violations. There are no significance thresholds for commercial space launch GHG emissions, nor has the FAA identified specific factors to consider in making a significance determination for GHG emissions. There are currently no accepted methods of determining significance applicable to commercial space launch projects given the small percentage they contribute.

3.1.2.1 Alternative 1 (Proposed Action), Increase Launch Cadence

The combined net change in emissions analysis (also a General Conformity Applicability Analysis for nonattainment and maintenance areas) indicated a potential significant impact to air quality; therefore, a further in-depth evaluation of air impacts and a General Conformity Determination would be required.

With the exception of launch, barge, and crane activities, emissions were calculated using the USAF Air Conformity Applicability Model (ACAM). ACAM does not provide functionality for launch activities; these emissions were calculated using engine-specific emissions factors derived from PERCORP and VIPER models. The barge and crane activities emissions were calculated using 2023 Port of Los Angeles Emissions Inventory Methodology Report. Emission estimates were also calculated using the California Emissions Estimator Model (CalEEMod), which are presented in Appendix E. While this section presents summary tables of each component activity, Appendix E includes detailed calculation tables and air modeling output reports.

3.1.2.1.1 Operations

Operations under the Proposed Action would generate VOCs, NOx, CO, SOx, PM_{10}, and $PM_{2.5}$ emissions from stationary and mobile sources, including vehicle trips from passenger vehicles and heavy-duty trucks, marine vessels, booster launches and landings, launch vehicle processing, and off-road equipment used for maintenance. Annual emissions of the Proposed Action would not exceed the Prevention of Significant Deterioration threshold of significance for VOC, NOx, CO, SOx, PM_{10}, or $PM_{2.5}$ in the SBCAPCD. As such, project operations under Alternative 1 would not have an adverse effect on air quality in the SBCAPCD jurisdiction (Table 3.1-3).

Table 3.1-3. Estimated criteria pollutant emissions produced under the Alternative 1 from operational activities in the SBCAPCD

Source	Annual Emissions (tons per year)						
	VOC	NO_x	CO	SO_x	PM_{10}	$PM_{2.5}$	Pb
Operational Activities	12.26	57.09	71.95	1.48	2.09	2.00	0.01
Baseline	8.02	8.01	2.89	0.05	0.10	0.10	0.00
Delta (Alternative 1, Proposed Action – Baseline)	4.24	49.08	69.06	1.43	1.99	1.90	0.01
Prevention of Significant Deterioration Threshold	250	250	250	250	250	250	25

Threshold Exceeded	No	No	No	No	No	No	No

Notes: (1) Table includes criteria pollutant precursors (e.g., VOCs). Ozone is a secondary pollutant tracked by its precursor. (2) CO = carbon monoxide, NO_X = nitrogen oxides, Pb = lead, PM_{10} = particulate matter ≤ 10 microns in diameter, $PM_{2.5}$ = particulate matter ≤ 2.5 microns in diameter, SO_X = sulfur oxides, VOC = volatile organic compounds, Pb = lead, nm = nautical miles, (3) Individual values may not add up exactly to total values due to rounding.

As shown in Table 3.1-4, annual emissions of the Proposed Action would not exceed the General Conformity *de minimis* threshold of significance for VOC, NOx, CO, SOx, PM_{10}, or $PM_{2.5}$ in the VCAPCD. As such, project operations under Alternative 1 would not have an adverse effect on air quality in the VCAPCD jurisdiction.

Table 3.1-4. Estimated criteria pollutant emissions produced under Alternative 1 from operational activities in the VCAPCD

Source	Annual Emissions (tons per year)						
	VOC	**NO_x**	**CO**	**SO_x**	**PM_{10}**	**$PM_{2.5}$**	**Pb**
Operational Activities	2.11	25.18	37.40	0.50	0.54	0.54	0.00
Baseline	0.19	0.88	0.85	0.00	0.03	0.03	0.00
Delta (Alternative 1, Proposed Action – Baseline)	1.92	24.30	36.55	0.50	0.51	0.51	0.00
General Conformity De Minimis Threshold	50	50	100	100	100	100	25
Threshold Exceeded	**No**	**No**	**No**	**No**	**No**	**No**	**No**

Notes: (1) Table includes criteria pollutant precursors (e.g., VOCs). Ozone is a secondary pollutant tracked by its precursor. (2) CO = carbon monoxide, NO_X = nitrogen oxides, PM_{10} = particulate matter ≤ 10 microns in diameter, $PM_{2.5}$ = particulate matter ≤ 2.5 microns in diameter, SO_X = sulfur oxides, VOC = volatile organic compounds, Pb = lead, nm = nautical miles, (3) Individual values may not add up exactly to total values due to rounding.

As shown in Table 3.1-5, annual emissions of the Proposed Action would not exceed the General Conformity *de minimis* threshold of significance for VOC, CO, SOx, PM10, or PM2.5 in the SCAQMD. However, emissions of NOx would exceed the threshold. As such, a general conformity determination is necessary to determine if the Proposed Action under Alternative 1 would have an adverse effect on air quality in the SCAQMD jurisdiction.

Table 3.1-5. Estimated criteria pollutant emissions produced under Alternative 1 from operational activities in the SCAQMD

Source	Annual Emissions (tons per year)						
	VOC	**NO_x**	**CO**	**SO_x**	**PM_{10}**	**$PM_{2.5}$**	**Pb**
Operational Activities	2.68	33.36	46.66	0.68	0.76	0.76	0.01
Baseline	0.34	2.1	1.35	0.05	0.07	0.07	0.00
Delta (Alternative 1, Proposed Action – Baseline)	2.34	31.26	45.31	0.63	0.69	0.69	0.01
General Conformity De Minimis Threshold	10	10	100	250	100	70	25
Threshold Exceeded	**No**	**Yes**	**No**	**No**	**No**	**No**	**No**

Notes: (1) Table includes criteria pollutant precursors (e.g., VOCs). Ozone is a secondary pollutant tracked by its precursor. (2) CO = carbon monoxide, NO_X = nitrogen oxides, Pb = lead, PM_{10} = particulate matter ≤ 10 microns in diameter, $PM_{2.5}$ = particulate matter ≤ 2.5 microns in diameter, SO_X = sulfur oxides, VOC = volatile organic compounds, Pb = lead, nm = nautical miles, (3) Individual values may not add up exactly to total values due to rounding.

3.1.2.1.2 Airspace Impacts

Airspace closures associated with commercial space operations would result in additional aircraft emissions mainly from aircraft being re-routed and expending more fuel. Minimal, if any, additional emissions would be generated from aircraft departure delays because the FAA has rarely, if ever, received reportable departure delays associated with launches at VSFB. Based on SpaceX's proposal, airspace-related impacts could increase up to a maximum of 50 times per year. Any delays in aircraft departures from affected airports would be short-term. Therefore, these emissions increases are not expected to result in an exceedance of a NAAQS for any criteria pollutant. Emissions from aircraft being re-routed would occur above 3,000 ft (the mixing layer) and thus would not affect ambient air quality. Therefore, airspace closures associated with the Proposed Action under Alternative 1 are not expected to result in significant air quality impacts.

3.1.2.1.3 General Conformity Impacts

The USEPA's General Conformity Rule (40 CFR part 93, Subpart B, and 40 CFR Part 51, Subpart W, as adopted by reference in SCAQMD Rule 1901, September 1994) establishes an Applicability Analysis for ascertaining which Federal actions are subject to the General Conformity requirements for nonattainment or maintenance areas. A GCR Applicability Analysis for each nonattainment and maintenance area was performed and indicated a potential significant impact to air quality within the Los Angeles-South Coast Air Basin Extreme Ozone Nonattainment Area. Therefore, a GCR Determination is required. In the other two air districts, which also adopted 40 CFR Part 51, Subpart W, the proposed emissions do not exceed the *de minimis* levels for the proposed actions.

The GCR Determination process is intended to demonstrate that a proposed Federal action will not: (1) cause or contribute to new violations of a NAAQS; (2) interfere with provisions in the applicable SIP for maintenance of any NAAQS; (3) increase the frequency or severity of existing violations of any standard; or (4) delay the timely attainment of any standard. As such, for general conformity determination, the proposed federal action needs to conform to the latest approved SIP/Air Quality Management Plan (AQMP). The SCAB is designated as an extreme nonattainment area for ozone, serious nonattainment for $PM_{2.5}$ and maintenance area for CO. In order to accommodate projects subject to general conformity requirements and to streamline the review process, general conformity budgets for NOx and VOC emissions are established in the AQMP. The 2016 AQMP, which is the latest plan approved by USEPA, established set aside accounts to accommodate emissions subject to general conformity requirements. The set-aside accounts include 730 tons per year (tpy) of NOx and 182.5 tpy of VOC each year starting in 2017 through 2030, and 182.5 tpy of NOx and 73 tpy of VOC each year in 2031 and thereafter.

Alternative 1 exceeds the GCR Applicability Analysis *de minimis* threshold of NOx beginning in the year of 2025 and would be held steady during the lifetime of the project at 31.26 tpy. If this alternative is selected, a GCR Determination will be required for NOx emissions for the Los Angeles- South Coast Air Basin Extreme Ozone Nonattainment Area. The GCR Determination must be completed in accordance with CAA Sec. 176(c) [42 U.S.C. Sec. 7506(c)], as implemented in the South Coast Air Quality Management District

(SCAQMD) Rule 1901. The GCR Applicability Analysis indicated a GCR Determination is required for NOx emissions which exceed 10 tpy as the area is an Extreme Nonattainment area for Ozone (O_3).

Starting in 2025 through 2030, SCAQMD has committed adequate emissions from the 2016 AQMP (current applicable SIP) General Conformity Budget to support the entirety of this Proposed Action. Prior to implementing the Proposed Alternative, a GCR Determination must be documented and approved. For details of the SCAQMD's commitment, refer to SCAQMD's letter to SLD 30 dated 26 September 2024 which is attached in Appendix E. Upon achieving a GCR Determination, Alternative 1 would not have a significant adverse impact on air quality within the SCAQMD jurisdiction (Table 3.1-6). Operations beyond 2030 would require additional coordination with SCAQMD and an additional GCR Determination.

Table 3.1-6. Estimated criteria pollutant emissions produced under Alternative 1 from operational activities in the SCAQMD with the 2016 AQMP Commitment Starting in 2025

Source	**Annual Emissions (tons per year)**						
	VOC	**NO_x**	**CO**	**SO_x**	**PM_{10}**	**$PM_{2.5}$**	**Pb**
Operational Activities	2.68	33.36	46.66	0.68	0.76	0.76	0.01
Baseline	0.34	2.1	1.35	0.05	0.07	0.07	0.00
2016 AQMP General Conformity Budget Emissions from SCAQMD	0.00	31.26	0.00	0.00	0.00	0.00	0.00
Delta (Alternative 1, Proposed Action – Baseline)	2.34	0.00	45.31	0.63	0.69	0.69	0.01
General Conformity De Minimis Threshold	10	10	100	250	100	70	25
Threshold Exceeded	**No**	**No**	**No**	**No**	**No**	**No**	**No**

Notes: (1) Table includes criteria pollutant precursors (e.g., VOCs). Ozone is a secondary pollutant tracked by its precursor. (2) CO = carbon monoxide, NO_X = nitrogen oxides, Pb = lead, PM_{10} = particulate matter ≤ 10 microns in diameter, $PM_{2.5}$ = particulate matter ≤ 2.5 microns in diameter, SO_X = sulfur oxides, VOC = volatile organic compounds, Pb = lead, nm = nautical miles, (3) Individual values may not add up exactly to total values due to rounding.

3.1.2.2 Alternative 2 (Modified Proposed Action), Increase Launch Cadence While Maintaining Operations in Compliance with GCR Requirements

The combined net change in emissions analysis (also a GCR Applicability Analysis for nonattainment and maintenance areas) indicated impacts to air quality would not be significant. Given this alternative entails a modified version of the Proposed Action (Alternative 1), all emissions calculations were performed using the same procedures and methodologies as Alternative 1.

3.1.2.2.1 Operations

Operations (excluding harbor operations as described in Section 2.1.6) under Alternative 2 would generate VOCs, NOx, CO, SOx, PM_{10}, and $PM_{2.5}$ emissions from stationary and mobile sources, including vehicle trips from passenger vehicles and heavy-duty trucks, marine vessels, booster launches and landings, launch vehicle processing, and off-road equipment used for maintenance. Annual emissions of Alternative 2 would remain the same as Alternative 1 and would not exceed the DAF's Insignificant Indicators for VOC, NOx, CO, SOx, PM_{10}, or $PM_{2.5}$ in the SBCAPCD. As such, project operations under Alternative 2 would not have an adverse effect on air quality in the SBCAPCD jurisdiction.

Annual emissions of Alternative 2 (excluding harbor operations as described in Section 2.1.6) would remain the same as the Alternative 1; therefore, as shown in Table 3.1-7 and Table 3.1-8, annual emissions of these Alternatives would not exceed the GCR *de minimis* threshold of significance for VOC, NOx, CO, SOx, PM_{10}, or $PM_{2.5}$ in the SBCAPCD nor VCAPCD. As such, project operations under Alternative 2 would not have an adverse effect on air quality in the SBCAPCD or the VCAPCD jurisdictions.

Table 3.1-7. Estimated criteria pollutant emissions produced under the Alternative 2 from operational activities in the SBCAPCD

Source	**Annual Emissions (tons per year)**						
	VOC	**NO_x**	**CO**	**SO_x**	**PM_{10}**	**$PM_{2.5}$**	**Pb**
Operational Activities	11.29	44.1	56.81	1.27	1.84	1.74	0.01
Baseline	8.02	8.01	2.89	0.05	0.10	0.10	0.00
Delta (Alternative 1, Proposed Action – Baseline)	3.27	36.09	53.92	1.22	1.74	1.64	0.01
Prevention of Significant Deterioration Threshold	250	250	250	250	250	250	25
Threshold Exceeded	**No**	**No**	**No**	**No**	**No**	**No**	**No**

Notes: (1) Table includes criteria pollutant precursors (e.g., VOCs). Ozone is a secondary pollutant tracked by its precursor. (2) CO = carbon monoxide, NO_X = nitrogen oxides, Pb = lead, PM_{10} = particulate matter ≤ 10 microns in diameter, $PM_{2.5}$ = particulate matter ≤ 2.5 microns in diameter, SO_X = sulfur oxides, VOC = volatile organic compounds, Pb = lead, nm = nautical miles, (3) Individual values may not add up exactly to total values due to rounding.

Table 3.1-8. Estimated criteria pollutant emissions produced under Alternative 2 from operational activities in the VCAPCD

Source	**Annual Emissions (tons per year)**						
	VOC	**NO_x**	**CO**	**SO_x**	**PM_{10}**	**$PM_{2.5}$**	**Pb**
Operational Activities	0.88	10.49	15.99	0.22	0.22	0.22	0.00
Baseline	0.19	0.88	0.85	0.00	0.03	0.03	0.00
Delta (Alternative 1, Proposed Action – Baseline)	0.69	9.61	15.14	0.22	0.19	0.19	0.00
General Conformity De Minimis Threshold	50	50	100	100	100	100	25
Threshold Exceeded	**No**	**No**	**No**	**No**	**No**	**No**	**No**

Notes: (1) Table includes criteria pollutant precursors (e.g., VOCs). Ozone is a secondary pollutant tracked by its precursor. (2) CO = carbon monoxide, NO_X = nitrogen oxides, PM_{10} = particulate matter ≤ 10 microns in diameter, $PM_{2.5}$ = particulate matter ≤ 2.5 microns in diameter, SO_X = sulfur oxides, VOC = volatile organic compounds, Pb = lead, nm = nautical miles, (3) Individual values may not add up exactly to total values due to rounding.

Alternative 2 entails modifying the Alternative 1's operations, as described in Section 2.1.6, to keep the annual net change in emissions below the 10 tpy GCR *de minimis* value for NOx (an ozone precursor). This would be accomplished through fewer operating hours and/or different boat routes to reduce emissions within nonattainment areas. As shown in Table 3.1-9, annual emissions of Alternative 2 would not exceed the General Conformity *de minimis* threshold of significance for VOC, NOx, CO, SOx, PM10, or PM2.5 in the SCAQMD.

Table 3.1-9. Estimated criteria pollutant emissions produced under Alternative 2 from operational activities in the SCAQMD

Source	Annual Emissions (tons per year)						
	VOC	NO_x	CO	SO_x	PM_{10}	$PM_{2.5}$	Pb
Operational Activities	0.78	8.00	13.92	0.29	0.22	0.22	0.01
Baseline	0.34	2.1	1.35	0.05	0.07	0.07	0.00
Delta (Alternative 2 – Baseline)	0.44	5.90	12.57	0.24	0.15	0.15	0.01
General Conformity De Minimis Threshold	10	10	100	250	100	70	25
Threshold Exceeded	**No**	**No**	**No**	**No**	**No**	**No**	**No**

Notes: (1) Table includes criteria pollutant precursors (e.g., VOCs). Ozone is a secondary pollutant tracked by its precursor. (2) CO = carbon monoxide, NO_X = nitrogen oxides, Pb = lead, PM_{10} = particulate matter ≤ 10 microns in diameter, $PM_{2.5}$ = particulate matter ≤ 2.5 microns in diameter, SO_X = sulfur oxides, VOC = volatile organic compounds, Pb = lead, nm = nautical miles, (3) Individual values may not add up exactly to total values due to rounding.

3.1.2.2.2 Airspace Impacts

Airspace Impacts under Alternative 2 are the same as Alternative 1 impacts.

3.1.2.2.3 General Conformity Impacts

The USEPA's GCR (40 CFR Part 51, Subpart W, as adopted by reference in SCAQMD Rule 1901, September 1994) establishes a GCR Applicability Analysis for ascertaining which Federal actions are subject to the General Conformity requirements for nonattainment or maintenance areas.

Alternative 2 has no significant impact on air quality and meets the GCR requirements. Operation activities would be modified within the Los Angeles-South Coast Air Basin Ozone Extreme Nonattainment Area to remain below *de minimis* levels (i.e., less than 10 tpy). SpaceX calculated the reasonably foreseeable scenario of restricted operations to demonstrate NOx emissions associated with this action's operations can be maintained below 10 tpy *de minimis* value for the near future. While this scenario was well below the *de minimis* value, operations may increase, but will not exceed the 10 tpy *de minimis* value. To ensure activities are maintained below the *de minimis* value, SpaceX would calculate and keep a weekly running total of NOx emissions associated with operations and will halt all operations within SCAQMD prior to exceeding 10 tpy of NOx emission.

As operations at the harbor are the source of the Nox emissions, any additional harbor operations that could result in exceeding the 10 tpy *de minimis* value for NOx would need to be reassessed to remain consistent with the GCR requirements, that are applicable to the Los Angeles-South Coast Air Basin Ozone Nonattainment Area at the time of reassessment, if required.

3.1.2.3 No Action Alternative

Under the No Action Alternative, increased launch cadence on VSFB would not occur, resulting in no impacts on air quality, beyond those described in the 2023 SEA.

3.1.2.4 Climate

3.1.2.4.1 Alternative 1 and 2

CalEEMod was used to calculate the annual GHG emissions from all emission sources (Appendix E) for the Proposed Action. Estimated operational GHG emissions from Alternative 1 would be approximately 45,990 metric tons CO_2e per year. When accounting for the Baseline emissions, Alternative 1 would result in an additional 17,935 metric tons of CO_2e per year. Alternative 2 would result in similar GHG emissions, a total addition of 13,205 metric tons of CO_2e per year.

The social cost of GHG (SC-GHG) is an economic concept used to quantify the monetary value of the long-term societal damage caused by the emission of GHGs into the atmosphere. This metric seeks to capture the various adverse impacts associated with GHG emissions, such as climate change, health problems, ecosystem damage, and economic losses. By assigning a dollar value to these damages, the SC-GHG provides a tool for policymakers, businesses, and governments to assess the true costs of emitting CO_2, CH_4, N_2O, and other GHGs. Alternative 1 would have a SC-GHGs of over $6.3 million under a 3% discount rate, and over $9.2 million at a 2.5% discount rate. Alternative 2 would have a SC-GHGs of over $4.9 million under a 3% discount rate, and over $7.1 million at a 2.5% discount rate. Since publication of the Interim Estimates, USEPA has been working on new estimates for the SC-GHGs. These estimates reflect recent advances in scientific literature on climate change and its economic impacts and incorporate recommendations made by the National Academies of Science, Engineering, and Medicine. Under USEPA's draft estimates for SC-GHGs, Alternative 1 would have a SC-GHG of over $14.7 million under the 2.5% discount rate, under the 2% discount rate over $23.8 million, and at a 1.5% discount rate over $40.1 million. Alternative 2 would have a SC-GHG of over $9.4 million under the 2.5% discount rate, under the 2% discount rate over $15.1 million, and at a 1.5% discount rate over $25.4 million. By assigning a dollar value to the damages associated with GHG emissions, policymakers and decision-makers can better evaluate the costs and benefits of actions aimed at reducing emissions. The SC-GHGs provides a tool to make more informed choices about climate-related policies, regulations, and investments.

An emerging area of study of rocket launches is the potential effects to ozone and emissions in the upper atmosphere. Scientific literature on this topic is limited and the science itself is poorly understood, and in some cases not yet studied (World Meteorological Organization 2022). Much of the body of literature concerning potential environmental impacts of rockets relates to solid rocket motors, which Falcon 9 does not use. The limited studies of emissions from rocket engines using liquid propellent reveal that while they do result in some stratospheric ozone loss, solid rocket motors are responsible for orders of magnitude greater loss (Dallas 2020). The World Meteorological Organization's 2022 Scientific Assessment of Ozone Depletion noted rocket launches presently have a small effect on total stratospheric ozone (much less than 0.1% (World Meteorological Organization 2022). Thus, the Proposed Action is not expected to result in significant impacts to climate due to ozone depletion or upper atmosphere emissions.

Airspace closures associated with commercial space operations would result in additional aircraft emissions mainly from aircraft being re-routed and expending more fuel, including CO_2. These temporary increases in aircraft emissions could increase up to a maximum of 50 times per year. The amount of time that affected aircraft spend being re-routed would be short-term and the number of aircraft that would be impacted per launch would not be expected to produce additional emissions that would have a notable impact on climate. Therefore, the increases in GHGs caused by short-term airspace closures during commercial space operations under the Proposed Action is not expected to result in significant climate-related impacts.

The FAA has not established a significance threshold for climate, nor has the FAA identified specific factors to consider in making a significance determination for GHG emissions. The scientific community is continuing efforts to better understand the impact of aviation emissions on the global atmosphere. The FAA is leading and participating in a number of initiatives intended to clarify the role that commercial aviation plays in GHG emissions and climate. The FAA, with support from the U.S. Global Change Research Program and its participating federal agencies, has developed the Aviation Climate Change Research Initiative in an effort to advance scientific understanding of regional and global climate impacts of aircraft emissions.

3.1.2.4.2 No Action Alternative

Under the No Action Alternative, increased launch cadence on VSFB would not occur, resulting in no impacts on climate, beyond those described in the 2023 SEA.

3.2 Noise

3.2.1 Affected Environment

A detailed description of noise/sound, ambient sound guidance documents, Federal Interagency Committee on Urban Noise (1980) criteria, and USEPA noise standards is contained in Appendix F. Additionally, noise modeling, using RNOISE software to estimated rocket engine noise (Plotkin et al. 1997a; Plotkin 2010) and PCBoom software to estimate sonic boom levels (Page et al. 2010; Bradley et al. 2018) was performed to estimate sound levels generated from the proposed activities at SLC-4. is the model results are referenced herein, but provided in detail in Appendix F (KBR 2024).

The sound ROI includes noise-sensitive receptors and ambient noise levels in the area potentially affected by rocket engine noise and sonic booms. Rocket engine noise and sonic booms are acute, non-sustained, and unpredictable. A sonic boom is an impulsive noise similar to thunder caused when an aircraft or rocket vehicle exceeds the speed of sound. Booms with overpressures of about 1.0 pound per square foot (psf) are generally audible and can startle people, but generally do not cause adverse effects such as damage to structures (Plotkin et al. 1997b; Benson 2013; National Oceanic and Atmospheric Administration [NOAA] 2024). A boom below that magnitude could be heard by someone who is expecting it and listening for it, but usually would not be noticed. The 1.0 psf sonic boom noise contour will also fully encompass any areas affected by launch, landing, and static fire rocket engine noise, when considering A-weighted decibels (dBA; A-weighting is an adjustment applied to sound measurement to reflect how a noise is perceived by the human ear). Therefore, the ROI for noise was determined by examining the 1.0 psf sonic boom contours from model results.

3.2.1.1 Noise Metrics

3.2.1.1.1 Day-Night Average Sound Level & Community Noise Equivalent Level

The Day-Night Average Sound Level (DNL) metric is the energy-averaged sound level measured over a 24-hour period, with a 10 dBA penalty assigned to noise events occurring between 10 p.m. and 7 a.m.

(acoustic night). The A-weighted DNL is the standard noise metric used by the U.S. Department of Housing and Urban Development, FAA, USEPA, and the DOD (used surrounding air installations). Most people are exposed to sound levels of 50–55 dBA DNL or higher on a daily basis. Noise-sensitive land uses, such as housing, schools, and medical facilities, are considered compatible in areas where the DNL is less than 65 dBA. Therefore, the 65 dBA DNL noise contour is typically used to determine compatibility of military operations with local land use.

Per FAA Order 1050.1F, Community Noise Equivalent Level (CNEL) may be used in lieu of DNL for FAA actions needing approval in California. CNEL, like DNL, is an energy-averaged sound level measured over a 24-hour period. CNEL, like DNL adds a ten times weighting (equivalent to a 10 dBA "penalty") to each operation between 10:00 p.m. and 7:00 a.m. CNEL also includes a three times weighting (equivalent to an approximately 5 dBA penalty) for each operation during evening hours (7:00 p.m. to 10:00 p.m.). As such, DNL and CNEL are very similar and have been determined to be a reliable measure of long-term community annoyance and will be used for this analysis. Transient residential use such as motels may be considered compatible within the 65 dBA CNEL noise contour where adequate noise attenuation is provided.

Noise exposure from sonic booms that exceeds the significance threshold of C-weighted day-night average noise level (CDNL) 60 dBC (C-weighted decibels) for impulsive noise sources (equivalent to DNL 65 DbA) is a significant impact (FAA 2020). The FAA uses CDNL to assess cumulative annoyance from impulsive noise like sonic booms, while using other metrics to evaluate hearing loss and other noise related health effects (FAA 2024). Given unique characteristics of commercial space operations, the FAA's guidance recommends that other supplemental noise metrics may also be used in conjunction with DNL "to describe and assess noise effects for commercial space operations" (FAA 2024). The FAA does not use these supplemental metrics to make decisions. Rather, the FAA has established a system of noise measurement that comprises a single, core decision-making metric, the A-weighted DNL. Under FAA Order 1050.1F, significant noise impacts would occur if the Proposed Action would increase noise by DNL 1.5 dB or more for a noise sensitive area that is exposed to noise at or above the DNL 65 dBA noise contour, or that will be exposed at or above the DNL 65 dB level due to a DNL 1.5 dB or greater increase in noise exposure, when compared to the No Action alternative for the same timeframe. FAA's NEPA implementing policies and procedures did not exempt commercial space transportation from this threshold. See FAA Order 1050.1F at Exhibit 4-1. Until the FAA revises its noise policy, all actions including commercial space transportation actions, are subject to this metric and significance threshold[9].

[9] The FAA determined that changes in transportation use, public expectations, and technology warranted a review of its civil aviation noise policy. On January 13, 2021, the FAA published in the Federal Register a notice entitled, "*Review of FAA Aircraft Noise Policy and Research Efforts: Request for Input on Research Activities to Inform Aircraft Noise Policy*", 86 FR 2722, which described the FAA's noise research portfolio and a first of its kind nationally scoped survey that updated FAA's understanding of the dose-response relationship between exposure to aircraft noise and community annoyance (Neighborhood Environmental Survey or NES). FAA also requested input on the FAA's research activities that would inform the FAA's noise policy and would inform the future direction of the FAA noise research portfolio. The NES showed that a higher percentage of people were "highly annoyed" by aircraft noise across all levels of noise exposure that were studied. In addition to setting forth the FAA noise policy and research efforts, this Notice described the results of research into the societal benefits and costs of noise mitigation measures. On May 1, 2023, the FAA published in the Federal Register a notice entitled "*Request for Comments on the Federal Aviation Administration's Review of the Civil Aviation Noise Policy, Notice of Public Meeting*" (88 FR 26641). In this notice, the FAA announced that it intends to consider how changes to the FAA civil aviation noise policy may better inform agency decisions and

3.2.1.1.2 Equivalent Sound Level

The Equivalent Sound Level (L_{eq}), measured in decibels (dB), is a cumulative noise metric that represents the average sound level (on a logarithmic basis) over a specified period of time—for example, an hour, a school day, daytime, nighttime, weekend, facility rush periods, or a full 24-hour day.

3.2.1.1.3 Maximum Sound Pressure Level

The maximum sound pressure level (L_{max}) is the highest time-weighted sound level measured during a noise event during a given period of time. Often, this parameter will be described along with information about the weightings used (for example, L_{Amax} indicates the maximum level measured with A-weighting). It is important to note that this is not the same as L_{peak}, which is the highest instantaneous sound level, in dB, with no weighting.

3.2.1.1.4 Pounds per Square Foot

While rocket launches are typically measures in Lmax or L_{eq}, psf is used to present units of peak overpressure. The peak pressure of a sonic boom in psf can be converted to the peak sound pressure level in decibels (L_{peak}) by the mathematical relationship of: $L_{peak} = 127.6 + 20 \log_{10}(psf)$.

3.2.1.2 Sensitive Receptors

Noise sensitive areas are those areas where noise interferes with normal activities. These include residential, educational, health, and religious sites, parks, recreational areas, wildlife refuges, and cultural sites. Users of designated recreational areas are considered sensitive receptors. Noise sensitive land uses on and near VSFB, southern Santa Barbara County, and Ventura County include residential areas, hospitals, schools, and libraries. No human sensitive receptors are located on or near the SLC-4 project sites. In addition, with the exception of being a recreational area, there are no other human sensitive receptors at Channel Islands National Park which is within the overflight path.

3.2.1.3 Ambient Noise Conditions

Existing noise levels on VSFB are quite low due to the large areas of undeveloped landscape and sparse noise sources. Background noise levels are primarily driven by wind noise; louder noise levels can be found near industrial facilities and transportation routes, including the railway. On VSFB, ambient one-hour average sound level measurements range from around 35 to 60 dB (Thorson et al. 2001). Regularly occurring sources of instantaneous noise near the ROI include crashing ocean surf, which generates approximately 78 dBA (6.6 ft tall waves) and can be louder during high surf events (Bolina & Abom 2010).

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the types of impacts FAA considers in making decisions (e.g., community annoyance, certain types of adverse health impacts highly correlated with aviation noise exposure). The FAA requested suggestions of potential improvements to how the FAA analyzes, explains, and presents changes in exposure to civil aviation noise. In this notice, the FAA specifically sought public comments on whether it should establish noise thresholds for low-frequency events, such as those associated with the launch and reentry of commercial space transportation vehicles authorized by the FAA Office of Commercial Space Transportation, which metrics should be used to establish these noise thresholds, and the appropriate noise exposure level to define the threshold of significant noise impacts. As part of this policy review, FAA is also examining the body of scientific and economic literature to understand how aviation noise correlates with annoyance as well as environmental, economic, and health impacts. The FAA is also evaluating whether any of these impacts are statistically significant and the metrics that may be best suited to disclose them. Until this policy development process is concluded, the FAA will continue to rely on DNL to make decisions regarding the significance of potential noise impacts.

Ambient sound levels were characterized at Surf Beach, approximately 5.3 mi north of SLC-4 reported at 45.5 dBA L_{eq} at night, 51.8 dBA L_{eq} during the day, and 53.1 dBA L_{eq} during the evening. Rocket launches and aircraft overflights create louder intermittent noise levels, while ambient in-air noise levels are driven primarily by wind and wave noise. Noise levels in the adjacent city of Lompoc are primarily driven by transportation noise and regional aircraft activities. DNLs are typically between 55 and 65 dBA (City of Lompoc 2014).

3.2.2 Environmental Consequences

Per FAA Order 1050.1F, noise impacts would be significant if the action would increase noise by DNL 1.5 dBA or more for a noise-sensitive area that is exposed to noise at or above the DNL 65 dBA noise exposure level, or that will be exposed at or above the DNL 65 dBA level due to a DNL 1.5 dBA or greater increase, when compared to the No Action Alternative for the same timeframe. For example, an increase from DNL 65.5 dB to 67 dB is considered a significant impact, as is an increase from DNL 63.5 dBA to 65 dBA. The CNEL may be used in lieu of DNL for FAA actions in California. Per 40 CFR Part 1501.3(d)(2), the analyses below also consider the intensity (loudness) and context (proximity to sensitive receptors) in determining if noise impacts would be significant.

3.2.2.1 Alternative 1 and 2

The scope of this noise analysis is limited to the launch, boost-back, and landing of the Falcon 9 as described in Chapter 2. Vessel transit activities are excluded from the noise analysis as their activity is removed from sensitive receptors. There are two noise components to the Proposed Action: 1) continuous engine noise created by the launch, during static fire tests (lasting several seconds), during launch ascent (lasting several minutes), and during first stage and booster landings (lasting approximately 60 seconds); and 2) impulsive sonic booms created during the launch of the rocket and the returning first stages and boosters (both lasting less than one second). Static fire, launch engine noise, landing engine noise and impacts on human sensitive receptors are presented in units of dBA. Sonic booms are presented in terms of psf.

3.2.2.1.1 Static Fire, Launch, and Landing Rocket Engine Noise

The 90 dBA through 130 dBA L_{max} contours for engine noise during Falcon 9 launches at SLC-4 are shown in Figure 3.2-1. These contours represent the maximum levels estimated for each Falcon 9 launch at SLC-4. The higher contours (100 – 130 dBA L_{max}) are located within about 4 mi of SLC-4. Only the 90 dBA L_{max} contour extends beyond the VSFB property line to the western side of Lompoc, CA (Figure 3.2-1; KBR 2024). Real-world noises that may be similar include power mower (96 dBA L_{max}), a motorcycle passing by at 25 ft (90 dBA L_{max}), or an active car wash standing 20 ft away (89 dBA L_{max}). If a Falcon 9 launch occurs during the day, when background levels are in the 50 to 60 dBA L_{max} range, residents of Lompoc may notice launch noise levels above 70 dBA L_{max} and up to 90 dBA L_{max} (KBR 2024). If the same launch occurs during the night, when background levels are lower than during the day (e.g., below 40 to 50 dBA L_{max} range), Lompoc residents, the residents of Orcutt, CA to the north, and Conception, CA to the south may notice launch noise levels that exceed 60 dBA L_{max} (KBR 2024). A prevailing on-shore or off-shore breeze may also strongly influence noise levels in these communities.

Launch events are the loudest single events of all the proposed Falcon 9 flight and test operations. Accordingly, Falcon 9 launch single event noise levels were evaluated to guidelines for hearing conservation and potential for structural damage. An estimate of the areas in the vicinity of Falcon 9 launches at SLC-4, where a hearing conservation program should apply, was made using Occupational Safety and Health Administration's (OSHA) permissible daily noise exposure limit of 115 dBA L_{max} (slow response) for a duration of 0.25 hours or less. Noise levels are less than OSHA's 115 dBA L_{max} upper noise limit guideline at distances greater than approximately 1.5 mi from the launch pads (KBR 2024). Falcon 9 launch noise events last a few minutes at most, at a single location, with the highest noise levels occurring for less than a minute such that OSHA's 115 dBA L_{max} daily noise exposure limit is not expected to be exceeded (KBR 2024).

For Falcon 9 booster landings at SLC-4, the 90 dBA L_{max} contour for engine noise is entirely within the VSFB property line (Figure 3.2-1). Residents of Lompoc, CA may notice Falcon 9 landing event levels above 60 dBA L_{max} especially for nighttime events. Compared with the Falcon 9 orbital launch noise levels, discussed above, Falcon 9 descent/landing noise levels at SLC-4 are considerably lower due to the much lower total engine thrust and limited firing schedule used for landing operations.

The 90 dBA L_{max} contour for Falcon 9 static fire events at SLC-4 does not extend off VSFB property (Figure 3.2-1). To the west of SLC-4, this contour extends much farther out due to modeling sound propagation over water compared with propagation over land to the east. Residents of Lompoc, CA may hear Falcon 9 static test events above 60 dBA L_{max}, and particularly at night and if onshore wind conditions favor sound propagation to the east (KBR 2024).

The potential for structural damage due to launch, landing, and static fire test events was assessed using the conclusions from a recent, applicable study to ascertain whether range activities (i.e., test, evaluation, demilitarization, and training activities of items such as weapons systems, ordinance, and munitions would cause structural damage; Fenton & Methold 2016). The study concluded that structural damage becomes improbable below 140 dB L_{max} (unweighted). No glass or plaster damage is expected below 140 dB L_{max} and no damage is expected below 134 dB L_{max} (Fenton & Methold 2016).

Applying these criteria indicates that no damage is expected from engine noise generated during Falcon 9 launches or any of the other Falcon 9 operations that generate lower noise levels than launches. The 134 dB L_{max} contour for all Falcon 9 flight and test operations is well within VSFB property, such that no significant off-base impacts, including Lompoc, are expected (KBR 2024). The unweighted L_{max} 110 dB through 140 dB contours estimated for Falcon 9 orbital launch events at SLC-4 is shown in Figure 3.2-2. Falcon 9 launch events from SLC-4 are estimated to generate L_{max} of 134 dB approximately 0.5 mi from the launch pads, well within VSFB property (KBR 2024).

3.2.2.1.2 Community Noise Equivalent Level

The FAA defined land use compatibility guidelines for aviation noise exposure that are also applicable to rocket noise exposure. These guidelines consider the noise limit for residential land use compatibility to be DNL 65 dBA (or 65 dBA CNEL as explained in Section 3.2.1.1). CNEL was estimated using RNOISE for projected launch, landing, and static fire test operations at SLC-4. The results indicated that none of the operation types alone are expected to cause adverse CNEL (KBR 2024; Appendix F). CNEL was also assessed for the proposed maximum cadence, which includes all combinations of these operation types assuming an almost equal distribution between night and day activities. The resulting CNEL estimates for the combined annual operations are shown in Figure 3.2-5. The 65 dBA CNEL contour is located entirely within the VSFB property and does not include residential land use. Therefore, the Proposed Action would not result in significant impacts related to noise and noise-compatible land use.

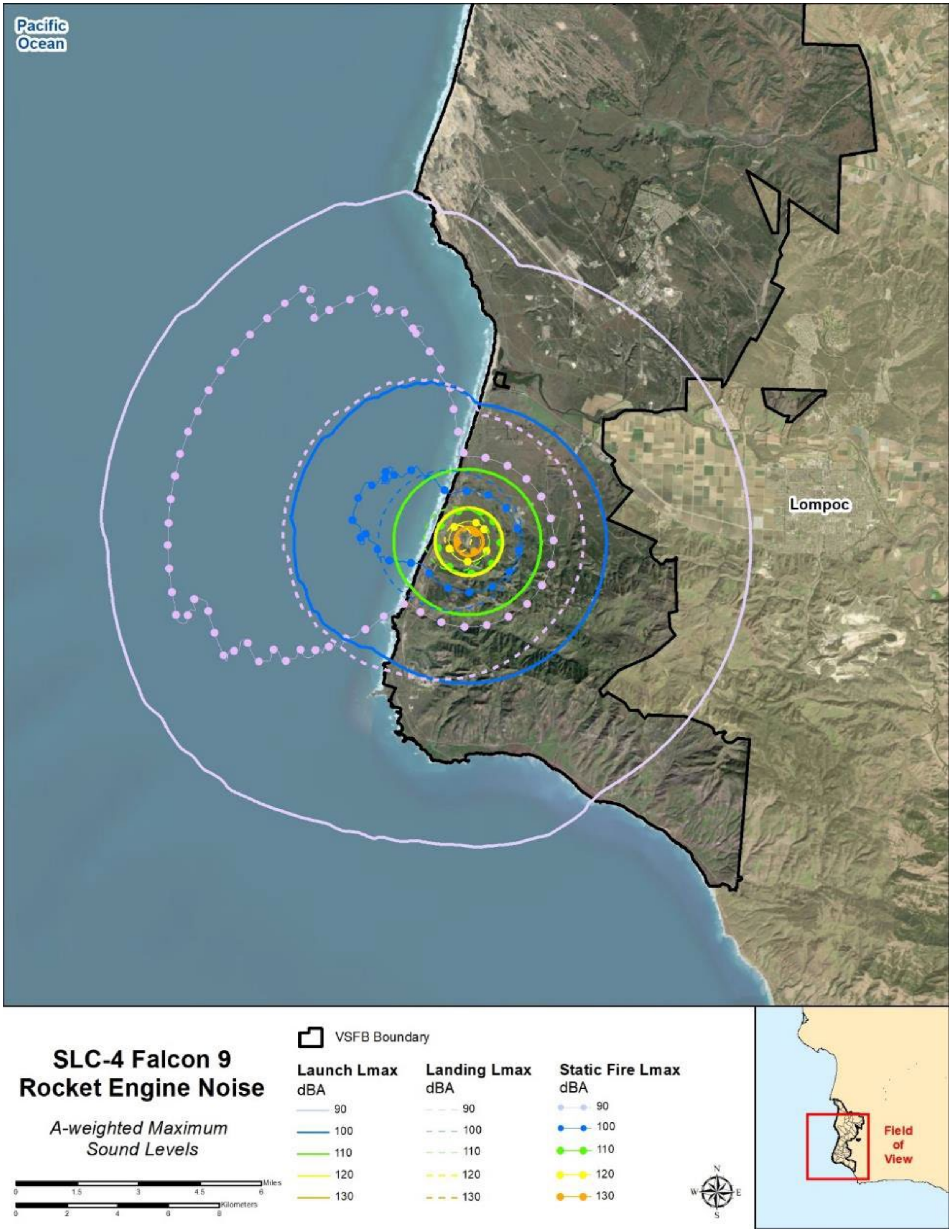

Figure 3.2-1. Falcon 9 static fire, launch, and landing rocket engine noise model results at SLC-4

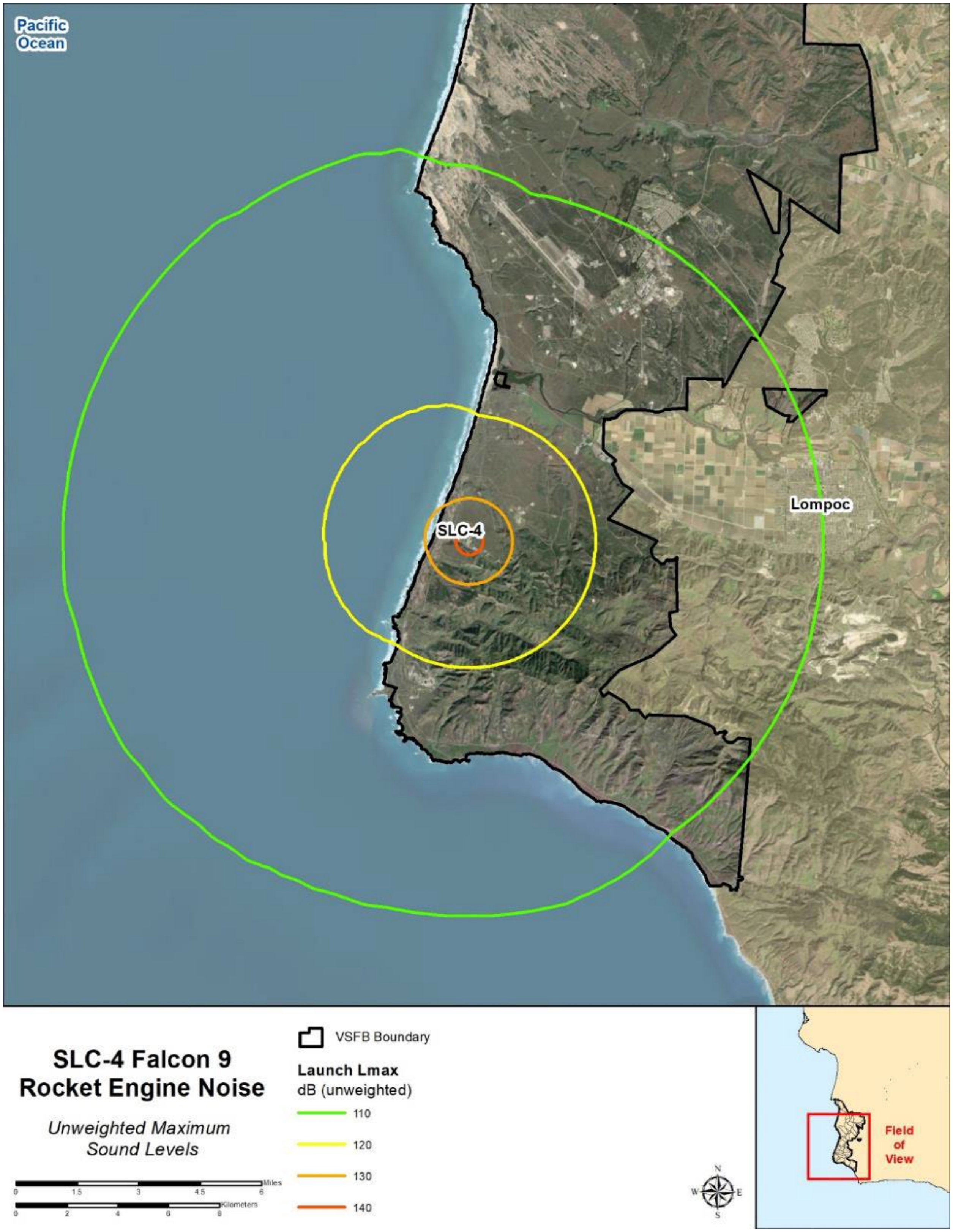

Figure 3.2-2. Unweighted L_{max} contours for Falcon 9 launch at SLC-4

3.2.2.1.3 Launch and Landing Sonic Boom

Sonic Boom from Falcon 9 Launch at SLC-4

Sonic boom model profiles for Falcon 9 launches from SLC-4 are similar to those analyzed in Section 3.2 of the 2023 SEA, with the exception of an increase in frequency due to higher cadence. Falcon launches with easterly trajectories may result in sonic booms that impact eastern Santa Barbara, Ventura, and northwestern Los Angeles Counties (Figure 3.2-3). To supplement the typical model output of sonic boom contours, DAF conducted additional sonic modeling for the ascent phase of easterly trajectories to capture potential variability in the noise environment. For these trajectories sonic booms may impact a sub-portion of the potential impact area shown in Figure 3.2-3, which shows the conglomeration of 125 different model results. Probabilities were then derived from this modeling to predict the potential location and intensity of a sonic boom. Of these, 15% of the model runs predicted sonic boom impacts in eastern Santa Barbara County; 50% of the sonic boom levels were less than 0.25 psf, approximately 17% were greater than 1.0 psf, and 0.3% were greater than 2.0 psf. The highest level predicted was 2.13 psf. 97% of model runs predicted impacts in Ventura County; 65% were less than 0.25 psf, approximately 14% were greater than 1.0 psf, 0.04% were greater than 2.0 psf. The highest predicted boom level was 2.03 psf. Of the 125 model results, 94% of model runs predicted impacts in western Los Angeles County; 95% were less than 0.25 psf and none were greater than 0.75 psf. A 2.13 psf overpressure equates to a CDNL of 42.6 dBC, well below the 60 dBC significance threshold. However, CDNL is not a useful metric for ascent sonic booms as they are heavily dependent on the actual trajectory and atmospheric conditions thus the actual location of the sonic boom is expected to vary between launches.

Sonic Boom from Falcon 9 Landings at SLC-4

Sonic boom footprints for Falcon 9 first stage landings at SLC-4 were modeled using PCBoom software and sample mission trajectories that depict an estimated worst-case scenario in terms of boom levels and extent of the impact footprint (KBR 2024). Figure 3.2-4 shows an example sonic boom footprint, in the form of overpressure contours in psf for the Falcon 9 first stage landing at SLC-4. The boom levels in the vicinity of the SLC-4 landing pad range from about 5.0 to 9.5 psf. Boom levels on VSFB range from 0.1 to 5.0 psf in areas away from the landing pad. The broad crescent, with boom levels of 0.1 psf is located mostly over the Pacific Ocean, however this contour surrounds VSFB and Lompoc, CA, and Orcutt, CA to the east, as well as Conception, CA to the south. If all 12 landings at SLC-4 were to occur at night with overpressures of 4 psf on Lompoc, the corresponding CDNL would be 59.4 dBC, below the 60 dBC significance threshold. This is a conservative analysis, as landings could occur at any time of day and are not expected to consistently result in overpressure levels of that magnitude in populated areas.

Sonic Boom from Falcon First Stage Landings Downrange in the Pacific Ocean

Similar engine noise and noise impacts would occur during landings of the Falcon 9 first stage boosters offshore of California (minimum distance of 12 nm within the Proposed Landing Area), which has been analyzed in Section 3.2 of the 2023 SEA and would not result in any different impacts as discussed in these documents, with the exception of an increase in frequency due to higher cadence. Since the noise from offshore landing activities would occur far from sensitive receptors, there would be no significant impacts associated with implementing the landings at the offshore locations.

Overall Sonic Boom Effects

In general, booms in the 0.2 to 0.3 psf range could be heard by someone who is expecting it and listening for it, but usually would not be noticed. Booms of 0.5 psf are more likely to be noticed, and booms of 1.0 psf are certain to be noticed. Therefore, during launches with easterly trajectories, people in eastern Santa Barbara and Ventura Counties would occasionally hear sonic booms and sometimes experience sonic booms just over 2 psf. These would likely startle people if they were not anticipating it. People living in western Los Angeles County may occasionally hear a sonic boom, but generally at levels that would not be noticed. People in Lompoc, CA are likely to notice booms from first stage and booster landings at SLC-4, as are people located on VSFB and other populated areas around VSFB. People located within the 1.0 psf and 2.0 psf region (see Figure 3.2-4) would likely be startled and possibly annoyed. Announcements of upcoming Falcon 9 launches and landings serve to warn people about these noise events and are likely to help reduce adverse reactions to these noise events.

As described in Section 3.2.2.1.1, the duration of a noise event plays heavily into OSHA's permissible daily noise exposure. A sonic boom is typically between 300 and 600 milliseconds in duration. As such, the contribution to the daily exposure is extremely minimal and would not contribute substantially towards reaching a CNEL of 65 dBA. Further, injury to the ear has been noted above levels of 8,000 Pascals (Fisher 2008), which is roughly the same as a 170 psf boom, very far above predicted levels for the Falcon 9, thus injuries would not occur.

Boom levels over land, which are less than 5.0 psf in most areas, are unlikely to cause structural damage. Materials in good condition do not normally fail under sonic boom levels below 6 psf (NOAA 2023). NOAA publishes overpressure levels of concern that indicate the typical pressure for glass failure is 21.6 psf, although glass failure could occur at 5.76 psf (NOAA 2023). In 1965, NASA conducted a study of potential structural effects from sonic booms near the White Sands Missile Range and found that there was no structural damage until 8 psf (after more than 1500 tests), but that damage could occur to glass, plaster, tile, and stucco that was already in a vulnerable condition (Benson 2013). Sonic booms above 1.5 psf in the Lompoc, eastern Santa Barbara County, and Ventura County are expected to be infrequent events and would vary in impact location. The DAF and SpaceX will also notify the public prior to missions with the potential to impact these areas so that the public can anticipate and prepare for the potential disturbance.

Per FAA regulations and the Commercial Space Launch Act (CSLA), SpaceX is required to carry insurance to cover claims by third parties that result from licensed activities, including any structural damage. The FAA requires that SpaceX carry insurance in the amount of the "Maximum Probable Loss," which is determined on a launch-by-launch basis by the FAA and is up to $500,000,000 per launch. In the event that structural damage results from noise-induced vibrations or sonic booms, any such claims of damage would be subject to the insurance policy terms and process specified by the CSLA and the FAA regulations.

Therefore, there would be no significant impacts from sonic booms produced during landing at SLC-4 resulting from Alternative 1 or 2.

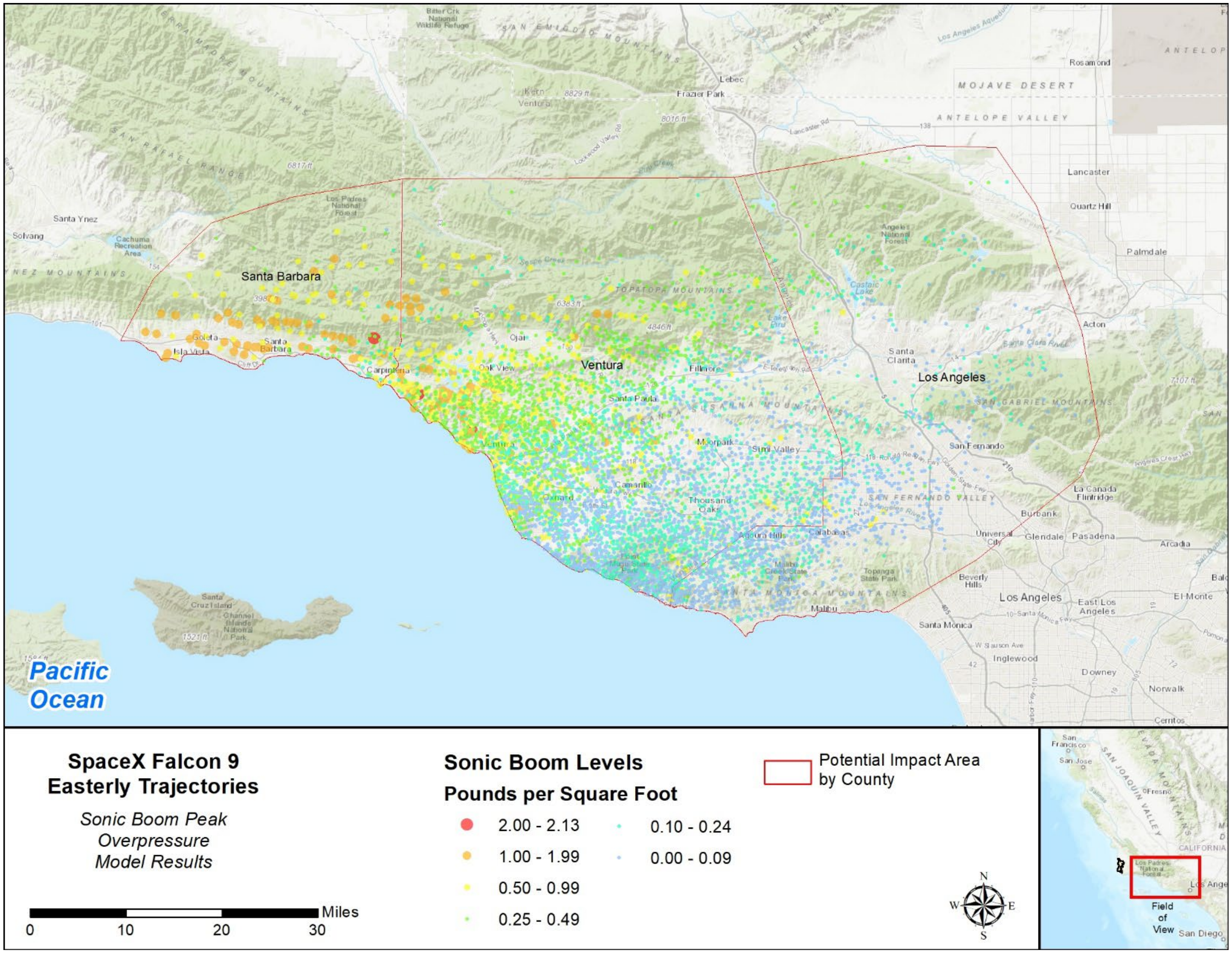

Figure 3.2-3. Sonic boom model results for 125 runs for easterly SpaceX Falcon 9 trajectories showing range of possible boom impact areas and levels, depending on meteorological conditions (Note: the image is intended to show the array of potential sonic booms; no single launch would result in impacts across the entire areas depicted nor at the specific levels depicted).

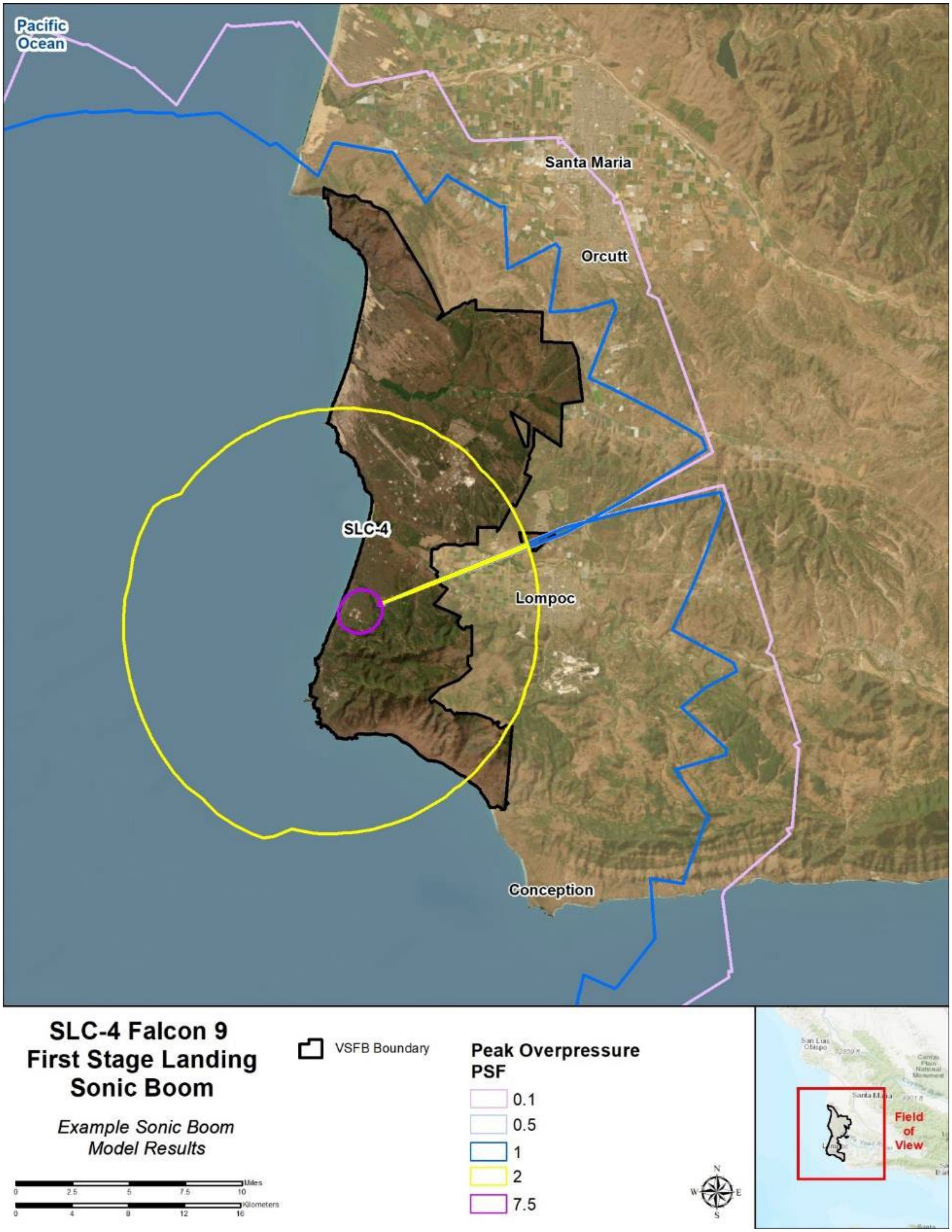

Figure 3.2-4. Example sonic boom model results for Falcon 9 first stage landing at SLC-4W

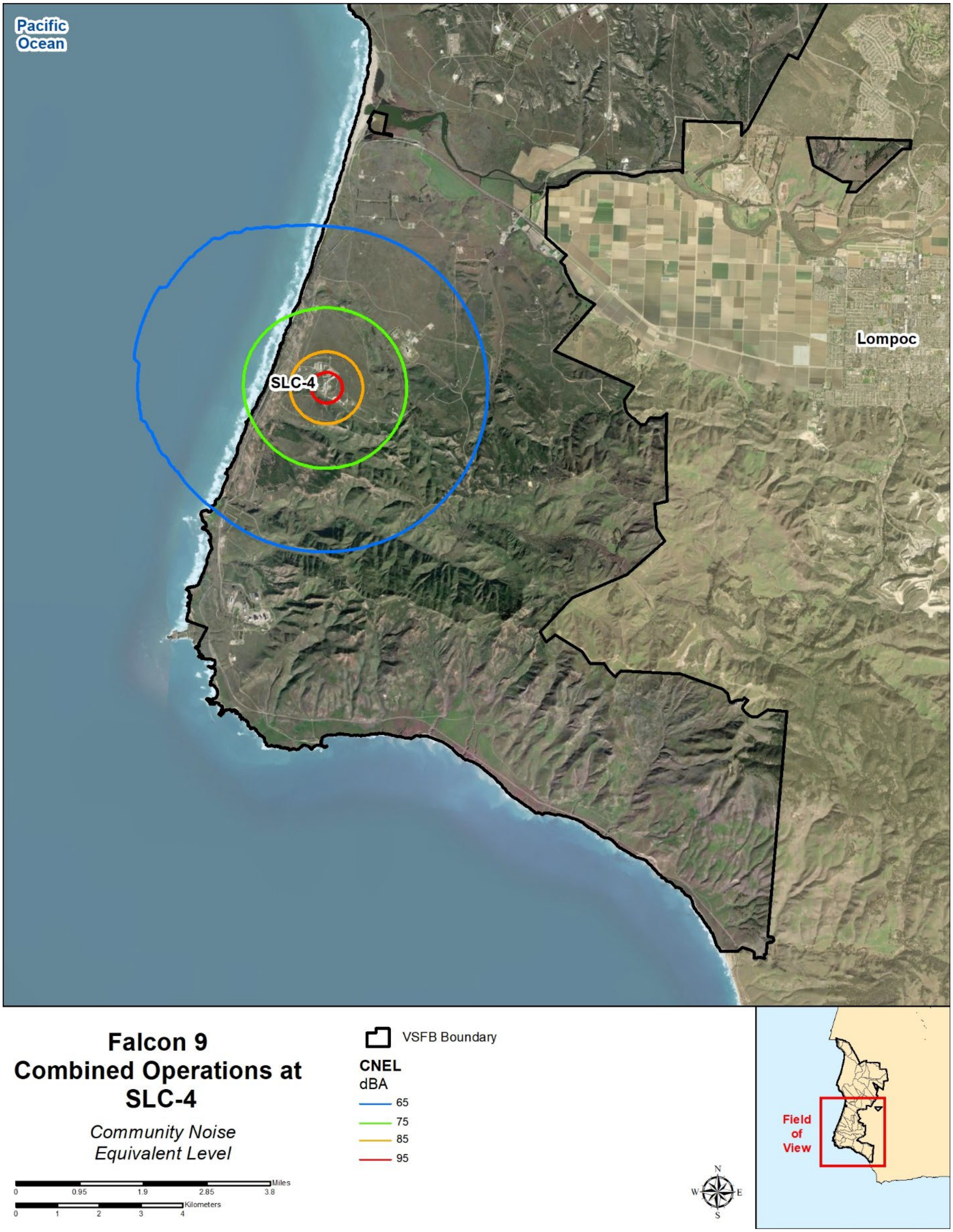

Figure 3.2-5. Falcon 9 CNEL contours for combined operations at SLC-4

3.2.2.1.4 Airspace

Airspace closures associated with commercial space operations could result in temporarily grounded aircraft at affected airports and re-routing en-route flights on established alternate flight paths. The FAA has rarely, if ever, received reportable departure delays associated with launches at VSFB. Aircraft could be temporarily grounded if airspace above or around the airport is closed. Ground delays are also used under some circumstances to avoid airborne reroutes. If aircraft were grounded, noise levels at the airport could temporarily increase as the planes sit idling waiting for takeoff. Depending on the altitude at which aircraft approach an airport, there could be temporary increases in noise levels in communities around the airports. However, aircraft would travel on existing en-routes and flight paths that are used daily to account for weather and other temporary restrictions. Not all launch and reentry missions would affect the same aircraft routes or the same airports and re-routing associated with launch-related closures represents a small fraction of the total amount of re-routing that occurs from all other reasons in any given year. Any incremental increases in noise levels at individual airports would only last the duration of the airspace closure periodically and a meaningfully change existing DNL at the affected airports and surrounding areas is not expected. Therefore, airspace closures due to commercial space operations are not expected to result in significant noise impacts.

3.2.2.2 No Action Alternative

Under the No Action Alternative, increased launch cadence on VSFB would not occur, resulting in no impacts on the noise environment, beyond those described in the 2023 SEA.

3.3 Terrestrial Biological Resources

3.3.1 Affected Environment

Under Section 7 of the ESA of 1973, as amended (16 USC Section 1531, et seq.), federal agencies must assess project effects on species that are federally listed or proposed for listing based on the best scientific and commercial data available. Section 7 consultations with the USFWS and NMFS are required for federal projects that have the potential to jeopardize the continued existence of listed species or destroy or adversely modify critical habitat. Also, when evaluating project impacts USSF policy is to consider other federal special status species, state-listed protected species, and species protected by state law. In California, these include species that the California Department of Fish and Wildlife (CDFW) designates per the California Fish and Game Code Sections 3511, 4700, 5050, and 5515 as “fully protected” wildlife species. "Fully protected" designation means the species is at risk of extinction within California. This term was used before California’s Endangered Species Act became law. California also protects species of special concern. Although SLD 30’s Integrated Natural Resource Management Plan is not subject to California’s requirements, SLD 30 protects and conserves these species when practicable and consistent with the military mission. SLD 30 also must comply with requirements of the Migratory Bird Treaty Act (MBTA) of 1918 (16 USC Sections 703-712) as amended. This MBTA protects native migratory birds, including their eggs, active nests, and young.

The ROI for terrestrial biological resources includes areas potentially impacted by sonic boom, rocket engine noise, and increased water usage, which includes VSFB and the surrounding region, as well as the NCI.

3.3.1.1 Methodology

The DAF reviewed prior special status species survey and monitoring data, biological reports, and California Natural Diversity Database (CNDDB) records to assess the documented and potential occurrence, distribution, and habitat use of plants and animals, including special status species, within the region potentially affected by the Proposed Action.

3.3.1.2 Wildlife Resources

Common birds within the ROI include house finch (*Carpodacus mexicanus*), Brewer's blackbird (*Euphagus cyanocephalus*), cliff swallow (*Hirundo pyrrhonota*), barn swallow (*Hirundo rustica*), and California thrasher (*Toxostoma redivivum*). Amphibians within the ROI include the Baja California treefrog (*Pseudacris hypochondriaca*), Monterey ensatina (*Ensatina eschscholtzii*), and black-bellied slender salamander (*Batrachoseps nigriventris*). Reptiles include western fence lizard (*Sceloporus occidentalis*), western skink (*Eumeces skiltonianus*), and southern Pacific rattlesnake (*Crotalus oreganus helleri*). Various mammal species are also expected to occur within the ROI, including brush rabbit (*Sylvilagus bachmani*), coyote (*Canis latrans*), black bear (*Ursus americanus*), and California ground squirrel (*Otospermophilus beecheyi*). Small mammals include kangaroo rats (*Dipodomys* spp.) and pocket gopher (*Thomomys bottae*). Bat species in the area include big brown bat (*Eptesicus fuscus*) and western red bat (*Lasiurus blossevillii*). The Northern Channel Islands (NCI) host the island scrub jay (*Aphelocoma insularis*), Channel Islands spotted skunk (*Spilogale gracilis amphialus*), island fox (*Urocyon littoralis*), and the island deer mouse (*Peromyscus maniculatus santacruzae*).

3.3.1.3 Special Status Wildlife Species

Species were considered "special status" if they met at least one of the criteria listed in Table 3.3-1. Potential occurrence was determined based on past documentation of special status species within the vicinity of the ROI and suitability of habitat and occurrence within the region (Table 3.3-2 through Table 3.3-7). Detailed information is contained in Appendix A.

Table 3.3-1. Terrestrial special status species considered

Special-Status Biological Resources
Plant and wildlife species that are federally listed, proposed for listing, or candidates for listing
Plant and wildlife species that have been delisted
Plant and wildlife species that are state listed or candidates for listing
California fully protected species
Wildlife species considered California Species of Special Concern by CDFW
Plant species listed as endangered, threatened, or rare by the state of California
Golden eagles and bald eagles protected under the Bald and Golden Eagle Protection Act
Federal Birds of Conservation Concern
Winter roost locations for monarch butterflies protected under the Local Coastal Plan of Santa Barbara County

Table 3.3-2. Federal and State special status invertebrate species occurrence within the ROI

Species	Status		Occurrence within the ROI
	Federal	California	
Crotch bumble bee (*Bombus crotchii*)	-	SSC	Present in the noise footprint on VSFB, in eastern Santa Barbara, Ventura, and western Los Angeles Counties.
Monarch butterfly (*Danaus plexippus*)	C	Special Animal	Overwintering stands within noise footprint on VSFB, in eastern Santa Barbara, Ventura, and western Los Angeles Counties.

Notes: C = Candidate for listing under the ESA; SSC = California State Species of Special Concern; "Special Animals" is a broad term used to refer to all the animal taxa tracked by the CDFW.

Table 3.3-3. Special status fish species occurrence within the terrestrial portion of the ROI

Species	Status		Occurrence within the ROI
	Federal	California	
Tidewater goby (*Eucyclogobius newberryi*)	FT	-	Historic occurrence in Honda Creek on VSFB; surveys have not detected since 2001. Present in San Antonio Creek and Jalama Creek on VSFB. Present in coastal streams within the noise footprint in eastern Santa Barbara, Ventura, and western Los Angeles Counties.
Unarmored Threespine Stickleback (*Gasterosteus aculeatus*)	FE	SE	Currently extirpated on Honda Creek on VSFB; historic introduction in Honda Creek in 1984. No individuals have been detected in Honda Creek since the late 1990's. Present in San Antonio Creek on VSFB.
Arroyo chub (*Gila orcuttii*)	-	SSC	Not present on Honda Creek and San Antonio Creek on VSFB. Present within the noise footprint on Malibu and Calleguas Creeks in Ventura and western Los Angeles Counties.
Steelhead - southern California DPS (*Oncorhynchus mykiss*)	FE	Candidate	Present within the noise footprint in coastal streams and rivers of Santa Barbara (including VSFB) and western Los Angeles Counties.

Notes: DPS = Distinct Population Segment; FE = Federally Endangered Species; FT = Federally Threatened Species; SE = State Endangered Species; SSC = California State Species of Special Concern

Table 3.3-4. Special status amphibian species occurrence within the terrestrial portion of the ROI

Species	Status		Potential Occurrence within the ROI
	Federal	California	
California tiger salamander (*Ambystoma californiense*)	FE	ST	Not on VSFB. Present within noise footprint in Santa Barbara County.
Coast range newt (*Taricha torosa*)	-	SSC	Not on VSFB. Present within the noise footprint in coastal streams of Santa Barbara, Ventura, and western Los Angeles Counties
California red-legged frog (*Rana draytonii*)	FT	SSC	Present in aquatic habitats within noise footprint in Santa Barbara County, including VSFB.
Arroyo toad (*Anaxyrus californicus*)	FE	SSC	Not on VSFB. Present within noise footprint in Santa Barbara, Ventura, and Los Angeles Counties.
Western spadefoot (*Spea hammondii*)	P	SSC	Present within noise footprint in Santa Barbara (including VSFB), Ventura, and Los Angeles Counties.

Notes: FE = Federally Endangered Species, FT = Federally Threatened Species; P = proposed for listing under the ESA; SSC = California State Species of Special Concern; ST = State Threatened Species

Table 3.3-5. Special status reptile species occurrence within the terrestrial portion of the ROI

Species	Status		Potential Occurrence within the ROI
	Federal	California	
Northern legless lizard (*Anniella pulchra*)	-	SSC	Present within the noise footprint in Santa Barbara County, including VSFB.
Southern legless lizard (*Anniella stebbinsi*)	-	SSC	Not on VSFB. Present within the noise footprint in Ventura and western Los Angeles Counties.
Coastal whiptail (*Aspidoscelis tigris stejnegeri*)	-	SSC	Not on VSFB. Present within the noise footprint in western Los Angeles County.
Coast horned lizard (*Phrynosoma blainvillii*)	-	SSC	Present within the noise footprint in Santa Barbara (including VSFB), Ventura, and western Los Angeles Counties.
Southwestern pond turtle (*Actinemys pallida*)	P	SSC	Present within the noise footprint in coastal streams and wetlands of Santa Barbara (including VSFB), Ventura, and western Los Angeles Counties.

Two-striped garter snake (*Thamnophis hammondii*)	-	SSC	Present within the noise footprint in Honda Creek on VSFB and the noise footprint in western Santa Barbara County. Potential occurrence in the noise footprint in eastern Santa Barbara and western Los Angeles Counties.

Notes: P = proposed for listing under the ESA; SSC = State Candidate Species

Table 3.3-6. Special status bird species occurrence within the terrestrial portion of the ROI

Species	Status		Potential Occurrence within the ROI
	Federal	California	
Allen's hummingbird (*Selasphorus sasin*)	BCC	-	Present within noise footprint in Santa Barbara (including VSFB), Ventura, and western Los Angeles Counties.
Bald eagle (*Haliaeetus leucocephalus*)	BCC; BGEPA	SE; Fully Protected	Documented occasional flyovers on VSFB; foraging habitat within noise footprint. Rarely present within the noise footprint in eastern Santa Barbara, Ventura, and western Los Angeles Counties.
Bank swallow (*Riparia riparia*)	-	ST	Present within noise footprint in Santa Barbara (including VSFB), Ventura, and western Los Angeles Counties.
Belding's savannah sparrow (*Passerculus sandwichensis beldingi)*	-	SE	Present in coastal plains within the noise footprint in Santa Barbara (including VSFB), Ventura, and western Los Angeles Counties.
Black oystercatcher (*Haematopus bachmani*)	BCC	-	Present on sandy beaches and cliffs of VSFB shoreline and within the noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.
Black skimmer (*Rynchops niger*)	BCC	-	Present in nearshore ocean waters within the noise footprint in Santa Barbara (including offshore of VSFB), Ventura, and western Los Angeles Counties.
Brant (*Branta bernicla*)	-	SSC	Present in nearshore ocean waters within the noise footprint in Santa Barbara (including offshore of VSFB), Ventura, and western Los Angeles Counties.
Burrowing owl (*Athene cunicularia*)	BCC	SSC	Winters in burrows in grassland areas impacted by noise. Breeding on VSFB has not been documented in optimal breeding habitat on Base since 1984 (reflects a well-documented county-wide decline of the species). Present in coastal plains and agricultural lands within the noise footprint in eastern Santa Barbara, Ventura, and western Los Angeles Counties.

Species	Status		Potential Occurrence within the ROI
	Federal	California	
California brown pelican (*Pelecanus occidentalis californicus*)	-	Fully Protected	Present in nearshore ocean waters and roosts on beaches and rocks within the noise footprint in Santa Barbara (including VSFB), Ventura, and western Los Angeles Counties.
California condor (*Gymnogyps californianus*)	FE	SE	One documented brief occurrence on VSFB in 2017 within noise footprint. Unlikely to be present on VSFB. Present within noise footprint in Ventura County.
California least tern (*Sterna antillarum browni*)	FE	SE	Present in noise footprint in Santa Barbara (including VSFB), Ventura, and western Los Angeles Counties.
Coastal California gnatcatcher (*Polioptila californica californica*)	FT	SSC	Not on VSFB. Present within the noise footprint in Ventura and western Los Angeles Counties.
Costa's hummingbird (*Calypte costae*)	BCC	-	Present within the noise footprint in Santa Barbara (including VSFB), Ventura, and western Los Angeles Counties.
Golden eagle (*Aquila chrysaetos*)	BGEPA	Fully Protected	Present within noise footprint on VSFB and Santa Barbara County. Rare in Ventura and western Los Angeles Counties.
Grasshopper sparrow (*Ammodramus savannarum*)	-	SSC	Present in coastal plains within the noise footprint in Santa Barbara (including VSFB), Ventura, and western Los Angeles Counties.
Lawrence's goldfinch (*Spinus lawrencei*)	BCC	-	Present in shrub and riparian habitat within noise footprint in Santa Barbara (including VSFB), Ventura, and western Los Angeles Counties.
Least Bell's vireo (*Vireo bellii pusillus*)	FE	SE	Present within noise footprint in Santa Barbara (including VSFB), Ventura, and western Los Angeles Counties.
Light-footed Ridgeway's rail (*Rallus obsoletus levipes*)	FE	SE	Not on VSFB. Present in coastal salt marshes within the noise footprint of Ventura County.
Loggerhead shrike (*Lanius ludovicianus*)	BCC	SSC; Nesting	Documented in shrub and riparian habitat within noise footprint in Santa Barbara (including VSFB), Ventura, and western Los Angeles Counties.
Long-billed curlew (*Numenius americanus*)	BCC	-	Present on rocky coastline at low tide and beaches within noise footprint in Santa Barbara (including VSFB), Ventura, and western Los Angeles Counties.
Marbled godwit (*Limosa fedoa*)	BCC	-	Present on sandy beaches and rocky coastline at low tide within noise footprint in Santa Barbara (including VSFB), Ventura, and western Los Angeles Counties.

Species	Status		Potential Occurrence within the ROI
	Federal	**California**	
Marbled murrelet (*Brachyramphus marmoratus*)	FT	SE	Present in nearshore ocean waters within noise footprint in Santa Barbara (including offshore of VSFB), Ventura, and western Los Angeles Counties.
Northern harrier (*Circus hudsonius*)	-	SSC; Nesting	Present in grassland within noise footprint in Santa Barbara (including VSFB), Ventura, and western Los Angeles Counties.
Nuttall's woodpecker (*Dryobates nuttallii*)	BCC	-	Present in riparian habitat within noise footprint in Santa Barbara (including VSFB), Ventura, and western Los Angeles Counties.
Oak titmouse (*Baeolophus inornatus*)	BCC	-	Present in riparian and non-native tree habitat within noise footprint in Santa Barbara (including VSFB), Ventura, and western Los Angeles Counties.
Peregrine falcon (*Falco peregrinus anatum*)	BCC; Nesting	Fully Protected; Nesting	Present in coastal habitat within noise footprint in Santa Barbara (including VSFB), Ventura, and western Los Angeles Counties.
Short-billed dowitcher (*Limnodromus griseus*)	BCC	-	Present on rocky coastline at low tide and beaches within noise footprint in Santa Barbara, (including VSFB) Ventura, and western Los Angeles Counties.
Southwestern willow flycatcher (*Empidonax traillii extimus*)	FE	SE	Not present on VSFB. Present within the noise footprint in inland Santa Barbara Country and Ventura and western Los Angeles Counties.
Whimbrel (*Numenius phaeopus*)	BCC	-	Present on rocky coastline at low tide and beaches within noise footprint in Santa Barbara (including VSFB), Ventura, and western Los Angeles Counties.
Western snowy plover (*Charadrius nivosus nivosus*)	FT; BCC	SSC; Nesting	Present on rocky coastline at low tide, nests on sandy beaches within noise footprint in Santa Barbara (including VSFB), Ventura, and western Los Angeles Counties.
Willet (*Tringa semipalmata*)	BCC	-	Present on rocky coastline at low tide and beaches impacted by noise in Santa Barbara (including VSFB), Ventura, and western Los Angeles Counties.
White-tailed kite (*Elanus leucurus*)	-	Fully Protected; Nesting	Present in riparian and non-native tree habitat within noise footprint in Santa Barbara (including VSFB), Ventura, and western Los Angeles Counties.

Species	Status		Potential Occurrence within the ROI
	Federal	California	
Yellow warbler (*Setophaga petechia*)	BCC	SSC; Nesting	Present in riparian habitat within noise footprint in Santa Barbara (including VSFB), Ventura, and western Los Angeles Counties.

Notes: BCC = Federal Bird of Conservation Concern; BGEPA = Bald and Golden Eagle Protection Act; FE = Federally Endangered Species; FT = Federally Threatened Species; SE = State Endangered Species; ST = State Threatened Species; SSC = California State Species of Special Concern
* "Special Animals" is a broad term used to refer to all the animal taxa tracked by the CDFW.

Table 3.3-7. Special status mammal species occurrence within the terrestrial portion of the ROI

Species	Status		Potential Occurrence within the ROI
	Federal	California	
Pallid bat (*Antrozous pallidus*)	-	SSC	Present within the noise footprint in Santa Barbara (including VSFB), Ventura, and western Los Angeles Counties.
Spotted bat (*Euderma maculatum*)	-	SSC	Present within the noise footprint in Santa Barbara (including VSFB), Ventura, and western Los Angeles Counties.
Townsend's big-eared bat (*Corynorhinus townsendii*)	-	SSC	Present within the noise footprint in Santa Barbara (including VSFB), Ventura, and western Los Angeles Counties.
Western red bat (*Lasiurus blossevillii*)	-	SSC	Present within the noise footprint in Santa Barbara (including VSFB), Ventura, and western Los Angeles Counties.
Western mastiff bat (*Eumops perotis californicus*)	-	SSC	Present within the noise footprint in Santa Barbara (including VSFB), Ventura, and western Los Angeles Counties.
San Diego desert woodrat (*Neotoma lepida intermedia*)	-	SSC	Present within the noise footprint in Santa Barbara (including VSFB), Ventura, and western Los Angeles Counties.
South coast marsh vole (*Microtus californicus stephensi*)	-	SSC	Not on VSFB. Present within the noise footprint in Ventura County.
Southern California saltmarsh shrew (*Sorex ornatus salicornicus*)	-	SSC	Not on VSFB. Present in coastal salt marshes of Ventura County.
American badger (*Taxidea taxus*)	-	SSC	Present within noise footprint in Santa Barbara (including VSFB), Ventura, and western Los Angeles Counties.

Notes: SSC = California Species of Special Concern

3.3.2 Environmental Consequences

3.3.2.1 Alternative 1 and 2

The following factors were used to determine if a significant impact on biological resources would result from implementing each alternative:

- Per 40 CFR 1501.3(d), "agencies shall examine both the context of the action and the intensity of the effect. In assessing context and intensity, agencies should consider the duration of the effect. Agencies may also consider the extent to which an effect is adverse at some points in time and beneficial in others (for example, in assessing the significance of a habitat restoration action's effect on a species, an agency may consider both any short-term harm to the species during implementation of the action and any benefit to the same species once the action is complete). However, agencies shall not offset an action's adverse effects with other beneficial effects to determine significance (for example, an agency may not offset an action's adverse effect on one species with its beneficial effect on another species)."

Per FAA Order 1050.1F, impacts would be significant if the USFWS or NMFS determines that the action would be likely to jeopardize the continued existence of a federally listed threatened or endangered species or would result in destroying or adversely modifying federally designated critical habitat.

Impacts on biological resources would occur if project-related activities directly or indirectly affect special status species or their habitats. These impacts can be short- or long-term impacts. For example, short-term or temporary impacts can be from noise and long-term impacts can be from the lost habitat supporting wildlife populations.

Potential impacts on biological resources from the Proposed Action include the following:

- Indirect impacts resulting from water use, which could be extracted from the San Antonio Creek Basin;
- Project-related noise disrupting breeding, foraging, or roosting behaviors; and
- Project-related noise causing habitat abandonment, including breeding or roosting sites.

3.3.2.1.1 Wildlife Resources

Temporary disturbances to terrestrial wildlife species within the ROI would occur during the launch, landing, and static fire events. Wildlife responses to noise can be behavioral or physiological, ranging from mild, such as an increase in heart rate, to more damaging effects on metabolism and hormone balance. Because responses to noise are species specific, exact predictions of the effects on each species are unreliable without data pertaining to the behavioral responsiveness and physiological sensitivity to noise of those species or similar species.

Noise during launches, landing, and static firings at SLC-4 are expected to elicit a startle response in terrestrial wildlife species that may either see or hear these activities. Wildlife hearing thresholds (the range of noise frequencies that species can perceive) could potentially shift (i.e., partial hearing loss or reduction in sensitivity to certain frequencies) either permanently or temporarily in wildlife if they are active on the surface close to SLC-4 during launch, landing, or static fire events. Engine noise would reach as high as 150 dB L_{max} with sonic booms up to 9.5 psf at SLC-4. However, vegetation management within and around SLC-4 reduces wildlife presence above ground in these areas. Exceptionally little sound is transmitted between the air-water interface; thus, in-air sound would not have a significant effect on submerged animals (Godin 2008). Because the areas where loud noises would occur are relatively small (see Section 3.2), the noise events are temporary, and wildlife presence is reduced due to vegetation management, potential hearing threshold shifts are unlikely or would affect relatively few individuals and not expected to have population-level impacts. Therefore, would not have a significant effect on wildlife resources.

At maximum cadence, the Proposed Action would use up to 18.6 ac-ft of water per year. This would represent an increase of approximately 0.7 percent of the total annual water usage on VSFB. The current water source for VSFB is via an existing connection between State Water and the VSFB water supply system. VSFB primarily relies on State Water; however, during annual maintenance that lasts two to three weeks, VSFB utilizes four water wells in the San Antonio Creek Basin. Even if pumping this entire volume of water from the San Antonio Creek groundwater basin, it would have an indetectable effect of water levels and flow rates in the creek (Cromwell & Faunt 2024). The Proposed Action's water usage would therefore be discountable and not result in any measurable impacts to flow rates, hydration periods, or water levels in San Antonio Creek.

3.3.2.1.2 Special Status Terrestrial Species

Potential impacts to ESA-protected species would be similar to those described in Section 4.3.1 of the 2023 SEA; however, six ESA-protected species were not included in the 2023 SEA that are within the Proposed Action's ROI due to expansion of the area of potential noise impacts: California tiger salamander, arroyo toad, southwestern willow flycatcher, least Bell's vireo, California gnatcatcher, and light-footed clapper. Because of the lack of any potential physical impacts to these species' habitats and the unlikelihood of noise impacts, the DAF determined the Proposed Action may affect, but not likely to adversely affect these species. A detailed discussion of potential effects to all ESA-protected species and their critical habitat within the ROI is included in the Biological Assessment (Appendix A) and summarized in Table 3.3-8. The USFWS issued a Biological Opinion (BO) in March 2023 addressing impacts to species listed under the ESA for 36 Falcon 9 launches annually and provided an incidental take statement for species likely to be adversely affected. SLD 30 completed ESA Section 7 consultation with USFWS regarding the Proposed Action. The resultant BO (USFWS 2024; Appendix A) assessed the effects of 16 additional launches between 1 October and 31 December 2024, not to exceed a total of 50 Falcon 9 launches during 2024. Additional consultation will occur with USFWS for launches in 2025 and beyond.

As discussed for non-listed species, the increased tempo of launches and landings would increase the frequency at which listed and proposed species and migratory birds could respond behaviorally and physiologically to noise. There could potentially be a corresponding increase in effects such as long-term habitat avoidance and decreased reproductive success. Some individuals may become habituated to increased noise events and vibration and exhibit diminishing responses over time. It is not feasible to predict the number of exposures that would correspond to these types of effects. Given the lack of quantitative thresholds, population monitoring may be used to evaluate long-term noise impacts. Monitoring of western snowy plover, California least-tern, California red-legged frog (CRLF), and other species occurs currently at VSFB and is expected to continue. If monitoring results indicated population effects, SLD 30 would develop a response strategy accordingly with USFWS.

As discussed in Section 3.2.2, potential sonic booms impacting mainland California during ascent are generally expected to be of low magnitude and infrequent. Due to the lack of any coupled visual stimuli, sonic booms created during missions with easterly trajectories are not expected to have long-term adverse effects on ESA-protected species.

Increased launch frequency would also increase the occurrence of nighttime lighting at SLC-4. SpaceX is developing a lighting management plan in coordination with SLD 30 and USFWS to reduce potential impacts due to nighttime lighting.

During launch, CRLF may be injured or killed as a result of the release of hot water and vapor into Spring Canyon from the flame bucket (a concrete pit under the rocket that receives the rocket engine flame and is filled with water to reduce vibrations of the vehicle during launch). An assessment of Spring Canyon in 2013 (MSRS 2014), in July 2017 (MSRS 2017a), and in February 2023 during record rainfall levels (MSRS 2023) found no suitable aquatic habitat within Spring Canyon within or downstream of the vegetation management area. In addition, since 2017, across 11 survey efforts to perform minimization measures associated with the 2017 Biological Opinion (USFWS 2017), no suitable habitat has been found in this area. Routinely mowing the vegetation in the area impacted by water and vapor also reduces the suitability and attractiveness of the site for CLRF occupancy. It is therefore unlikely that CRLF occupy this area on a regular basis and no direct impacts during vegetation management activities or water release are anticipated.

Table 3.3-8. Federally listed species with potential to occur within ROI and summary of effects determinations

Common Name	Scientific Name	Federal Listing	Critical Habitat	Effects Determinations for the Proposed Action
Tidewater Goby	*Eucyclogobius newberryi*	Endangered	No Effect	May affect, not likely to adversely affect.
Unarmored Threespine Stickleback	*Gasterosteus aculeatus williamsoni*	Endangered	Not designated	May affect, not likely to adversely affect.
California Tiger Salamander	*Ambystoma californiense*	Endangered	No Effect	May affect, not likely to adversely affect.
California Red-legged Frog	*Rana draytonii*	Threatened	No Effect	**May affect, likely to adversely affect.**
Arroyo Toad	*Anaxyrus californicus*	Endangered	No Effect	May affect, not likely to adversely affect.
Western Spadefoot	*Spea hammondii*	Unlisted	N/A	May affect, not likely to adversely affect.

Common Name	Scientific Name	Federal Listing	Critical Habitat	Effects Determinations for the Proposed Action
Southwestern Pond Turtle	*Actinemys pallida*	Unlisted	N/A	**May affect, likely to adversely affect.**
Marbled Murrelet	*Brachyramphus marmoratus*	Threatened	Designated, no overlap with Action Area	May affect, not likely to adversely affect.
Southwestern Willow Flycatcher	*Empidonax traillii extimus*	Endangered	No Effect	May affect, not likely to adversely affect.
Least Bell's Vireo	*Vireo bellii pusillus*	Endangered	Designated, no overlap with Action Area	May affect, not likely to adversely affect.
Western Snowy Plover	*Charadrius nivosus*	Threatened	No Effect	**May affect, likely to adversely affect.**
California Least Tern	*Sternula antillarum browni*	Endangered	Not designated	**May affect, likely to adversely affect.**
California Condor	*Gymnogyps californianus*	Endangered	No Effect	May affect, not likely to adversely affect.
California Gnatcatcher*	*Polioptila californica californica*	Threatened	No Effect	May affect, not likely to adversely affect.
Light-footed Clapper Rail	*Rallus obsoletus levipes*	Endangered	Not designated	May affect, not likely to adversely affect.

The terms and conditions and reasonable and prudent measures identified in the 2024 BO (USFWS 2024; Appendix A) would be implemented. With continued species monitoring and implementation of measures required by the USFWS, increased Falcon launches would not be likely to jeopardize the continued existence of a federally listed threatened or endangered species or result in the destruction or adverse modification of federally designated critical habitat resources. In addition, these measures would decrease the potential for long-term habitat and species loss, as well as adverse effects on reproductive success, mortality rate, or ability to sustain minimum population levels, such that there would be no significant impact.

3.3.2.2 No Action Alternative

Under the No Action Alternative, increased launch cadence on VSFB would not occur, resulting in no impacts on terrestrial biological resources, beyond those described in the 2023 SEA.

3.4 Marine Biological Resources

3.4.1 Affected Environment

The ROI for marine biological resources includes areas potentially affected by sonic boom, rocket engine noise, and first stage and fairing recovery activities. The DAF has monitored pinnipeds during launch-related sonic booms on the NCI during numerous launches over the past two decades, and determined in collaboration with NMFS, there are generally no significant behavioral disruptions caused to pinnipeds by sonic booms less than 1.0 psf; therefore, the ROI for marine mammals potentially disturbed by a sonic boom was determined by examining the 1.0 psf sonic boom contours from model results. The ROI also includes the proposed landing and fairing recovery area (Figure 2.1-2), the NCI, and support vessel routes between the Port of Long Beach, the proposed landing area, and VSFB Harbor.

3.4.1.1 Marine Species

Fish, sea turtles, and marine mammal species protected under the ESA or MMPA, and managed by NMFS, have the potential to occur in the ROI. Detailed background information on ESA-listed fish, sea turtles, and marine mammals, including status and maps showing occurrence in the project area, can be found in Appendix B.

Table 3.4-1. ESA-listed fish species occurrence within the ROI

Common Name	Scientific Name	DPS or ESU	Federal Status	Presence in ROI
Steelhead	*Oncorhynchus mykiss*	Southern California Coast	FE	Documented in the nearshore and offshore waters.
Chinook salmon	*Oncorhynchus tshawytscha*	5 ESUs[1]	FT	Specific ESUs present or potentially present in the nearshore and offshore waters.
Coho salmon	*Oncorhynchus kisutch*	4 ESUs[2]	FT	Documented in the nearshore and offshore waters.
Green sturgeon	*Acipenser medirostris*	Southern	FT	Likely present primarily along continental shelf waters of the West Coast
Oceanic whitetip shark	*Carcharhinus longimanus*	-	FT	Present in open ocean waters from Southern California to Peru
Scalloped hammerhead shark	*Sphyrna lewini*	Eastern Pacific	FE	Present in coastal and semi-oceanic water in temperate and tropical regions

Notes: DPS = Distinct Population Segment; ESU = Evolutionarily Significant Unit; FE = federally endangered; FT = federally threatened

[1] Chinook salmon ESUs include California Coastal (FT), Central Valley Spring-Run (FT), Lower Columbia River (FT), and Sacramento River Winter-Run (FT)

[2] Coho salmon ESUs include Central California Coast (FT) and Southern Oregon and Northern California Coasts (FT).

Table 3.4-2. ESA-listed turtle species occurrence within the ROI

Common Name	Scientific Name	DPS or ESU	Federal Status	Presence in ROI
Green sea turtle	*Chelonia mydas*	East Pacific Central North Pacific	FT	Present in offshore and nearshore subtropical waters
Leatherback sea turtle	*Dermochelys coriacea*	-	FE	Present in offshore and nearshore waters
Olive ridley sea turtle	*Lepidochelys olivacea*	Mexico Pacific Coast	FE	Present in offshore and nearshore waters
Hawksbill sea turtle	*Eretmochelys imbricata*	-	FE	Present in offshore and nearshore waters of Mexico
Loggerhead turtle	*Caretta caretta*	North Pacific	FE	Present in small numbers in offshore waters generally north of Point Conception

Notes: DPS = Distinct Population Segment; ESU = Evolutionarily Significant Unit; FE = federally endangered; FT = federally threatened

Table 3.4-3. Special status marine mammal species occurrence within the ROI

Common Name	Scientific Name	DPS or ESU	Federal Status	Presence in ROI
Blue whale	*Balaenoptera musculus*	-	FE; MMPA	High densities in summer/fall; single individuals in winter/spring
Fin whale	*Balaenoptera physalus*	-	FE; MMPA	Higher densities in the summer and fall, present year-round
Gray whale	*Eschrichtius robustus*	Western North Pacific	FE; MMPA	Present during seasonal migration in the winter and spring
Humpback whale	*Megaptera novaeangliae*	Mexico	FT; MMPA	Individuals present year-round with higher seasonal presence during the summer migrations from Mexico and Central America
		Central America	FE; MMPA	
Killer whale	*Orcinus orca*	Southern Resident	FE; MMPA	occasionally present offshore of Central and Southern California
Sei whale	*Balaenoptera borealis*	-	FE; MMPA	Present year round with more likely presence in the winter and spring
Sperm whale	*Physeter macrocephalus*	-	FE; MMPA	Present year round with a preference for deep waters and the continental shelf break and slope
Steller sea lion	*Eumetopias jubatus*	-	MMPA	Documented in coastal waters within the noise footprint
Northern elephant seal	*Mirounga angustirostris*	-	MMPA	Documented in coastal waters within the noise footprint
Pacific harbor seal	*Phoca vitulina richardii*	-	MMPA	Documented in coastal waters within the noise footprint
California sea lion	*Zalophus californianus*	-	MMPA	Documented in coastal waters within the noise footprint
Guadalupe fur seal	*Arctocephalus townsendi*	-	FT; MMPA	Primarily present at NCI and between 50 and 300 km offshore seasonally when not at rookeries in Mexican waters
Southern sea otter	*Enhydra lutris nereis*	-	FT; MMPA	Present along coast of California from Santa Barbara County and north; present along coast of San Nicolas Island

Notes: DPS = Distinct Population Segment; ESU = Evolutionarily Significant Unit; FE = federally endangered; FT = federally threatened; MMPA = Marine Mammal Protection Act

3.4.1.2 Marine Reserves

Under the National Marine Sanctuaries Act, the NOAA established national marine sanctuaries for marine areas with special conservation, recreational, ecological, historical, cultural, archaeological, scientific, educational, or aesthetic qualities. The Channel Islands National Marine Sanctuary (CINMS) is a collection of marine reserves and marine sanctuaries located at the Channel Islands approximately 40 mi south of SLC-4 (Figure 3.4-1). CINMS regulations listed in 15 CFR Parts 922.71–922.74. Section 922.72(a)(1) prohibits taking any marine mammal, sea turtle, or seabird within or above the CINMS, except as authorized by the MMPA, ESA, MBTA, or any regulation promulgated under the MMPA, ESA, or MBTA.

The coastline from Purisima Point to just south of Point Arguello has been designated as the Vandenberg State Marine Reserve (VSMR) pursuant to California's Marine Managed Areas Improvement Act (Figure 3.4-1). The VSMR management objectives include providing for complete protection of a diverse area containing shallow hard and soft habitats, kelp beds, and associated marine life.

The Chumash Heritage National Marine Sanctuary (CHNMS) was formally designated on October 11, 2024. The CHNMS encompasses an area of the Pacific Ocean from Gaviota Creek to Santa Rosa Creek and out to the western slope of the Santa Lucia Bank. The Final Rule[10] for the sanctuary included an exemption for existing Department of Defense Activities, including launch and landing activity originating from VSFB.[11]

3.4.2 Environmental Consequences

3.4.2.1 Alternative 1 and 2

3.4.2.1.1 ESA-listed Fish

The Proposed Action potentially impacts ESA-listed fishes shown in Table 3.4-1 occurring within the ROI. Section 4.4.1 of the 2023 SEA analyzed the potential effects of physical disturbance and impacts by fallen objects, ship strike, entanglement, and ingestion of expended materials on ESA-listed fish and determined that these would be discountable (DAF 2023). The DAF conducted informal Section 7 consultation with NMFS, which concurred potential impacts ***may affect, but not likely to adversely affect*** ESA-listed fish species through a LOC issued on 20 January 2023 (Appendix B). The Proposed Action has not been modified in a manner that would result in different types of stressors or levels of stressors that were not considered in the written concurrence or would result in take of ESA-listed fish species; nor would the Proposed Action affect ESA-listed fish species or critical habitat in a manner or to an extent not previously considered. The DAF conducted informal Section 7 consultation with NMFS, which concurred through an LOC issued on 17 April 2024 (Appendix B). The DAF would continue to implement all applicable minimization, monitoring, and avoidance measures in the LOC and the environmental protection measures (EPMs) included in Appendix L.

3.4.2.1.2 ESA-listed Sea Turtles

The Proposed Action potentially impacts ESA-listed sea turtles shown in Table 3.4-2 occurring within the ROI. Section 4.4.1 of the 2023 SEA analyzed the potential effects of physical disturbance and impacts by fallen objects, ship strike, entanglement, and ingestion of expended materials on ESA-listed sea turtles

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[10] https://www.federalregister.gov/documents/2024/10/16/2024-23607/chumash-heritage-national-marine-sanctuary

[11] https://nmssanctuaries.blob.core.windows.net/sanctuaries-prod/media/chumash/2024-chnms-feis-vol-2.pdf

and determined that these would be discountable (DAF 2023). The DAF conducted informal Section 7 consultation with NMFS, which concurred potential impacts ***may affect, but not likely to adversely affect*** ESA-listed sea turtle species through a LOC issued on 20 January 2023 (Appendix B).

The Proposed Action has not been modified in a manner that would result in different types of stressors or levels of stressors that were not considered in the written concurrence; nor would the Proposed Action affect ESA-listed sea turtles or critical habitat in a manner or to an extent not previously considered. The proposed recovery area is larger than analyzed in Section 4.4.1 of the 2023 SEA and overlaps the range of the Central North Pacific Distinct Population Segment (DPS) of the green sea turtle, which was not included in the NMFS 2023 LOC. The DAF conducted informal Section 7 consultation with NMFS, which concurred through an LOC issued on 17 April 2024 (Appendix B). The DAF would continue to implement all applicable minimization, monitoring, and avoidance measures in the LOC and the EPMs included in Appendix L.

3.4.2.1.3 ESA-listed Cetaceans

The Proposed Action potentially impacts the ESA-listed cetaceans shown in Table 3.4-3 occurring within the ROI. Section 4.4.1 of the 2023 SEA analyzed the potential effects of physical disturbance and impacts by fallen objects, ship strike, entanglement, ingestion of expended materials, and noise on ESA-listed cetaceans and determined that these would be discountable (DAF 2023). The DAF conducted informal Section 7 consultation with NMFS, which concurred potential impacts ***may affect, but not likely to adversely affect*** ESA-listed cetacean species through a LOC issued on 20 January 2023 (Appendix B). The Proposed Action has not been modified in a manner that would result in different types of stressors or levels of stressors that were not considered in the written concurrence or would result in take of ESA-listed cetacean species; nor would the Proposed Action affect ESA-listed cetacean species or critical habitat in a manner or to an extent not previously considered. The DAF conducted informal Section 7 consultation with NMFS, which concurred through an LOC issued on 17 April 2024 (Appendix B). The DAF would continue to implement all applicable minimization, monitoring, and avoidance measures in the LOC and the EPMs included in Appendix L.

3.4.2.1.4 MMPA-Protected Pinnipeds

Noise and visual disturbance can cause variable levels of disturbance to pinnipeds that may be hauled out within the areas of exposure, depending on the species exposed and the level of the sonic boom. NMFS has previously determined that the only potential stressors associated with the specified activities that could cause harassment of marine mammals (i.e., rocket engine noise, sonic booms) only have the potential to result in harassment of marine mammals that are hauled out of the water (NMFS 2019a). As a result, not all Falcon 9 first stage recoveries are expected to result in harassment of marine mammals. First stage recoveries throughout the majority of the proposed landing area will not result in landing engine noise or sonic booms greater than 1.0 psf impacting mainland or islands. The DAF has monitored pinnipeds during launch-related sonic booms on the NCI during numerous launches over the past two decades and determined that there are generally no significant behavioral disruptions caused to pinnipeds by sonic booms less than 1.0 psf. Generally, only a portion of the animals present tend to react to sonic booms, and reactions vary greatly by species.

The DAF has also monitored pinnipeds on VSFB during many launches to characterize the effects of noise and visual disturbance on pinnipeds during numerous launches over the past two decades, and determined in collaboration with NMFS, there are generally no substantial behavioral disruptions or anything more than temporary affects to the number of pinnipeds hauled out on VSFB. Again, reactions between species are also different. For example, Pacific harbor seals (PHS) and California sea lion tend to be more sensitive to disturbance than northern elephant seals. Normal behavior and numbers of hauled out pinnipeds typically return to normal within 2 to 4 hours or less (often within minutes) after a launch event. No observations of injury or mortality to pinnipeds during monitoring have been attributed to past launches.

Under the MMPA, NMFS issued a Final Rule for taking marine mammals incidental to VSFB launches (NMFS 2024a), and a LOA (NMFS 2024b; Appendix B). The LOA, which will expire on 9 April 2029, allows launch programs to unintentionally take small numbers of marine mammals during launches. The Proposed Action would not result in exceedance of take thresholds as identified in the 2024 LOA. The DAF is required to comply with the LOA listed conditions and address NMFS concerns regarding marine mammals at VSFB. Under the current LOA, semi-monthly surveys (two surveys per month) must be conducted to monitor the abundance, distribution, and status of pinnipeds at VSFB.

The DAF assessed acoustic impacts to marine mammals to analyze potential acoustic impacts for pinniped haulouts in eastern Santa Barbara, Ventura, and Los Angeles Counties to determine if the increased impact is covered by the estimated take totals in the LOA (NMFS 2024b; Appendix B). Full details of this analysis are provided in Appendix B. Below is a summary of the findings.

Two harbor seal haulouts were identified on the mainland in the geographic noise footprint, the Carpinteria Harbor Seal Rookery and the Point Mugu Lagoon haulout. The DAF applied NMFS thresholds as the best available science to estimate level of take resulting from in-air non-impulsive (rocket engine noise) noise and impulsive (sonic boom) for harbor seals at these haulouts. During missions with easterly trajectories, the received engine noise levels (non-impulsive noise) would be substantially less than the NMFS threshold for behavioral disturbance for harbor seals. Additionally, acoustic monitoring in Ventura County for five SpaceX missions with easterly trajectories, engine noise has been below ambient noise levels and thus could not be measured. Therefore, engine noise is substantially below NMFS thresholds for behavioral disruption of harbor seals and thus no takes are anticipated at either the Carpinteria Harbor Seal Rookery or the Point Mugu Lagoon haulout.

To analyze the potential for take due to sonic boom (impulsive noise), the sonic boom model outputs were compared to harbor seal haulout locations. Approximately 39% of missions with easterly trajectories are predicted to impact the Carpinteria Harbor Seal Rookery. 88% of the boom levels were predicted to be less than 1.0 psf, and 98% were predicted to be less than 2.0 psf. The highest predicted level was 3.7 psf. For the Point Mugu Lagoon haulout, approximately 93% of missions with easterly trajectories are predicted to impact the site. However, 99.8% of the boom levels were predicted to be less than 1.0 psf, and 100% were predicted to be less than 1.5 psf. The highest predicted level was 1.6 psf. Sonic booms of approximately 1 psf are expected to generally correspond to the NMFS threshold of 100 dB SEL for behavioral disruption for harbor seals. This is supported by over two decades of pinniped monitoring by the DAF during sonic booms caused by numerous launches where the DAF has observed that there are generally no significant behavioral disruptions caused to pinnipeds by sonic booms less than 1 psf.

VSFB's LOA permits a total of 11,135 PHS to be incidentally taken by Level B harassment (behavioral disruption) annually due to launch activities (NMFS 2024b). Although this total did not include estimates of take at haulouts on the south coast of eastern Santa Barbara, Ventura, and northwestern Los Angeles Counties, any increase in annual take by Level B harassment of PHS (estimated to be 2,868 per year total) would be offset by a reduction in take on San Miguel Island (SMI). This is because as the trajectory of the Falcon 9 and resultant sonic boom moves more to the east and approaches 140 to 145 degrees the sonic boom no longer overlaps SMI, where there are large numbers of PHS and other pinnipeds. It is therefore unnecessary to increase the number of permitted takes by Level B harassment of PHS under the LOA, despite the change in geographic area of potential impacts. The DAF provided this analysis to NMFS 2 August 2024.

MMPA-protected marine mammals have the potential to be disturbed during RORO operations. However, we do not anticipate adverse effects because the EPMs in Appendix L, including entering the harbor to the extent possible at high tides when pinnipeds are not present, initiating any nighttime activities before dusk, and slowly starting any noisy activities, would help minimize and avoid any behavior disruptions.

Considering the authorizations and EPMs in place, including the required monitoring, the Proposed Action would not result in significant impacts on MMPA protected pinnipeds.

3.4.2.1.5 ESA-listed Guadalupe Fur Seal

The Proposed Action potentially impacts the ESA-listed Guadalupe fur seal. Section 4.4.1 of the 2023 SEA analyzed the potential effects of sonic booms on the NCI on Guadalupe fur seal (DAF 2023). In general, Guadalupe fur seals are relatively insensitive to disturbance, occur in low numbers at SMI in isolated locations, and are adept at jumping into the water if they do flee from a disturbance (Harris 2015). Section 4.4.1 of the 2023 SEA and Appendix B contain more detailed Guadalupe fur seals behavioral reaction discussion. The DAF conducted informal Section 7 consultation with NMFS, which concurred potential impacts were *not likely to adversely affect* the Guadalupe fur seal through a LOC issued on 20 January 2023 (Appendix B). The Proposed Action has not been modified in a manner that would result in different types of stressors or levels of stressors that were not considered in the written concurrence or would result in take of Guadalupe fur seals; nor would the Proposed Action affect Guadalupe fur seal in a manner or to an extent not previously considered. Critical habitat has not been designated for this species. Additionally, the LOA (NMFS 2024) allows unintentionally take of small numbers of Guadalupe fur seals during launches. The Proposed Action would not result in exceedance of take thresholds as identified in the 2024 LOA. The DAF is required to comply with the LOA listed conditions. The DAF would continue to implement all applicable minimization, monitoring, and avoidance measures in the LOC, LOA, and the EPMs included in Appendix L.

3.4.2.1.6 ESA-listed Southern Sea Otter

Appendix A includes maps depicting noise model results and the overlap with southern sea otter habitat discussed below. Areas directly offshore of SLC-4 would receive visual disturbance and noise levels of less than 130 dB L_{max} during Falcon 9 launches and approximately 110 dB L_{max} during up to 12 first stage landing at SLC-4W. During static fire events, noise directly off the coast of SLC-4 would be less than 125 dB L_{max} and there would be no associated visual disturbance. Landing at SLC-4W would also generate a sonic boom directly offshore that would range from approximately 1 to 5 psf. Otters are only occasionally observed along the coast between Purisima Point and Point Arguello transiting through the area between suitable habitat to the north and south. Beginning at the Boat Dock and continuing south along Sudden Flats, the inshore habitat supports expansive kelp beds and a relatively high density of otters. Noise levels would reach between approximately 100 and 110 dB L_{max} during up to 50 Falcon 9 launches from SLC-4 per year and less than 80 dB L_{max} during up to 12 first stage landing each year at SLC-4W in these areas. Sonic booms during up to 12 SLC-4W landings per year would range from approximately 1 to 4 psf along Sudden Flats.

Exceptionally little sound is transmitted between the air-water interface; thus, in-air sound would not have a significant effect on submerged animals (Godin 2008). In addition, according to Ghoul and Reichmuth (2014), "Under water, hearing sensitivity [of sea otters] was significantly reduced when compared to sea lions and other pinniped species, demonstrating that sea otter hearing is primarily adapted to receive airborne sounds." This study suggested that sea otters are less efficient than other marine carnivores at extracting noise from ambient noise (Ghoul & Reichmuth 2014). Therefore, the potential impact of underwater noise caused by in-air sound would be discountable.

Extensive launch monitoring has been conducted for sea otters on both north and south VSFB. No abnormal behavior, mortality, or injury of effects on the population has ever been documented for sea otter as a result of launch-related noise and visual disturbance (SRS Technologies, Inc. 2006a, 2006b, 2006c, 2006d, 2006e, 2006f, 2006g, 2006h; MSRS 2007a, 2007b, 2008a, 2008b, 2009; 2021c). Most recently, otters were monitored during four Falcon 9 launches from SLC-4 during 2023 and there were no discernible impacts on overall southern sea otter numbers at the monitoring site (MSRS 2024).

As detailed in Appendix A, most of the sonic boom energy is less than 250 hertz (Hz), well below the region of best sensitivity of the sea otter (2–22.6 kilohertz). While the sea otter would likely hear the sonic boom, it would only be responding to acoustic energy that is above 250 Hz and total sound levels much less than 135 dB L_{max}. As the sonic boom increases in pressure, it is likely that the sea otter would detect more energy, most notably in frequencies higher than 250 Hz. Appendix A presents a sonic boom spectrum and sea otter hearing sensitivity curve, along with an audiogram used to derive an auditory weighting function. The otter weighting function was applied to a timewave form recording of the June 2022 Falcon 9 SARah-1 launch and resulted in a peak level of approximately 70 dB L_{max} (see Appendix A), which by comparison to human hearing sensitivity is equivalent to the sound level of a household washing machine.

Otters have also been shown to quickly acclimate to disturbances from boats, people, and harassment devices (air horns). A summary of studies related to sea otters and disturbance is included in Appendix A. Extensive launch monitoring of sea otters on VSFB has shown that rocket disturbance is not a primary driver of sea otter behavior or using the habitat along Sudden Flats and has not had any apparent long-term consequences on populations, potentially indicating that this population has acclimated to launch activities. Therefore, impacts from noise or visual disturbance resulting from the Proposed Action is expected to be limited to minor behavioral disruption and insignificant.

Because there is very little overlap in the hearing sensitivity of otters and noise produced during rocket launches, otters would perceive very little noise during launch activities and the DAF has determined that impacts on southern sea otter would be insignificant as a result of the Proposed Action, including the collective effects of increased launch activities at VSFB. Therefore, the DAF determined that the Proposed Action may affect, but is not likely to adversely affect, the southern sea otter off VSFB's coast. The DAF completed Section 7 consultation with the USFWS for potential impacts on southern sea otter and would implement all applicable minimization, monitoring, and avoidance measures in the resultant BO (Appendix A) and the EPMs included in Appendix L.

3.4.2.1.7 Marine Reserves

The Proposed Action would not result in any adverse impacts to existing marine reserves. Sonic booms created by the Falcon 9 would reach above 5.0 psf at CINMS on rare occasions. The CINMS prohibitions do not apply to military activities carried out by the DOD, according to Section 3.5.9 of the CINMS Final Environmental Impact Statement (EIS), entitled "Department of Defense Activities" ("preexisting activities") as indicated in Section 922.72(b)(1). Section 3.5.9.1 of the CINMS Final EIS describes spacelift operations originating from VSFB and potential sonic booms from these activities as "pre-existing activities" (NMFS 2007). In addition, impacts to the CINMS would be temporary. Therefore, the Proposed Action would not result in significant impacts on the CINMS.

As stated in Section 3.4.1.2, the CHNMS included an exemption for existing Department of Defense Activities, including launch and landing activity originating from VSFB. Thus, there would be no significant impact on the CHNMS.

Noise levels produced during launch activities at SLC-4 would not change from those previously analyzed in Section 4.4.1 of the 2023 SEA. The CDFW and the DAF established a mutual Memorandum of Understanding for the VSMR. Within the VSMR, no take of living marine resources is permitted except take incidental to the mission critical activities of VSFB. Those activities include ones that are important for supporting and defending U.S. launch, range, expeditionary, exercise, test, training, and installation operations, including, but not limited to, space-launch vehicles. Impacts on marine resources within the VSMR would be temporary and limited to sonic boom and landing noise. Therefore, the Proposed Action under Alternative 1 and 2 would not result in significant impacts on VSMR.

3.4.2.1.8 Marine Debris

Impacts to marine and coastal resources by marine debris (parachute, parafoils, weather balloons, radiosondes, and residual fuels) under the Proposed Action were analyzed for potential impacts in Sections 4.4 (Marine Biological Resources), 4.5 (Water Resources) and 4.7 (Coastal Zone Management) of the 2023 SEA and would remain highly unlikely to occur and thus discountable, as the amount of debris would not increase per launch/landing, but only the frequency at which the launch/landing occur. Therefore, marine debris would not have a significant impact on marine resources.

3.4.2.2 No Action Alternative

Under the No Action Alternative, increased launch cadence on VSFB would not occur, resulting in no impacts on marine biological resources, beyond those described in the 2023 SEA.

3.5 Water Resources

3.5.1 Affected Environment

VSFB encompasses portions of two major and four minor drainage basins. San Antonio Creek and the Santa Ynez River represent the major basins, while Shuman Creek, Bear Creek, Honda Creek, and Jalama Creek comprise the minor basins on VSFB. The ROI for water resources include Spring Canyon, San Antonio

Creek, and the Pacific Ocean. Surface water in Spring Canyon is entirely on VSFB property, originating at the west end of the Santa Ynez Mountains, north of Honda Canyon. San Antonio Creek drains an area of approximately 154 mi^2 flowing westward and discharging into the Pacific Ocean. Groundwater from the San Antonio Creek basin supplies water for irrigation, domestic, industrial, and municipal purposes through pumping. The Government Accountability Office (GAO) identified VSFB as vulnerable to water-scarcity issues in 2019 (GAO 2019).

3.5.1.1 Surface Water

Surface water resources near SLC-4 include Spring Canyon and the Pacific Ocean. Mean rainfall for the region, measured at Surf from 1927 through 2021, is 11.2 inches (28.4 cm; County of Santa Barbara Public Works 2022). There are no federally designated Wild and Scenic Rivers within the vicinity of VSFB.

Spring Canyon lacks direct connection to the Pacific Ocean and lacks surface flow throughout almost the entire drainage, with flow occurring predominately during and immediately after rainfall (MSRS 2023). Riparian vegetation is removed from a portion of Spring Canyon annually within a 3.3-ac area to avoid and minimize impacts to nesting migratory birds. To protect Waters of the State (WOTS) and meet Basin Plan requirements, the Regional Water Quality Control Board (RWQCB) required implementing a monitoring and mitigation plan in lower Spring Canyon. Mitigation plan implementation is currently in its sixth year. Mitigation and monitoring protocols are described in the Spring Canyon Riparian Mitigation and Monitoring Plan for the Falcon 9 Launch and Landing Program at SLC-4, at Vandenberg Air Force Base, CA (MSRS 2017b).

3.5.1.2 Groundwater

VSFB includes parts of two groundwater basins and at least two sub-basins. The northern third of VSFB is within the San Antonio Creek Basin and the remaining areas are within the Santa Ynez River Basin and associated Lompoc Terrace and Cañada Honda sub-basins. SLC-4 is located in the Santa Ynez River groundwater basin/Lompoc Terrace sub-basin. Groundwater at SLC-4 has been described in Section 3.5.2 of the 2023 SEA and there is no new construction proposed at SLC-4, therefore, groundwater at SLC-4 is not considered further in this EA.

The current water source for VSFB, including SLC-4, is via an existing connection between State Water and the VSFB water supply system. VSFB primarily relies on State Water; however, during annual maintenance that last two to three weeks, VSFB utilizes four water wells in the San Antonio Creek Basin. Annual VSFB water use from 2019 through 2021 has averaged 910,500,000 gallons (2,794 ac-ft) per year. The San Antonio Creek Basin is considered in this EA due to the proposed water extraction requirements to support the increase in SLC-4 operations.

3.5.1.3 Waters of the United States and Wetlands

Spring Canyon has surface waters with flowing or standing water for only a short duration in direct response to significant precipitation (surface flow only occurs during and immediately after rain events and standing water may be present sporadically for hours to days after rainfall events). Surface flow in Spring Canyon percolates into the groundwater to pass beneath road embankments, but has no connectivity to the navigable waters of the Pacific Ocean; therefore, under the revised 2023 definition, it does not qualify as a WOTUS

3.5.1.4 Waters of the State and Wetlands

As analyzed in the 2018 SEA (DAF 2018), the RWQCB previously determined that vegetation management activities conducted in Spring Canyon to minimize impact to nesting migratory birds resulted permanent impacts to 1.12 ac to WOTS. To offset these impacts, the RWQCB required mitigation within a 2.6-ac site in lower Spring Canyon. The DAF began implementing riparian restoration at the site in 2018 and is currently in the sixth year of the mitigation plan.

3.5.1.5 Floodplains

The vegetation management area (discussed above) overlaps the 500-year and 100-year floodplains in Spring Canyon. Under EO 13690, floodplains analyses are required for, at a minimum, 500- and 100-year floodplains. EO 11988 requires federal agencies to reduce the risk of flood loss, minimize the impact of flood on human safety, and to restore and preserve the natural and beneficial values served by floodplains and evaluate alternatives prior to proceeding with federal actions that may affect floodplains.

3.5.2 Environmental Consequences

3.5.2.1 Alternative 1 and 2

3.5.2.1.1 Surface Water

Activities during launch operations would include using hazardous materials and generating wastewater that if not properly controlled and managed could result in an adverse impact to water resources. Best management practices would continue to be implemented to properly manage materials, and to reduce or eliminate project-associated runoff, which reduces the potential for adverse effects.

Wastewater discharges would continue to follow the conditions of the RWQCB letter for Enrollment in the General Waiver of Waste Discharge Requirements for SLC-4E Process Water Discharges to eliminate potential adverse effects to water quality. Any water that remains after launches or stormwater that accumulates within the trench would be tested for contamination. If contamination is encountered, the contents would be pumped out and disposed of per the waiver/permit and state and federal regulations.

Spring Canyon

Potential impacts to Spring Canyon have been described and analyzed in Section 4.5.1 of the 2023 SEA; therefore, surface water resources in Spring Canyon are not considered further in this EA. The DAF will continue to monitor water quality in Spring Canyon as described in the 2023 SEA. If water levels are at a level insufficient to sample, soil sampling would be conducted as outlined in the Biological Opinion (Appendix A).

San Antonio Creek

At maximum cadence, the Proposed Action would use up to 18.6 ac-ft of water per year. This would represent an increase of approximately 0.7 percent of the total annual water usage on VSFB. The U.S. Geological Survey (USGS) estimated this would result in less than a 0.6 percent decrease in base flow at San Antonio Creek if the entire 18.6 ac-ft were extracted from the San Antonio groundwater basin (Cromwell & Faunt 2024). However, the current source for water on VSFB is primarily State Water; therefore, any extraction from San Antonio Creek for the Proposed Action would be negligible. Since VSFB relies primarily on State Water and the amount of annual usage proposed under the Proposed Action is negligible, there would be no measurable impacts to flow rates, hydration periods, or water levels in San Antonio Creek. Therefore, impacts to surface water in San Antonio Creeks under the Proposed Action would not be significant.

Broad Ocean Area

Potential impacts to the broad ocean area during first stage recovery activities have been described and analyzed in Section 4.5.1 of the 2023 SEA. The expanded recovery area would not change the results of any prior analyses. Therefore, surface water resources in the broad ocean area are not considered further in this EA.

3.5.2.1.2 Groundwater

At maximum cadence, the Proposed Action would use up to 18.6 ac-ft of water per year. This would represent an increase of approximately 0.7 percent of the total annual water usage on VSFB. The USGS estimated this would result in less than a 0.6 percent decrease in base flow at San Antonio Creek if the entire 18.6 ac-ft were extracted from the San Antonio groundwater basin (Cromwell & Faunt 2024). However, the current source for water on VSFB is primarily State Water; therefore, any extraction from San Antonio groundwater basin for the Proposed Action would be negligible. Since VSFB relies primarily on State Water and the amount of annual usage under the Proposed Action is negligible there would be no measurable impacts to groundwater water levels in San Antonio groundwater basin or exacerbate water scarcity at VSFB or the surrounding area.

Therefore, the Proposed Action's water usage would be negligible and not contribute in any measurable way to the collective effects of water extraction requirements for all VSFB operations. Thus, impacts to groundwater in the San Antonio Creek Basin under the Proposed Action would not be significant.

3.5.2.1.3 Waters of the United States

None of the aquatic features assessed qualify as WOTUS; therefore, there would be no impacts to WOTUS as a result of implementation of the Proposed Action.

3.5.2.1.4 Waters of the State

To comply with the RWQCB mitigation requirements, the DAF is implementing mitigation in lower Spring Canyon to offset impacts to WOTS from vegetation removal activities in Spring Canyon at a 2:1 ratio within the same drainage (MSRS 2017b). The DAF began implementing riparian restoration at a 2.6 ac restoration site in 2018 and is currently in the sixth year of the mitigation plan. Therefore, impacts to WOTS under the Proposed Action would not be significant.

3.5.2.1.5 Floodplains

Potential impacts to the floodplain have been described and analyzed in Section 4.5.1 of the 2023 SEA and the Proposed Action would not cause any additional impacts beyond what was already considered. Therefore, impacts to floodplains are not considered further in this EA.

3.5.2.1.6 Conclusion

The Proposed Action would implement the best management practices and EPMs described in Appendix L which would protect surface and groundwater from exceeding any federal, State, or local regulatory agencies water quality standards. Wastewater discharges would continue to follow conditions of the

RWQCB letter for Enrollment in the General Waiver of Waste Discharge Requirements for SLC-4E Process Water Discharges that would protect groundwater quality. Therefore, the Proposed Action would not significantly impact water resources.

3.5.2.2 No Action Alternative

Under the No Action Alternative, increased launch cadence on VSFB would not occur, resulting in no impacts on water resources beyond those described in the 2023 SEA.

3.6 Cultural Resources

3.6.1 Affected Environment

Cultural resources encompass a range of sites, properties, and physical resources relating to human activities, society, and cultural institutions. Such resources include past and present expressions of human culture and history in the physical environment, such as prehistoric and historic archaeological sites, structures, objects, and districts that are considered important to a culture or community. Cultural resources also include aspects of the physical environment, namely natural features and biota that are a part of traditional ways of life and practices and are associated with community values and institutions.

The NHPA establishes national policy for protecting significant cultural resources that are considered "historic properties." Historic properties are defined as "any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in the National Register of Historic Places" (NRHP) (36 CFR Part 800.16).

The ROI for cultural resources includes VSFB's regional setting and the specific Proposed Action study area (the Area of Potential Effects [APE]). The cultural resources within the project area are discussed below. The APE of an undertaking is defined as "the geographic area or areas within which an undertaking may directly or indirectly cause alterations in the character or use of historic properties, if any such properties exist" (36 CFR Part 800-16(d)). The APE considers any physical, visual, or auditory effects that the project may have on cultural resources. Since no ground-disturbing or landscape-altering actions are proposed, the APE for the current project is limited to auditory effects and was predicated on vibratory impacts. These auditory effects include noise exceeding 120 dB and sonic booms exceeding 2.0 psf based on previous studies that have determined at which levels structures and archaeological resources could potentially be affected by rocket noise and sonic booms. Sound pressure levels below 120 dB (linear) are considered to have no material effects on structures (Fenton & Methold 2016).

The DAF previously found there would be no potential to cause effects to historic properties to any known historic properties from launches and landings at SLC-4. A discussion of historic properties within that APE is included in the *Final Supplemental Environmental Assessment Falcon 9 Cadence Increase at Vandenberg Space Force Base, California and Offshore landing Locations* (DAF 2023).

3.6.2 Environmental Consequences

3.6.2.1 Alternative 1 and 2

The DAF previously found there would be no potential to cause effects to historic properties to any known historic properties from launches and landings at SLC-4 (Appendix C). Under 36 CFR Part 800.4(d)(1), when the agency finds there are no historic properties present or there are historic properties present but the undertaking will have no effect upon them, the agency makes a no historic properties affected determination. The agency informs the State Historic Preservation Office (SHPO) and any consulting parties of this determination and may proceed if the SHPO concurs with the finding or fails to respond within 30 days. The SHPO did not respond to the DAF's previous "no historic properties affected" determination for launches and landings at SLC-4. Therefore, no further consultation is required.

3.6.2.2 No Action Alternative

Under the No Action Alternative, increased launch cadence on VSFB would not occur, resulting in no impacts on cultural resources beyond those described in the 2023 SEA.

3.7 Coastal Zone Management Act

3.7.1 Affected Environment

The CZMA (16 USC Section 1451, et seq.) is the primary federal law for managing coastal resources. Federal actions that have reasonably foreseeable effects on natural resources or land or water uses in the coastal zone, regardless of the project's location, are required to be consistent, to the maximum extent practicable, with the enforceable policies of federally approved state coastal management programs (16 USC Section 1456; 15 CFR Part 930). Federal agencies submit a CD to the state coastal management program when an action could foreseeably affect coastal resources. If a federal action would not foreseeably affect the coastal zone or coastal resources, then the federal agency may prepare a negative determination (ND) for that action. Neither the DAF nor FAA have established a significance threshold for coastal resources.

The ROI for coastal zone management extends to those coastal resources off VSFB property that may be affected by the Proposed Action, including natural resources, land uses, water uses, public access, and recreation within the California Coastal Zone (CCZ). The CCZ generally extends 1,000 yards inland and up to 3 nm seaward, but may extend up to 5 mi inland for significant coastal estuarine, habitat, and recreational areas and less than 1,000 yards inland in urban areas. SLC-4 is located on VSFB, property which is owned by the U.S. and operated by the DAF as the federal agency with full administrative authority and operational management over the federal property. As defined in Section 304 of the CZMA, the term "coastal zone" does not include "lands the use of which is by law subject solely to the discretion of or which is held in trust by the Federal government, its officers or agents." However, the DAF recognizes that actions outside the coastal zone may affect land or water uses or natural resources in the coastal zone off VSFB and therefore may be subject to the provisions of the CZMA.

In 1998, the USAF received the CCC's concurrence on a CD (CD-049-98) for south Base launch activity. In December 2003, the USAF received concurrence on ND-103-03 for implementing the Falcon 1 launch vehicle program at SLC-3W. In 2005, the USAF received concurrence on ND-088-05 for relocating the Falcon 1 program from SLC-3W to SLC 4. In 2010, the CCC concurred with the USAF on ND-055-10 for modifying SLC-4 infrastructure to meet SpaceX needs to include an anticipated maximum of up to 10 launches per year for Falcon 9 vehicles. In 2014, the CCC issued concurrence on ND-0035-14 for the SpaceX Dragon in flight abort test, constructing a SLC-4W landing pad and a single Falcon 9 rocket launch. In 2015, the USAF received concurrence on ND-0027-15 for 6 Falcon 9 launches per year and land on a barge or at SLC-4W. Even though launches were noted as anticipated to be up to 10 per year, formal consultation with CCC did not occur to increase the launch cadence from 6 to 12 launches. In 2023, the DAF determined that the Proposed Action would not affect and impact coastal uses or resources because measures will be taken to prevent, minimize, and mitigate effects. Therefore, for this Proposed Action the DAF requested CCC concurrence on a ND. The CCC issued concurrence with the ND on 5 May 2023 (ND-0009-23). However, the CCC reopened the ND on 15 December 2023 and issued a request to the DAF to take remedial action for inconsistencies in the project description and coastal zone effects in February 2024. The DAF subsequently submitted a CD to the CCC in March 2024. The CCC provided a conditional concurrence for the CD on 15 August 2024 (CD 0003-24). The DAF submitted a CD to the CCC on 9 July 2024 to address the potential impacts of SpaceX's increased cadence to 50 launches per year at SLC-4.

3.7.2 Environmental Consequences

3.7.2.1 Alternative 1 and 2

VSFB property is statutorily excluded from the coastal zone. Downrange landings would occur outside of state waters, and would not occur within intertidal areas, salt marshes, estuaries, or coral reefs. The Proposed Action does not include any coastal construction nor seafloor disturbing activities. However, effects from launch and landing (e.g., noise, public access restrictions) may occur within the California coastal zone. A detailed analysis of the Proposed Action's potential effects to the California coastal zone is discussed in the CD prepared for the Proposed Action (Appendix D). The DAF determined the Proposed Action was fully consistent with the enforceable policies of the California's approved coastal management plan. The DAF submitted the CD and requested concurrence from the CCC on 9 July 2024. DAF would incorporate measures agreed to for resolution of CCC's 36 launch conditional concurrence into the annual program of 50 launches. On 27 September 2024 the CCC staff published its report, recommending the full Commission vote to concur with the DAF CD. On 10 October 2024, the CCC voted 6-4 to object to the DAF's CD. Under the CZMA and its implementing regulations, the DAF may proceed with the proposed action over a CCC objection if it finds the Proposed Action is fully consistent with the enforceable policies of California's approved coastal management plan. See 15 CFR § 930.43(d)(1)-(2). The DAF will notify the CCC if it intends to proceed over the objection as required by 15 CFR § 930.43(e).

3.7.2.2 No Action Alternative

Under the No Action Alternative, increased launch cadence on VSFB would not occur, resulting in no impacts on coastal resources beyond those described in the 2023 SEA.

3.8 Department of Transportation Section 4(f)

3.8.1 Affected Environment

Section 4(f) of the DOT Act of 1966 (now codified at 49 USC Section 303), protects significant publicly owned parks, recreational areas, wildlife and waterfowl refuges, and public and private historic sites listed or eligible for listing on the NRHP. Section 4(f) provides that the Secretary of Transportation may approve a transportation program or project requiring the use of publicly owned land of a public park, recreation area, or wildlife and waterfowl refuge of national, State, or local significance, or land of an historic site of national, State, or local significance, only if there is no feasible and prudent alternative to the use of such land and the program or project includes all possible planning to minimize harm resulting from the use.

Procedural requirements for complying with Section 4(f) are set forth in DOT Order 5610.1D, *Procedures for Considering Environmental Impacts*. The FAA also uses Federal Highway Administration (FWHA) regulations (23 CFR Part 774) and FHWA guidance (e.g., Section 4(f) Policy Paper) when assessing potential impacts on Section 4(f) properties. These requirements are not binding to the FAA; however, the FAA may use them as guidance to the extent relevant to FAA projects.

The ROI for Section 4(f) is defined by launch and landing rocket engine noise, sonic booms, and potential debris impact corridors associated with launch trajectories. Potential Section 4(f) properties within the ROI would not receive rocket engine noise exceeding 100 dBA L_{max} (Figure 3.8-1). However, Point Sal State Park, Wall Beach, County of Santa Barbara Ocean Beach Park, Surf Beach, La Purisima Mission State Park, Miguelito Park, Jalama Beach County Park, Gaviota State Beach, Refugio State Beach, and El Capitan State Beach may occasionally receive sonic booms of 1 psf or greater (Figure 3.8-2).

FAA identified three Section 4(f) properties that might be subject to evacuation during launch operations: Jalama Beach County Park, Surf Beach, and County of Santa Barbara Ocean Beach Park. These parks offer various recreational options, including picnicking, surfing, whale watching, bird watching, nature photography, and fishing with peak attendance in summer and on holidays. Jalama Beach County Park also offers camping.

3.8.2 Environmental Consequences

Impacts on Section 4(f) properties would be significant if the FAA's Proposed Action involves more than a *de minimis* physical *use* of a Section 4(f) resource or constitutes a *constructive use* based on an FAA determination that the project would substantially impair the Section 4(f) resource. The concept of *constructive use* is that a project that does not physically use land in a park, for example, may still, by means of noise, air pollution, water pollution, or other impacts, dissipate its aesthetic value, harm its wildlife, restrict its access, and take it in every practical sense. *Constructive use* occurs when the impacts of a project on a Section 4(f) property are so severe that the activities, features, or attributes that qualify the property for protection under Section 4(f) are substantially impaired. Substantial impairment occurs only when the protected activities, features, or attributes of the Section 4(f) property that contribute to its significance or enjoyment are substantially diminished. This means that the value of the Section 4(f) property, in terms of its prior significance and enjoyment, is substantially reduced or lost. For example, noise would need to be at levels high enough to have negative consequences of a substantial nature that amount to a taking of a park or portion of a park for transportation purposes.

3.8.2.1 Alternative 1 and 2

The Proposed Action does not include any construction activities within, or actual physical taking of, a Section 4(f) property through the purchase of land or a permanent easement, physical occupation of a portion or all of Section 4(f) property, or alteration of structures or facilities on Section 4(f) property. Impacts to Jalama Beach County Park would result from occasional temporary evacuation of the public during launch/landing events. Surf Beach and County of Santa Barbara Ocean Beach Park would only be closed during SLC-4 landing events up to 12 times per year.

SLD 30 Range Safety would individually review launch trajectories for each mission to determine what areas would be affected since the hazard risk analysis is unique to each vehicle, history of reliability, and mission trajectory. If necessary for the safety of park visitors, the County Parks Department and the County Sheriff would evacuate the Jalama Beach County Park upon request from SLD 30 and under agreement between DAF and Santa Barbara County. The Proposed Action would comply with these procedures. Given the formal evacuation agreement in place and the temporary nature of the closure, implementation of the Proposed Action under Alternative 1 and 2 would not substantially diminish the protected activities, features, or attributes of any Section 4(f) properties and therefore would not result in substantial impairment of the properties.

All potential Section 4(f) properties in the ROI would experience sound levels less than 100 dBA L_{max} during launches, landings, and static fire events (Figure 3.8-1). First stage and booster landings at SLC-4 could create sonic booms between approximately 1.0 and 3.0 psf at Section 4(f) properties (Figure 3.8-2). However, there is no reasonable potential for launch-related noise to impair the majority of the Section 4(f) properties within the ROI because a quiet setting is not part of the significant attributes or features qualifying these properties for protection under Section 4(f).

Peak overpressures in the Channel Islands National Park may peak at 7.0 psf, across a very focused geographic area over the islands, although typical levels are 3 psf or less and vary in impact locations with every launch, mostly impacting the ocean (see Section 3.2.2). Although launch trajectories overfly the Channel Islands National Park, impacts would not be so severe that the activities, features, or attributes that qualify the Channel Island National Park for protection under Section 4(f) are substantially impaired.

Both rocket engine noise and sonic booms are classified as short-duration, intermittent events. Given the short duration of increased sound levels during a launch and the small area impacted, the FAA has preliminarily determined that noise generated during launches or landing would not substantially diminish the protected activities, features, or attributes of any of the potential Section 4(f) properties and therefore would not result in a *constructive use* of any potential Section 4(f) property. Additionally, given the history of beach and park closures for launches at VSFB, the formal evacuation agreement in place, and the temporary nature of the closures, the FAA has preliminarily determined that the Proposed Action would not substantially diminish the protected activities, features, or attributes of any of the potential Section 4(f) properties and therefore would not result in a *constructive use* of any Section 4(f) property. Therefore, implementation of the Proposed Action under Alternative 1 would not result in significant impacts to resources protected under Section 4(f) of the DOT Act.

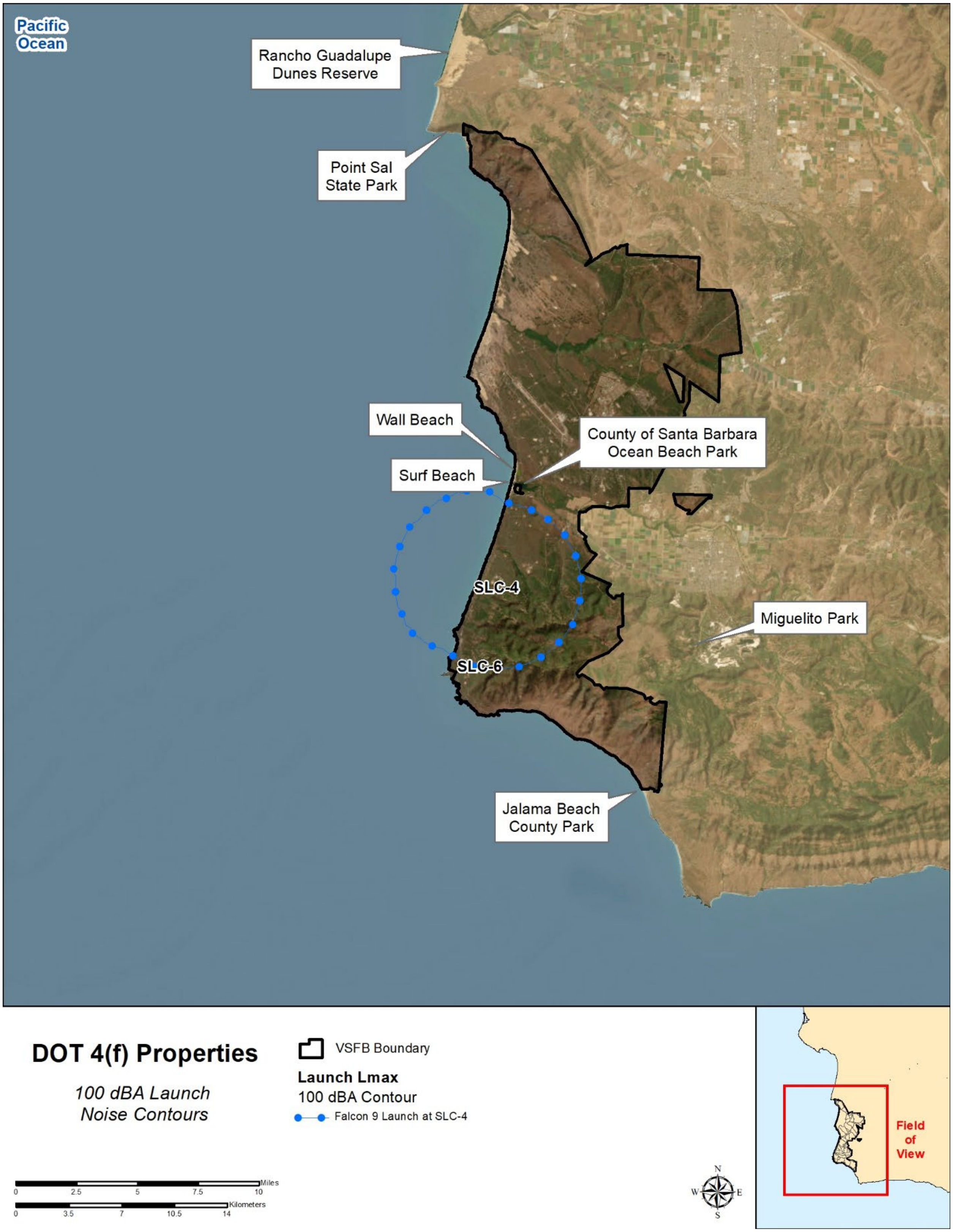

Figure 3.8-1. Potential DOT 4(f) properties and launch engine noise

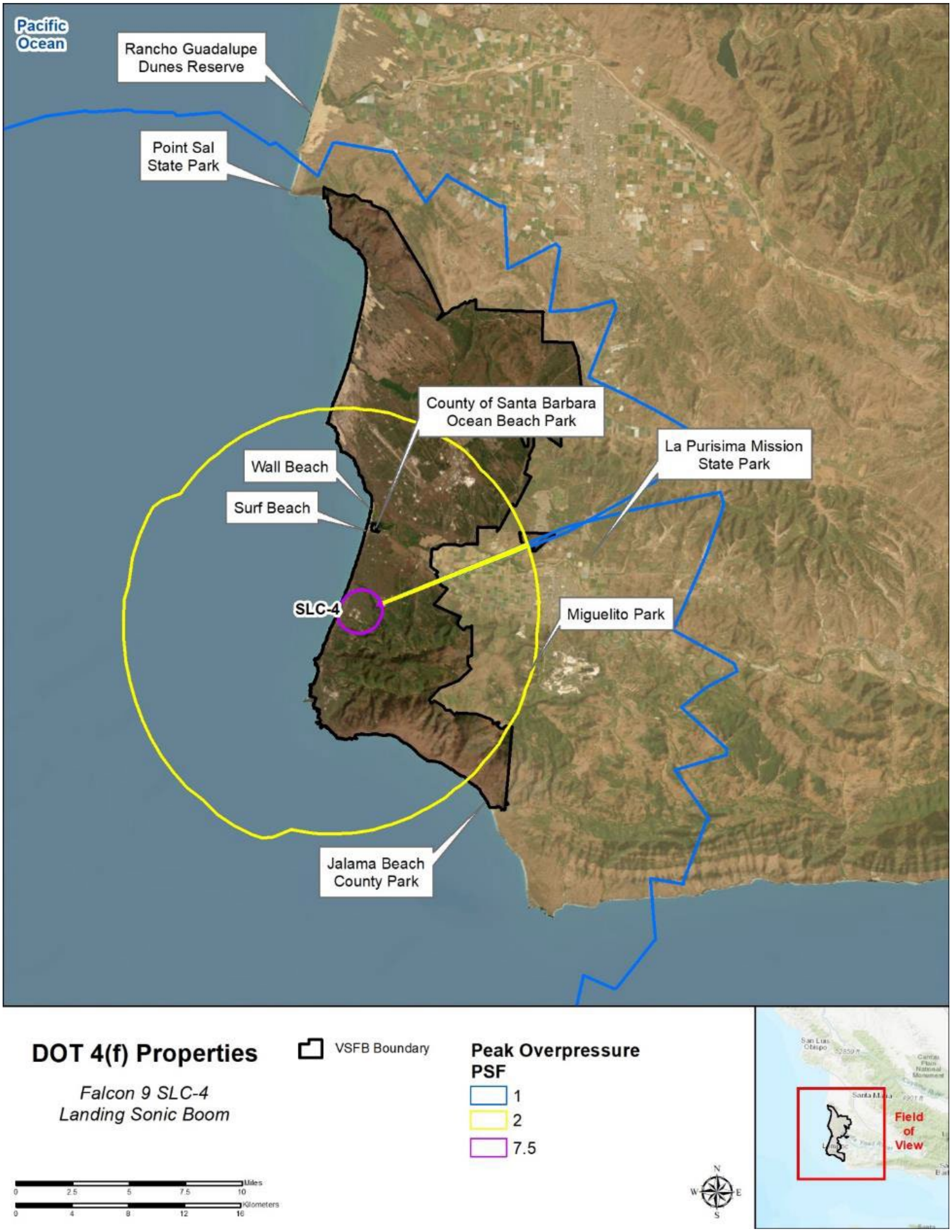

Figure 3.8-2. Potential DOT 4(f) properties and sonic boom for Falcon 9 first stage landing at SLC-4W

3.8.2.2 No Action Alternative

Under the No Action Alternative, increased launch cadence on VSFB would not occur, resulting in no impacts on Section 4(f) properties beyond those described in the 2023 SEA.

3.9 Utilities

3.9.1 Affected Environment

The ROI includes SLC-4 and south VSFB utilities (e.g., communications, electricity, domestic water supply, and domestic wastewater). Communications infrastructure at SLC-4 is provided by existing commercial fiber lines. Electrical infrastructure is primarily provided from the Pacific Gas and Electric Company substation north of VSFB, powered by the Diablo Canyon nuclear power plant. In 2023, SpaceX used 6.8 million kilowatt-hour (kW-hr) of electricity at SLC-4 and 1.6 million kW-hr at Building 398 (SpaceX 2024). VSFB primarily relies on State Water; however, during annual maintenance that lasts two to three weeks, VSFB utilizes four water wells in the San Antonio Creek Basin. Domestic wastewater at SLC-4 is managed by existing septic sewer systems. The GAO identified VSFB as vulnerable to water-scarcity issues in 2019 (GAO 2019).

3.9.2 Environmental Consequences

Impacts associated with utilities are related to changes in the supply (also referred to as capacity) or demand for a particular resource. As long as the capacity of a particular utility is higher than the demand for that resource, no impact occurs. However, if the demand exceeds the capacity or if the demand is increased beyond the resource's projected rate of increase, an impact would occur, and the significance of the impact is determined based on the degree to which the capacity is strained.

3.9.2.1 Alternative 1 and 2

Existing lines would provide communication and electricity to SpaceX facilities at SLC-4. The Proposed Action would add approximately 400 personnel, increase launch cadence at SLC-4, which would increase the demand for electricity, water, and the septic system. Electricity is primarily provided to VSFB from the Pacific Gas and Electric Company substation north of VSFB, powered by the Diablo Canyon nuclear power plant, and is expected to adequately support the proposed increase in annual cadence. The existing power infrastructure is sufficient to supply this electricity to SLC-4. During power outages, SpaceX would rely on existing portable backup generators for electricity for SLC-4. The existing communication system is sufficient to support increases in personnel and launch capacity.

At maximum cadence, the Proposed Action under would use up to 18.6 ac-ft of water per year, including increased water use for personnel and operations. The existing water systems are adequate to support increased water use, as discussed in Section 3.5.2.

The existing septic sewer systems at SLC-4 has sufficient capacity to support the increase in domestic wastewater associated with the Proposed Action (Pernell 2024). The septic system at Building 398 has planned improvements independent of the Proposed Action, thus would be able to support increased personnel use. Therefore, there would be no need to upgrade current sewer systems as a result of implementation of the Proposed Action and impacts on the domestic wastewater system would be negligible.

3.9.2.2 No Action Alternative

Under the No Action Alternative, increased launch cadence on VSFB would not occur, resulting in no impacts on utilities beyond those described in the 2023 SEA.

3.10 Socioeconomics

3.10.1 Affected Environment

Socioeconomic resources include the population, income, employment, and housing conditions of a community or affected environment. VSFB has a large effect on population and employment in northern Santa Barbara County, which encompasses Vandenberg Village, the City of Lompoc, the unincorporated area north of Lompoc, the Santa Maria Valley, and portions of the Santa Ynez Valley. The full economic impact of VSFB on the surrounding communities and the state of California is significant (over $1.75 billion/year). VSFB directly contributes more than $500 million each year to the economies of Santa Barbara County and California and is the second largest employer in Santa Barbara County (6,800 employees as of 2014), including 2,924 military personnel, 1,143 civil servants, and 2,822 non-appropriated fund, contractor, and private business personnel (USAF 2020).

Southern California's west coast is a leading recreational and commercial fishing area. Commercial fishing off the coast of VSFB is largely conducted by vessels from the Santa Barbara Harbor, Port San Luis, and Morro Bay Harbor. Fishing in areas potentially affected by SpaceX VSFB launches is limited compared to other areas but is valuable for select species. In 2023, area overflown by SpaceX's potential azimuths landed fish with total value of $18,037,773, or 11.2% of the value of the state's total landings (CDFW 2023).

In 2019, the U.S. Census Bureau estimated the Santa Barbara County population at 444,829 people. Santa Maria and Lompoc, with 106,224 and 43,232 residents respectively (U.S. Census Bureau 2019), are the first and third largest cities in the County (California Department of Finance 2022). The Bureau of Labor Statistics reported August 2021 results for the Santa Barbara-Santa Maria area of 208,600 total civilians employed. Of those employed, there were approximately 184,800 non-agricultural wage and salary employments. The August 2021 unemployment rate of the area was approximately 5.5 percent, below the state average of 7.5 percent and above national average of 5.2 percent (Bureau of Labor Statistics 2021).

As discussed in Appendix I (Dudek 2024), every eight years the State of California determines the anticipated number of housing units needed in each region across California. The methodology for determining the housing need considers factors such as the makeup and condition of the existing housing stock, existing and forecasted jobs, the projected population, and the availability of housing. Specifically, the State allocates the housing need by region and regional agencies work with jurisdictions to develop a methodology for divvying up the allocated housing need per jurisdiction. As determined by the State, the Santa Barbara County Association of Governments (SBCAG), which is the Metropolitan Planning Organization responsible for regional planning activities for all incorporated and unincorporated areas in Santa Barbara County, has an anticipated housing need of 24,856 additional housing units to be built between 2023-2031. SBCAG's Regional Housing Needs Allocation (RHNA) Plan establishes the methodology for allocating shares of the 24,856 needed housing units between each local government in the region. SBCAG's RHNA Plan relies on SBCAG's Regional Growth Forecast (RGF), which serves as a tool for long range regional planning. Specifically, the RGF provides input for the State Department of Housing and Community Development RHNA for the Santa Barbara County region.

The RGF captures existing and projected population, housing, and job growth for various industries in Santa Barbara County, its eight incorporated cities, and its major economic and demographic regions (i.e. VSFB), through 2050. Because the RGF forms the basis of the RHNA, job growth for the 2023-2031 RHNA projection period in all job industries is reflected in the calculation of the RHNA. Further, the RGF specifically projects anticipated employment at VSFB. In 2017, VSFB supplied an estimated amount of 6,250 jobs, accounting for about 3-percent of the region's total jobs. The RGF projects a total of 850 new jobs to be added in VSFB between 2017 and 2030, increasing the total to 7,100 jobs by 2030. The increase of 850 new jobs at the VSFB falls within SBCAG's RHNA Plan projection period of 2023-2031. This job growth at VSFB is captured by the SBCAG RGF and has been used to help determine and allocate housing needs in the region through the methodology used in the RHNA Plan. SBCAG's RHNA Plan divides the region into two subareas, the South Coast Housing Market Area and the North County Housing Market Area. The North County Housing Market Area includes the cities of Buellton, Guadalupe, Lompoc, Santa Maria, and Solvang, as well as the unincorporated areas of Orcutt, Guadalupe, Cuyama Valley, Lompoc Valley, and Santa Ynez within the jurisdiction of the County. Given the proximity to the base, many off-base employees of VSFB are likely to reside in the North County Housing Market Area. SBCAG's RHNA Plan has allocated portions of the regional housing need to each local jurisdiction in the region, including those in the North County Housing Market Area. Each of these jurisdictions has identified capacity to accommodate its housing need, demonstrating that there are sufficient development opportunities to meet the housing need.

IAW State law, local governments must demonstrate in their General Plan Housing Elements how they will accommodate their share of the regional housing need by identifying sites that are zoned for housing and can reasonably accommodate housing development. It should be noted that jurisdictions are only responsible for creating opportunities for the private market to build units specified in their RHNA and are not responsible for the actual construction of such units. The County's RHNA share is 5,664 total units for the 2023-2031 planning period. The County has divided its housing need of 5,664 into two subregions, the South Coast subregion and the North County subregion. Nearly three-quarters of the housing need (4,142 units) have been allocated to the South Coast subregion of the County, while the rest (1,522) were allocated to the North County subregion. Factoring in all vacant sites, future accessory dwelling unit development, pending projects, County-owned sites, and potential site rezones, the County's Housing Element identifies capacity for 13,986 units, far exceeding the total housing need. Of the County's identified housing capacity, capacity for 4,991 units is identified in the North County subregion. VSFB is located in the County's North County subregion and likely employees more households in the North County subregion than the South Coast subregion.

The City of Lompoc's housing need for the 2023-2031 planning period is 2,248 units. Their Housing Element identifies capacity through planned and approved projects, projected accessory dwelling unit development, and vacant and underutilized sites. Their total identified capacity is 2,407 units, an additional 7-percent beyond their housing need. The City of Santa Maria is the most populous city in the North County Housing Market Area and has a housing need of 5,418 units for the 2023-2031 planning period. The City of Santa Maria's Housing Element identifies capacity to accommodate 5,819 new housing units, which is 401 units beyond their housing need. Other cities in the North County Housing Market

Area, including Buellton, Guadalupe, and Solvang were allocated much fewer housing units due to their size. Buellton's capacity of 761 units, which includes both built and potential units, exceeds their housing need of 165 new housing units for the 2023-2031 period. Solvang's housing need for the same period is 191 housing units and their Housing Element identifies capacity for 343 units, which is 128 units beyond their need. The City of Guadalupe's Housing Element identified housing need is 431 new housing units for the same period, but the housing capacity is currently unknown as the City is in process of updating its housing element. If the City of Guadalupe is unable to identify adequate housing capacity, they are required by State law to rezone sites to ensure that adequate capacity will be made available to accommodate the entirety of the housing need.

3.10.2 Environmental Consequences

3.10.2.1 Alternative 1 and 2

The public's safety during launch operations is of upmost importance to DAF, FAA, USCG, and SpaceX, which includes the protection of maritime users near the launch vehicle's flight trajectory. The USCG notifies the public of the maritime hazard upon request by the range authority or by the launch operator if a Letter of Intent has been signed by USCG and SpaceX. As discussed in detail in Section 3.12, the USCG issues various types of NOTMARs that notify the public of the time and location of potential hazardous operations and do not explicitly prohibit vessels from entering the identified areas. FAA is also required to notify the public of all maritime hazard areas for each launch. If the risk, as calculated by SLD 30, within a portion of the maritime hazard area exceeds a threshold determined by the FAA, access to this smaller area, known as the "surveillance area" may be restricted in order for launch to be allowed to proceed.

Due to Falcon's reliability, SpaceX's surveillance areas for launches from VSFB have minimal impacts to maritime activities. For many missions, this closure area does not even leave land. Accordingly, only a small subset of fishing blocks within the vicinity of VSFB have the potential to be closed by each launch and for a relatively short period of time. The area within the hazard area, but not closed to vessel traffic, is approximately two blocks wide along each given trajectory. The DAF and SpaceX are committed to maintaining communication with fishermen to avoid and minimize any potential impacts to this industry, as discussed in detail in Appendix I. SpaceX plans to add up to 400 permanent staff over time at VSFB to support the Proposed Action. This increase in permanent personnel is a fraction of the civilian workforce of VSFB and Santa Barbara County and would not be expected to alter the existing levels of service for housing and social services on VSFB and the surrounding communities. The increase in personnel is expected to occur over time and SpaceX expects to hire a mix of local and non-local people. The Military Housing Office and VSFB leadership have been actively engaged in meeting with developers and local officials to inform them of housing needs for the base in the hopes it will encourage future housing development to address both current and future housing needs for both the local communities and the base.

A Housing Impact Study was completed for the Proposed Action (Appendix I) assessing the proposed job growth through the lens of regional housing need and available capacity to accommodate needed housing. As indicated in Table 3.10-1, all jurisdictions in the North County Housing Market Area with an approved housing element for the 2023-2031 planning period have identified adequate housing capacity that not only meets but exceeds the identified housing need. The County's North County subregion and Buellton in particular have identified housing capacity that is more than triple and quadruple the respective housing needs. In general, the North County Housing Market Area has more than enough housing capacity to meet the housing need. Not only have these jurisdictions provided capacity that captures expected growth at VSFB, as identified by the SBCAG RHNA Plan, but the jurisdictions that house the largest numbers of those employed at VSFB have capacity well beyond the housing need.

Table 3.10-1. Housing Capacity in North County Housing Market Area

Jurisdiction[1]	Total RHNA	Total Identified Capacity	Surplus	% of RHNA Planned
County of Santa Barbara - North County Subregion	1,522	4,991	3,469	327.9%
Lompoc	2,248	2,407	159	107.1%
Santa Maria	5,418	5,819	401	107.4%
Buellton	165	761	596	461.2%
Solvang	191	343	152	179.6%
Total	**9,544**	**13,321**	**4,777**	**139.6%**

[1] The City of Guadalupe is not included in this table since it has not updated its housing element to reflect the 6th Cycle RHNA.

The SBCAG RHNA Plan considers an anticipated growth at VSFB of 850 new jobs by 2030 in the determination of the housing need. Further, local jurisdictions surrounding the VSFB have identified adequate housing capacity to meet and far exceed the 2023-2031 housing need. The anticipated increase of 400 new permanent staff roles needed to support the Project will not have a housing impact beyond the Santa Barbara County existing and projected housing need, and further will not create a housing need beyond identified capacity. Additionally, depending on the proportion of local people hired, the need for housing new staff moving into the region from other areas would further decrease. While the Proposed Action would not significantly affect the demand for local housing and the need for social services and support facilities, the addition of added economic activity would result in a small but positive impact to the local economy. The indirect effects of material purchases and sub-contract labor force growth would also be a positive impact.

Potential socioeconomic impacts from re-routing aircraft due to commercial space operations would be similar to re-rerouting aircraft for other reasons (e.g., weather, runway closures, wildfires, military exercises, etc.). These include additional airline operating costs for increased flight distances and times resulting from re-routing aircraft and increased passenger costs as a result of impacted passenger travel, including time lost from delayed flights, flight cancellations, and missed connections. Alternatively, restricting or preventing a launch event would have socioeconomic impacts on SpaceX, commercial payload providers, and consumers of payload services. Operations would not result in closing any public airport or so severely restrict using surrounding airspace to prevent access to an airport for extended time. Given existing airspace closures for SpaceX operations are temporary and the FAA's previous analyses related to the NAS have concluded minor or minimal impacts on the NAS from commercial space launches, the FAA does not expect airspace closures would result in significant socioeconomic impacts. Local air traffic controls would coordinate with airports and aircraft operators to minimize launch operations effects on airport traffic flows, as well as traffic flows in en-route airspace. Therefore, the Proposed Action would not generate negative socioeconomic impacts on the region and would generate a small positive impact.

3.10.2.2 No Action Alternative

Under the No Action Alternative, increased launch cadence on VSFB would not occur, resulting in no impacts on socioeconomics beyond those described in the 2023 SEA.

3.11 Transportation

3.11.1 Affected Environment

The ROI for transportation includes railway, highway, arterial, and local roads that provide service to VSFB, the surrounding area, and the ROI. Existing roadway conditions are evaluated based on roadway capacity and traffic volume. The capacity reflects the ability of the network to serve the traffic demand of a roadway and depends on the roadway width, number of lanes, intersection control, and other physical factors.

VSFB is a federal military installation located approximately 5 mi west of the City of Lompoc. The main access route is Highway (Hwy) 101, a coastal four-lane divided freeway connecting Northern California to Southern California. Hwy 1, State Route (SR) 135, and SR 246 (Ocean Avenue) connect Hwy 101 to VSFB. When used with Hwy 101, SR 246, provides access to Lompoc to the east, and Santa Barbara to the southeast. SR 135 and SR 246 are primarily two-lane highways with four-lane expressway portions. The Caltrans traffic count for SR 246 at the western Lompoc city limit, the closest count to south VSFB, indicated an annual average daily traffic volume of 3,100 vehicles per day (Caltrans 2024), which is well below the capacity for a two-lane highway.

Most of VSFB can only be accessed by authorized military personnel and their families, Base civilian employees with approved identification, visitors with pre-approved authorization, and authorized contractors. There is no public access to the roadways within the ROI. Most roads on VSFB are in good operating condition or better with zero to minor, tolerable delays experienced by motorists. The ROI is located on south VSFB and is accessible by paved roads from the Solvang Gate. Project personnel would access the location by entering VSFB through the Solvang Gate from West Ocean Avenue, travel south on Arguello Road, west on Bear Creek Road, south on Coast Road, and to the destination on Kelp Road (Figure 3.11-1). There are no readily accessible alternate routes to SLC-4, although Surf Road would be a suitable egress road to the east during emergencies. Oversized transports utilize the Coast Gate rather than Solvang Gate to reduce impacts to vehicular traffic on south VSFB.

The Union Pacific Railroad (UPRR) operates a railway line that runs through VSFB and under the proposed flight path of the Falcon 9 launch vehicle. Up to 12 freight trains and 6 Amtrak passenger lines travel through VSFB daily (Envicom Corporation 2012; Amtrak 2022). Trains that would pass through a launch vehicle's flight path from VSFB are temporarily stopped at safety hold points during launches to reduce potential risk to people and property. The self-propelled modular transporter (i.e. the truck used to transport the first-stage booster) route from the VSFB Harbor to SLC-4 crosses the UPRR railway at the intersection of Tow Road and Coast Road (Figure 3.11-1).

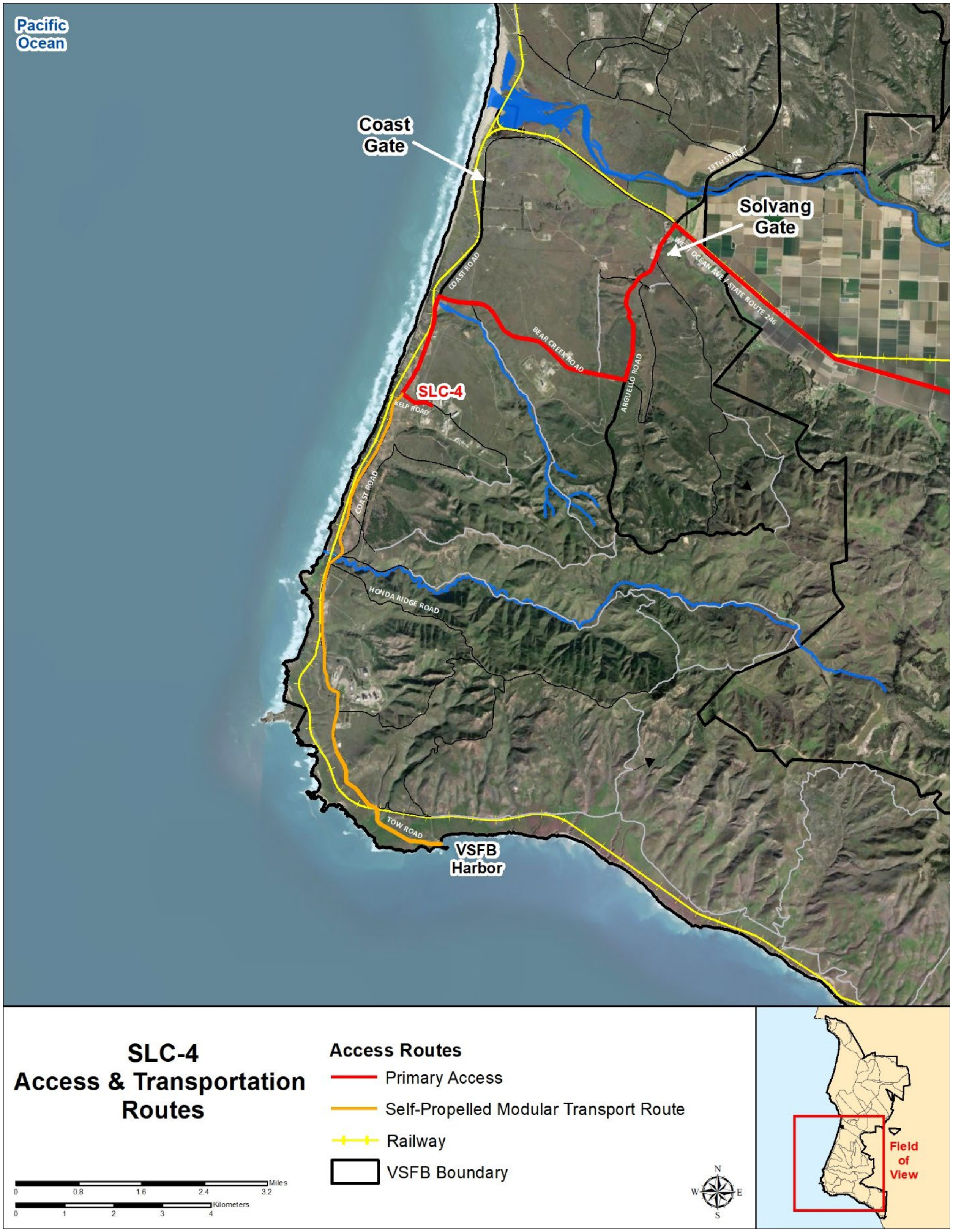

Figure 3.11-1. Main Access and Transportation Routes Associated with the Proposed Action

3.11.2 Environmental Consequences

3.11.2.1 Alternative 1 and 2

Given the low traffic volumes projected from increased operations, good level of service currently experienced on the roadways that would be affected by project activities on VSFB and nearby, and the relatively small increase in daily vehicle traffic that the Proposed Action would generate, no adverse effects to capacity would occur in the ROI roadways. Additionally, increased personnel would be anticipated to be working in shifts thus there is no anticipated adverse impacts to peak hour traffic.

Increased vehicle activity affects the integrity of roadway sections by increasing the flexures of the pavement. The design life for asphalt pavement, generally selected as either 10 or 20 years, drives engineering specifications for the road based upon the strength of the base soil and estimated number of truck trips that are expected during the design life of the pavement. If the number of truck trips is increased, the life of the pavement is shortened. While the current pavement condition on all affected roads is fair to good, added project-related vehicle traffic could cause faster-than-estimated pavement surface deterioration and require additional maintenance. Although an adverse effect, it would not be considered significant given that the number of vehicle trips per day anticipated from the Proposed Action is not high and the speed of pavement deterioration is influenced by more than truck traffic.

Increased oversized load transport is not expected to have a significant impact on operations on south VSFB, as these transports would utilize Coast Gate rather than Solvang Gate. SpaceX will continue to coordinate with SLD 30 to reduce operational impacts on VSFB staff and resources to support and conduct these operations.

Trains that would pass through a launch vehicle flight path from VSFB would be temporarily stopped at safety hold points during launches to reduce potential risk to people and property. SLD 30 2nd Range Operations Squadron (2 ROPS/DON), notifies a dedicated UPRR point of contact (POC) of launch date, times, and train hold point locations, typically 10 days before launch. At approximately 3 days prior to launch, UPRR's POC provides 2 ROPS/DON a schedule of impacted trains and in collaboration discusses if the trains must hold or can continue through. At 3 hours before launch, 2 ROPS/DON establishes phone communication with the UPRR POC to provide updates to the train schedule. After a launch has been completed 2 ROPS/DON notifies the UPRR POC that trains may continue on the route. The UPRR POC is on standby during each launch for any notifications needed for a launch anomaly that may impact the railroad track system. UPRR attempts to adjust schedules to avoid train delays due to launches; however, launch windows are typically minimal (typically instantaneous or several minutes) and during longer launch delays 2 ROPS/DON communicates with the UPRR POC to allow trains to move through the affected area; thereby minimizing potential impacts to train schedules.

The self-propelled modular transporter would need to cross the UPRR railway at the Tow Road and Coast Road intersection. The SLD 30 easement to cross the railway (DACA-09-5-82-35) states that crossing "will not obstruct or interfere with the passage of Railroad trains." The UPRR requires a UPRR employee to contact approaching train engineers via radio to alert the engineer of the Tow Road crossing. SpaceX would coordinate with the UPRR to ensure easement proper procedures are followed for each railway crossing event.

Therefore, the Proposed Action will not create any significant impacts to transportation.

3.11.2.2 No Action Alternative

Under the No Action Alternative, increased launch cadence on VSFB would not occur, resulting in no impacts to transportation resources beyond those described in the 2023 SEA.

3.12 Human Health and Safety

3.12.1 Affected Environment

The ROI for Human Health and Safety resources includes all areas where activities associated with the Proposed Action may impact human health and safety. This includes SLC-4, where current launch cadence would increase and workers would potentially be exposed to conditions that could adversely impact their health and safety, and all areas potentially impacted during launch operations. All VSFB activities are subject to Federal OSHA, Air Force Occupational Safety and Health (AFOSH), or California OSHA regulations and procedures requirements. SLC-4 is within a federal exclusive jurisdiction area; however, commercial entities may also comply with California OSHA and/or AFOSH requirements. The affected environment for Human Health and Safety includes all established regulations to minimize or eliminate potential risk to the general public and personnel involved in the proposed project. The Proposed Action would not involve construction activities.

Hazards associated with some past and present mission activities and operations on VSFB can limit locations where projects can be sited to ensure the health and safety of workers. Hazard zones and areas have been established on VSFB to protect workers from various hazards. Because of the existence of these zones and areas, personnel at SLC-4 may be exposed to hazardous materials and hazardous waste. In addition to these more obvious risks to human health and safety, the following physical features may be present nearby the Proposed Action and may adversely impact site personnel’s health and safety:

- Physical hazards, including road traffic, confined spaces, holes and ditches, uneven terrain, sharp or protruding objects, slippery soils or mud, unstable ground, and falling equipment/objects (e.g., nuts, bolts, equipment, boxes, containers, and other miscellaneous light-construction tools and materials).
- Biological hazards such as animals and plants (ticks, black widow spiders, rattlesnakes, and poison oak) and disease vectors (ticks, rodents, and common contagions).

3.12.1.1 General Public and On-Base Personnel Safety

The SLD 30 Safety Office is responsible for ensuring launch support personnel and the general public are safe from all launch operations and potential emergency public health risks as defined in Air Force Instruction (AFI) 91-202 (U.S. Air Force Mishap Prevention Program), Department of Defense Instruction (DODI) 6055.17, and 6200.03. AFI 10-2501 and AFI 10-2519 provide further guidance for DAF emergency management readiness and response to public health and safety issues. The SLD 30 Safety Office personnel would assess proposed mission profiles to ensure public safety criteria are met. Their evaluation would assess hazards associated with debris, toxics, and blast distant focusing overpressure for a normal launch. All launch, high-risk offshore, and airspace areas would be controlled and monitored to ensure public safety during launch operations. Launch day meteorological conditions would also be accounted for to ensure compliance with acceptable risk criteria.

3.12.1.2 Debris Impact Corridors

All VSFB launch programs are required to establish debris impact corridors as a part of their program's safety review in case of a launch anomaly that requires flight termination (14 USC Section 504, 14 CRF Part 450.147). When any launch, including a commercial launch, is scheduled to take place from VSFB, the SLD 30, Launch Safety (SLD 30/SEL) notifies the 2nd Range Operations Squadron (2 ROPS) of the associated hazard areas. SpaceX performs a debris analysis for the Falcon 9 before launching. SLD 30/SEL reviews and approves these analyses prior to authorizing any launch activities. Impact debris corridors would be established off the Santa Barbara County coast to meet security requirements and reduce hazards to persons and property during launch activities. Based on a mission's specific trajectory, specific debris impact areas would be determined for each launch. Once SLD 30/SEL notifies the 2 ROPS of hazard areas, 2 ROPS notifies the FAA so that appropriate airspace restrictions are in place during launches.

In addition, SLD 30 and USCG District Eleven review each SpaceX trajectory IAW the MOA (Appendix J) to develop risk plots and other materials for 14 CFR Part 450 compliance, including: (1) operating area and impact locations, (2) maritime vessel risk assessment and Ec/Pc plots, and (3) all materials necessary to develop a NOTMAR. The USCG would be responsible for issuing NOTMARs that provide hazard area locations before each mission event with ocean impacts. A NOTMAR provides notice of temporary changes in conditions or hazards in navigable waterways with maritime traffic to assist in mitigating risks for dangers associated with waterway users. This tool provides both an established and reliable line of communication with the maritime public. The NOTMAR would include the operations dates and times and coordinates of the hazardous operation area. The USCG issues a NOTMARs 30 days before launches from VSFB that defines the times and locations of avoidance areas related to launch activities. Local NOTMARs are broadcast via radio, posted in harbors along the coast, and published weekly by the USCG.

Offshore oil rigs located west of VSFB also have evacuation or shelter-in-place procedures in place for use during launch operations. The 2 ROPS notifies the Bureau of Safety and Environmental Enforcement to notify oil rig personnel of launch operations.

On south VSFB, the UPRR track passes approximately 0.5 mi west of SLC-4 and would be overflown by the launch vehicles. To reduce potential risk to people and property, railroad schedules and close coordination between train engineers and VSFB personnel would ensure that trains are never overflown. SLD 30/SEL defines appropriate railroad mile -markers to 2 ROPS, who coordinates with the Manager Road Operations to ensure trains are kept clear of debris area.

3.12.1.3 Security and Anti-Terrorism

Site security requirements, including those for security lighting and intrusion detection, are part of the requirements integral to launch program safety and detailed in DOD Manual 5220.22-M. Minimum Antiterrorism Standards for Buildings 4-010-01 was issued in July 2022 under the authority of DOD Instruction 2000.16, Antiterrorism Standards. This guidance requires DOD components to adopt and adhere to common definitions, criteria, and minimum construction standards for building to mitigate vulnerabilities and terrorist threats.

3.12.1.4 Existing Noise Environment

For a detailed description of noise as it relates to the Proposed Action, please see Section 3.2 and Appendix F. In addition to the information provided in that section, on VSFB, general ambient L_{eq1H} (the continuous sound level that would contain the same acoustical energy for 1 hour as the fluctuating sound levels during the same period) measurements have been found to range from around 35 to 60 dB (Thorson et al. 2001). Noise associated with launch and static fire events would be short term (seconds to minutes).

3.12.2 Environmental Consequences

An impact to Human Health and Safety would be considered significant if it were to create a potential public health hazard or to involve the improper use, production, or disposal of materials that pose a hazard to people in the affected area. An impact would also be considered significant if project activities were to pose a serious risk of fire, especially wildland fires, or were to involve potential obstruction of emergency response or evacuation routes in and around the project area.

3.12.2.1 Alternative 1 and 2

3.12.2.1.1 Launch Operations

Base personnel and general public safety during Falcon 9 launches would be ensured by federal emergency management readiness and response protocols detailed in Section 3.12.1.2. SLD 30 Range Safety would individually review launch trajectories to determine what areas would be affected since the hazard risk analysis is unique to each vehicle, history of reliability, and mission trajectory. The USCG would review and advise SLD 30 on all launch and reentry site evaluation risk assessments with focus on vessel navigation safety. The USCG supports SLD 30 with early warning communication to the maritime industry with NOTMAR, as discussed in Section 1.5, to assist with maritime safety and space operational review that have a maritime nexus. USCG District Eleven would evaluate SpaceX and SLD 30 navigation risk assessments with launch and reentry activities associated with commercial and recreational vessels on the high seas off the California Coast. The USCG evaluates every launch and reentry activity for risk to waterway users and the environment under this process. Security and anti-terrorism requirements outlined in Section 3.12.1.3 would provide launch program safety compliance.

To issue a Vehicle Operator License, the FAA requires all launch and reentry operations to comply with the necessary notification requirements, including issuance of NOTAMs, as discussed in Section 2.1.2. NOTAMs assist general aviation pilots in scheduling around any temporary disruption of flight activities in the area of operation and provide notice of unanticipated or temporary changes to components of, or hazards in, the NAS. The FAA issues a NOTAM at least 24 hours prior to a launch or reentry activity in the airspace to notify pilots and other interested parties of temporary conditions. Advance notice via NOTAMs and the identification of Aircraft Hazard Areas would assist pilots in scheduling around any temporary disruption of flight activities in the area of operation to reduce risk to human safety.

While adhering to these safety measures and procedures and EPMs described in Appendix L, there would not be significant impacts to human health and safety as a result of the Proposed Action.

3.12.2.2 No Action Alternative

Under the No Action Alternative, increased launch cadence on VSFB would not occur, resulting in no impacts on human health and safety beyond those described in the 2023 SEA.

3.13 Hazardous Materials and Waste Management

3.13.1 Affected Environment

The ROI for hazardous materials and waste management resources includes all areas potentially impacted during launch operations, where activities associated with the Proposed Action may be impacted by using hazardous materials and generating hazardous waste. Hazardous materials and wastes are those substances defined as hazardous by the Comprehensive Environmental Response, Compensation, and Liability Act (42 USC Chapter 103), as amended by the Superfund Amendments and Reauthorization Act (26 USC Section 9507); the Environmental Health Standards for the Management of Hazardous Waste (California Code of Regulations [CCR] Title 22); the Toxic Substances Control Act (15 USC Sections 2601–2671); the Solid Waste Disposal Act (42 USC Section 6903), as amended by the Resource Conservation and Recovery Act (RCRA; 42 USC Sections 6901-6992); and as defined in Title 8 CCR Section 5161. In addition, federal and state OSHA regulations govern protecting workplace personnel. In general, the definitions within the citations include substances that, because of their quantity, concentration, or physical, chemical, or infectious characteristics, may present substantial danger to public health and welfare, to workers, or to the environment.

3.13.1.1 Hazardous Materials at Vandenberg Space Force Base

Hazardous materials are compounds with the potential to harm human health and the environment through improper use, treatment, transportation, storage, or disposal in commercial, military, and industrial applications. They are harmful to life due to their concentrations and amounts, or physical and chemical attributes. Component hazardous materials, or hazardous constituents, are hazardous materials with low concentrations that will not cause acute adverse effects. Hazardous constituents are present in propellants, batteries, fuels, hydraulic fluids, and munitions, and may harm human and environmental health through water, soil, or air contact.

Operations at VSFB require military personnel and on-Base contractors to use hazardous chemicals in varying quantities throughout the Base. Using hazardous material on VSFB is regulated by the Hazardous Materials Management Process (HMMP; DAF 2020), per Air Force Manual (AFMAN) 32-7002, Environmental Compliance and Pollution Prevention, and 40 CFR Part 112, Spill Prevention, Control, and Countermeasure Plan. Emergency response procedures for hazardous materials spills are established in SLD 30's Installation Management Plan (SLD 30 Plan 10-2). SpaceX has prepared its own Emergency Response Plan per the SLD 30 Installation Management Plan. This Plan ensures that adequate and appropriate guidance, policies, and protocols regarding hazardous material incidents and associated emergency response are available to and followed by all installation personnel and commercial entities. For a spill, SpaceX would also be responsible for completing a Community Awareness and Emergency Response reporting form per local Santa Barbara County hazardous material and hazardous waste spill reporting requirements.

3.13.1.2 Hazardous Materials Transportation Safety

Hazardous materials such as propellants, ordnance, chemicals, and other hazardous material payload components must be transported to and on VSFB per DOT regulations for interstate and intrastate shipment of hazardous materials (Title 49 CFR Parts 100–199).

3.13.1.3 Hazardous Waste at Vandenberg Space Force Base

Hazardous wastes contain hazardous materials that may exist as any state of matter, which may cause, or significantly contribute to, an increase in the likelihood of mortality or serious illness. Substantial human and environmental risks may be present when hazardous waste is improperly used, stored, transported, or disposed. Hazardous waste at VSFB complies with RCRA Subtitle C (40 CFR Parts 260-273) and with California Hazardous Waste Control Laws as administered by the California Environmental Protection Agency Department of Toxic Substances Control (22 CCR Section 66260.10; 8 CCR Section 5192). These regulations require that hazardous wastes be handled, stored, transported, disposed of, or recycled according to defined procedures. The SLD 30 Hazardous Waste Management Plan (HWMP; SLD 30 Plan 32-7043-A; DAF 2022a) details hazardous waste packaging, turn-in, transportation, storage, recordkeeping, and emergency procedures. SpaceX follows all federal, state, and local laws regulating generating, storing, transporting, and disposing hazardous waste for current operations at SLC-4 and would continue to do so. SpaceX has also obtained a USEPA Generator identification number to manage and dispose hazardous waste generated from its site operations on VSFB.

3.13.1.4 Environmental Restoration Program at Vandenberg Space Force Base

In 1975, DOD facilities began implementing the Installation Restoration Program (IRP). The IRP was established under the Defense Environmental Restoration Program (ERP) to identify, characterize, and restore hazardous substance release sites, and provide a method of management under Section 211 of Comprehensive Environmental Response, Compensation, and Liability Act of 1980. The ERP is comprised of three programs: IRP, Military Munitions Response Program (MMRP), and building demolition and debris removal (AFI 32-7020). Once areas and constituents have been identified, the IRP is tasked to remove or monitor the hazards in an environmentally responsible manner. IRP sites are remediated through the Federal Facilities Site Remediation Agreement, a working agreement between the DAF and the RWQCB Central Coast Region and the Department of Toxic Substances Control Region 3. In addition to IRP sites, there are identified Areas of Concern (AOC), where potential hazardous material releases are suspected; and Areas of Interest (AOI), defined as areas with the potential for use or presence of a hazardous substance. To ensure the health and safety of personnel on VSFB, an analysis of MMRP and IRP sites, including AOCs and AOIs, within the Proposed Action area was performed in Sections 3.8.5 and 4.8.1.3 of the 2016 EA. The Proposed Action has not changed in a manner that would change the environmental consequences for the ERP program, thus this resource is not considered further in this EA.

3.13.2 Environmental Consequences

Factors considered in determining if implementing an alternative may have significant adverse impacts on hazardous materials and waste management include the extent or degree to which implementing an alternative would result in non-compliance with applicable regulatory requirements; or human exposure to hazardous materials and wastes, or environmental release above permitted limits. The FAA has not established a significance threshold for hazardous materials and pollution prevention. Potential impacts resulting from hazardous materials and hazardous waste are evaluated using federal, state, and local regulatory requirements, contract specifications, and Base operating constraints, as outlined in Section 3.13.1. Non-compliance with applicable regulatory requirements, human exposure to hazardous materials and wastes, or environmental release above permitted limits, would be considered adverse impacts.

3.13.2.1 Alternative 1 and 2

Compliance with all pertinent federal, state, and local laws and regulations, and applicable DAF and SLD 30 plans would govern all actions associated with implementing the Proposed Action and would minimize the potential for significant impacts. Launch support operations would use a small amount of products containing hazardous materials, including POLs, paints, solvents, oils, lubricants, acids, batteries, and chemicals. SpaceX would also generate a small number of waste tires each year through RORO operations and other pad support equipment during routine launch support. Payload processing would generate a small amount of empty containers, spent solvents, waste oil, spill cleanup materials (if used), and lead-acid batteries.

Fuels (i.e., rocket propellant-1) and oxidizers (i.e., liquid oxygen) would be the most significant hazardous materials onsite during operations. Loading and unloading operations would take place over appropriately designed and sized containment basins, with spill prevention and emergency response procedures in place. Proper handling practices of liquid fuels would adhere to 14 CFR Section 420.67 (*Separation distance requirements for handling incompatible energetic liquids that are co-located*) for liquid fuels and limit the risk of hazardous material releases due to leaking storage tanks, tanker trucks, delivery lines, or other infrastructure.

SpaceX would continue to identify, label, and accumulate any hazardous wastes IAW all applicable federal, state, and local regulations. Hazardous materials and wastes would be properly contained, manifested, and managed per applicable federal, state, and local regulations, AFIs, AFMANs, DOD Directives, the site-specific health and safety plan, and associated EPMs. Accidental releases of petroleum, oil, and lubricants from vehicles, equipment, and transformer leaks would generate hazardous wastes, resulting in potential adverse impacts on the ROI. All hazardous wastes and spills would be properly managed and disposed of per applicable federal, state, and local hazardous waste regulations and the HWMP (DAF 2022a). Hazardous materials and waste management regulations would follow procedures outlined in the HMMP (DAF 2020) and the HWMP DAF (2022). SpaceX and any contractors working at the site would make all reasonable and safe efforts to contain and control any spills or releases that may occur. For a spill or accidental release, SpaceX would implement an Emergency Response Plan and complete a Community Awareness and Emergency Response reporting form per local Santa Barbara County hazardous material and hazardous waste spill reporting requirements.

To protect water resources, any potentially contaminated wastewater would be collected, analyzed, and disposed of per CCR Title 22 & Title 27, Division 2, and the RWQCB General Waiver for Specific Discharges. Additional EPMs described in Appendix L would further ensure that the Proposed Action would not have a significant impact on water resources.

The amount of hazardous materials needed and the waste generated by the Proposed Action would have little to no impact on waste processing capacity. The EPMs described in Appendix L would be implemented. Therefore, the Proposed Action would not have a significant impact due to using and generating hazardous materials and hazardous wastes. With adherence to existing policies and procedures as outlined in the applicable federal, state, and local regulations, as well as the EPMs described in Appendix L, impacts from using hazardous materials associated with the Proposed Action under would not be significant.

3.13.2.2 No Action Alternative

Under the No Action Alternative, increased launch cadence on VSFB would not occur, resulting in no impacts on hazardous materials and waste management beyond those described in the 2023 SEA.

3.14 Solid Waste Management

3.14.1 Affected Environment

The ROI for solid waste management is VSFB. The regulatory environment for solid waste management establishes control of solid waste and promotes pollution prevention associated with the Proposed Action. Solid waste is generally defined as any discarded material that is not characterized by other specific regulatory requirements detailed in the RCRA (40 CFR Part 261.2). Solid waste is subject to corrective action under RCRA (42 USC Section 6901 et seq.). The regulatory environment for solid waste management reflects comprehensive federal, state, and local approaches to minimize waste generation and increase reuse and recycling.

Solid waste management on VSFB is directed by DODI 4715.23, Integrated Recycling and Solid Waste Management, and implemented in SLD 30's Integrated Solid Waste Management Plan (ISWMP; DAF 2015). AFMAN 32-7002, Environmental Compliance and Pollution Prevention, details requirements and programs that installations must comply with to successfully divert as much solid waste as economically feasible. The SLD 30 ISWMP requires source segregation of recyclable materials to the greatest extent possible. In 1989, the California Integrated Waste Management Act (Assembly Bill [AB] 939) has a policy goal of a 50% reduction of the quantity of solid waste disposed of in California landfills from a 1990 baseline, to be accomplished by 1 January 2000. To bolster the positive effects of AB 939, the Mandatory Commercial Recycling Regulation (AB 341) became law in 2012 and has a policy goal of CalRecycle to increase statewide solid waste diversions to 75% by 2020. The DOD Strategic Sustainability and Performance Plan listed a solid waste diversion goal of 50% and a C&D debris diversion rate of 60%. The DAF is committed to achieving these goals.

3.14.1.1 Pollution Prevention

The Pollution Prevention Act of 1990 (42 USC Sections 13101-13109) focused the national approach to environmental protection toward pollution prevention (P2). Implementing the USAF Environmental Management System (EMS; DODI 4715.17) carries P2 a step further toward mission sustainability principles. The P2 program is detailed in the SLD 30 HMMP and is aimed at achieving SLD 30 EMS objectives and targets, through documented practices, procedures, and operational requirements. SLD 30 implements EMS and its associated P2 program elements by the P2 hierarchy shown in Table 3.14-1.

Table 3.14-1. Pollution Prevention Hierarchy

1) Reduce (source reduction to prevent the creation of wastes)
2) Reuse (keep item or material for its intended purpose)
3) Recycle (use item or material for some other beneficial purpose)
4) Disposal (in an environmentally compliant manner, only as a last resort)

3.14.2 Environmental Consequences

Solid waste impacts are evaluated using federal, state, and local laws and regulations; permit conditions; and contract specifications. Adverse impacts would occur from noncompliance with applicable regulatory requirements or an increase in the amount of waste disposal that would exceed available waste management capacities. The FAA has not established a significance threshold for solid waste and pollution prevention.

3.14.2.1 Alternative 1 and 2

During launch operations and facilities maintenance, solid waste (cardboard packaging, wood, rags, plastic and aluminum bottles and cans, etc.) would be disposed of on a routine basis. Solid waste would be collected in on-site refuse containers and transported to the Santa Maria Transfer Station for waste disposal, diversion, and recycling. Solid waste would be minimized by strict compliance with VSFB's ISWMP. All materials that are disposed of off-base would be reported to the CEI Solid Waste Manager. The Santa Maria Regional Landfill would receive waste for disposal. The current remaining capacity of the landfill is 1,477,580 tons with a weekly throughput limit of 6,006 tons (CalRecycle 2023). The City of Santa Maria has also initiated development of a new landfill, the Santa Maria Integrated Waste Management Facility (Facility No. 42-AA-0076), located approximately 8 mi southwest of the City of Santa Maria. The new facility will have a design capacity of approximately 131 million CY of waste with an estimated closure date of 2105 (City of Santa Maria 2021). Therefore, there is adequate capacity to accommodate the additional solid waste that would be generated during launch operations.

Compliance with all applicable federal, state, local laws, and regulations, applicable SLD 30 plans and policies, and EPMs (Appendix L), would govern all aspects of the Proposed Action, and would avoid or minimize potential impacts related to solid waste or pollution prevention. Therefore, the Proposed Action would not have a significant impact on solid waste management.

3.14.2.2 No Action Alternative

Under the No Action Alternative, increased launch cadence on VSFB would not occur, resulting in no impacts on solid waste management beyond those described in the 2023 SEA.

4 CUMULATIVE IMPACTS

Cumulative impacts are defined by CEQ as "effects on the environment that result from the incremental effects of the action when added to the effects of other past, present, and reasonably foreseeable actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions" (40 CFR Part 1508.1). The FAA analyzes the potential cumulative impacts IAW CEQ regulations and FAA Order 1050.1F. The effects of the Proposed Action, in combination with the effects of other relevant past, present, and reasonably foreseeable future projects, are evaluated in this cumulative effects analysis. The depth of this analysis is commensurate with the potential for significant impacts. Any future federal agency actions modifying the launch program would be subject to environmental review.

Spatial boundaries were delineated to determine the area and projects the cumulative impacts analysis would address. The spatial boundary is VSFB, the city of Lompoc, the NCI, and the broad ocean area, which accounts for all potential cumulative impacts. Past, present, and reasonably foreseeable actions at VSFB and the surrounding area include current and future aircraft operations at the airport, rocket launches, rocket engine testing, development in the local area related to activities at VSFB, and any other development that may occur as a result of economic growth in the area. The projects identified in the following sections include those that had or have the potential to affect the environmental impact categories analyzed in this EA. The No Action Alternative is not analyzed because it would have no cumulative effects on the environment. As noted in Section 1.1, DAF may analyze a proposal to modify SLC-6 at VSFB to launch Falcon 9 and Falcon Heavy launches and increase cumulative launch cadence of Falcon 9 and Falcon Heavy on VSFB to 100 launches per year. That proposal is not additive to the Proposed Action, thus there would be no contemporaneous cumulative effects. Potential significant impacts of cumulative impacts of that proposal will be analyzed in the forthcoming EIS (which will include impacts from the Proposed Action).

4.1 Past Actions

Past actions at VSFB, the city of Lompoc, and the NCI are primarily tied to commercial and military rocket launches, construction on VSFB's launch pads, regular military, and commercial use of VSFB (e.g., takeoffs, landings, launches), and Lompoc community development projects (Table 4.1-1).

Table 4.1-1. Past Actions Recently Completed at or around VSFB

- Military and commercial rocket launches and regular aircraft take-offs and landings at VSFB
- Voluntourism restoration project on San Nicolas Island[1]
- Completion of a 22.5 megawatts solar farm on VSFB[2]
- Completion of Building 7000 on VSFB with LEED Gold certified[3]
- Kids Motorsports Park at River Park[4]

Sources: [1]Kleist 2018, [2]VSFB 2018, [3]Balance Green Consulting 2022, [4]City of Lompoc 2016

4.2 Present Actions

Present actions at VSFB include military and commercial rocket launch programs and several residential developments in the adjacent City of Lompoc (Table 4.2-1).

Table 4.2-1. Present Actions at or around VSFB

- SpaceX commercial rocket launches and landings[1]
- Firefly commercial rocket launches[2]
- Boeing X-37B Spaceplane landings by DAF[3]
- Regular aircraft take-offs and landings, at VSFB
- Approved private development projects in Lompoc[4] including:
    - Community Health Centers of the Central Coast
    - Summit View Homes
    - Mosaic Walk - 13 Unit Residential Project
    - Burton Ranch
    - Coastal Meadows 42-Unit Residential Infill Project
    - River Terrace Residential Development
- Construction of Strauss Wind Energy Project in Lompoc[5]
- Lompoc Valley Parks, Recreations and Pool Foundation Project - Lompoc Motorsport Park[6]
- Pier Construction on Santa Cruz Island[7]
- Maintenance, repair, minor construction/alteration and renovation work and/or design or design/build on real property at VSFB[8]

Sources: [1]DAF 2023, [2]Gray 2022, [3]DAF 2022b, [4]City of Lompoc 2024, [5]Department of Planning and Development Santa Barbara County 2019, [6]City of Lompoc 2016, [7]National Park Service 2024, [8]GovTribe 2019

4.3 Reasonably Foreseeable Actions

Reasonably foreseeable future actions at VSFB include continued launches of both commercial and military launch vehicles, regular military aircraft takeoffs and landings, and the development of residential and community real estate in Lompoc (Table 4.3-1).

Table 4.3-1. Reasonably Foreseeable Actions

- Regular aircraft take-offs and landings, at VSFB
- Modification of SLC-6 on VSFB to support Falcon 9 and Falcon Heavy launches and increase cumulative launch cadence of Falcon 9 and Falcon Heavy on VSFB to 50 launches per year.
- May increase up to 110 space vehicle launches annually (inclusive of the proposed 100 Falcon 9/Falcon Heavy launch cadence above) with DOD and commercial payloads from VSFB
- Further infrastructure development for expanded commercial space launch capabilities at VSFB[1]
- Approved private development projects in Lompoc[2]
    - Community Health Centers of the Central Coast
    - Summit View Homes
    - Mosaic Walk - 13 Unit Residential Project
    - Burton Ranch
    - Coastal Meadows 42-Unit Residential Infill Project
    - River Terrace Residential Development

Sources: [1]Erwin 2022, [2]City of Lompoc 2024

4.4 Alternative 1 and 2

The impacts of the Proposed Action were analyzed for their potential to result in cumulative impacts when added to other past, present, and reasonably foreseeable future actions. The potential cumulative impacts on those resources are described below.

4.4.1 Air Quality

Past, present, and reasonably foreseeable future actions have resulted and will result in air emissions in the ROI. Construction of residential and commercial projects in and around VSFB, along with air and space craft operations, would result in increased emissions. All emissions would be temporary and not likely to result in an exceedance of air quality standards, including the NAAQS. Additionally, ecological restoration projects and renewable energy projects, including the Strauss Wind Energy Project, in and around VSFB would result in improved air quality and net-negative GHG emissions.

The Proposed Action, Alternative 1, would result in air emissions during project transport activities, site preparation, mobilization activities, and static fire and launch events. Generally, the emissions are relatively insignificant outside the Los Angeles-South Coast Air Basin. When combined with other past, present, and reasonably foreseeable future actions, the Proposed Action is the only alternative expected to result in an exceedance of Ozone (NOx as a precursor) GCR *de minimis* threshold value. Therefore, the Proposed Action has the potential to result in significant cumulative impacts on air quality. However, SCAQMD verified that the Proposed Action's emissions are accounted for in the 2016 AQMP (the most current SIP) which will provide the basis for a future GCR Determination. Upon a GCR Determination, Alternative 1 is not expected to result in a significant cumulative impact on air quality.

Alternative 2 would result in air emissions during project transport activities, site preparation, mobilization activities, and static fire and launch events. When combined with other past, present, and reasonably foreseeable future actions, Alternative 2 is not expected to result in exceedance of any air quality standards, including the GCR *de minimis* threshold values, because of the low amount of emissions and some of the activities being temporary in nature. Therefore, Alternative 2 is not expected to result in a significant cumulative impact on air quality.

4.4.2 Noise

Noise effects associated with launch and missile activities on VSFB are relatively short (typically no more than several minutes per event). Appropriate environmental analyses are conducted for these activities. Noise produced during the additional launches under the Proposed Action would not contribute a significant cumulative impact to the noise setting within the ROI. Each noise event from launches would last less than two minutes. The anticipated offshore sonic boom events resulting from launches would be infrequent. Therefore, the Proposed Action, with other past, present, or reasonably foreseeable projects, would not result in significant cumulative noise impacts.

4.4.3 Terrestrial Biological Resources

The Proposed Action would potentially impact wildlife and special status resources within the ROI, these impacts would not be significant and overall long-term consequences are unlikely. All avoidance and minimization measures presented in Appendix L would be implemented as required. Therefore, the incremental contribution of the Proposed Action, when added to the impacts of all other past, present, and reasonably foreseeable future actions, would not result in significant cumulative impacts on terrestrial biological resources, including impacts on ESA-listed species.

4.4.4 Marine Biological Resources

General threats to marine mammals include water quality degradation (chemical pollution), commercial industries (fisheries bycatch, explosive pest deterrents, and other interactions), noise, hunting, vessel strike, marine debris, disease and parasites, power plant entrainment, and climate change. Potential impacts of actions that affect marine mammals include mortality, injury, disturbance, and reduced fitness, including reproductive, foraging, and predator avoidance success. The susceptibility of marine mammals to these outcomes often depends on proximity, severity, or vulnerability to the stressor and vulnerability can be increased as multiple stressors compound on an individual.

The Proposed Action would potentially impact pinnipeds hauled out within the ROI, as presented in Section 3.4.2. Pinnipeds hauled out on land would be affected by noise and visual disturbance during launch, landing, and static fire events. The analysis indicates the Proposed Action would not have a significant impact on pinnipeds within the ROI. Overall, long-term consequences for hauled out pinnipeds are unlikely given the long history of monitoring that has documented pinniped reactions at haulouts to similar events. Therefore, the incremental contribution of the Proposed Action, when added to the impacts of all other past, present, and reasonably foreseeable future actions, would not result in significant impacts on marine mammals in the ROI or beyond.

4.4.5 Water Resources

Projects on VSFB, including the Proposed Action, are required to utilize site-specific best management practices and conduct site restoration, as necessary, to minimize impacts on water quality. Any potential adverse effects should be avoided or minimized through implementing measures described in Appendix L, identified in environmental documents completed for other projects, in environmental documents for future projects, and/or identified and established by VSFB for Operations and Maintenance projects. Therefore, the Proposed Action, when added to the impacts of all other past, present, and reasonably foreseeable future actions, would not result in significant cumulative impacts on water resources.

4.4.6 Cultural Resources

General threats to cultural resources in the ROI include construction, demolition, infrastructure development, and maintenance projects. Cumulative impacts would result if project activities caused major ground disturbances in areas of high paleontological sensitivity, or that may contain intact subsurface prehistoric or historic archaeological resources, or incremental changes that collectively and over time impact the NRHP eligibility or listing status of a historic property. All projects on VSFB are evaluated for potential cultural resources impacts. Evaluation for NRHP eligibility, Section 106 consultation, and Native American consultation are conducted. These processes stipulate avoidance and minimization measures to protect sensitive archaeological resources. Therefore, the incremental contribution of the Proposed Action, when added to the impacts of all other past, present, and reasonably foreseeable future actions, would not result in significant cumulative impacts on cultural resources.

4.4.7 Coastal Zone Management

The Proposed Action would not adversely affect land use or cause significant impacts to coastal uses or resources in the coastal zone, as defined in the CZMA. Past, present, and reasonably foreseeable actions that may have had the potential to affect or may affect coastal uses or resources have been and would be analyzed ensuring such actions were or would be fully consistent with the enforceable polices of the approved CCMP. Actions would also conform to DAF and DoD regulations and planning principles, including Best Management Practices and INRMPs, to ensure no significant impacts to coastal resources. Actions have been and would continue to be assessed pursuant to NEPA, and other applicable laws, and any potential effects or impacts would be analyzed and disclosed while simultaneously engaging in coordination and cooperation with the CCC, when required pursuant to the CZMA. Therefore, implementing the Proposed Action, with other past, present, or reasonably foreseeable projects would not result in significant cumulative impacts on the coastal zone., with these requirements and planning processes in place.

4.4.8 Department of Transportation Act Section 4(f) Properties

The DAF would comply with the closure agreement with Santa Barbara County and would not exceed or increase the current cumulative allowable annual evacuations of Jalama Beach County Park across all present and reasonably foreseeable launch programs on VSFB. SLD 30 Range Safety would individually review future launch programs to determine if additional closures are necessary and what areas would be affected since the hazard risk analysis is unique to each vehicle, launch location, and mission trajectory. SLD 30 is working to avoid restrictions to public access while accounting for risk to human health and safety and has determined there is no need to restrict access to Ocean Beach County Park or Surf Beach for launches with downrange first stage landing on a droneship and launches with first stages expended in the Pacific Ocean that do not fly over or pass within close proximity these locations. Ocean Beach County Park closures would not exceed 12 times per year as previously described in the 2018 SEA. Therefore, implementing the Proposed Action with other past, present, or reasonably foreseeable projects would not result in significant cumulative impacts on Section 4(f) properties.

4.4.9 Utilities

Past, present, and future projects on VSFB would contribute to increases in demand for utility resources; however, utility capacity would be required to be greater than demand. SLD 30 will extend utilities to reach launch facilities, but the existing utility capacity is greater than the anticipated demand to support launch facilities for 110 cumulative launches and supporting infrastructure. The substation that supports south base launch facilities is capable of supporting over 1,000 amps of distribution loads. SLD 30 profiles the loads for every launch, and has not exceeded 100 amps of usage. The existing system can support 10 times the current load, well within the requirements for cumulative launches. If existing utility capacity is not greater than the anticipated demand, SLD 30 would improve utility capacity during infrastructure development for expanded commercial space launch capabilities at VSFB and thus help offset cumulative impacts to utility resources. Additionally, American Water Operations & Maintenance, which operates the water distribution and wastewater collection systems at VSFB, is saving approximately 22 million gallons/year by re-introducing potable water into the system during fire-hydrant flushing instead of disposing of the water in storm drains (Air Force Civil Engineer Center [AFCEC] 2015). Therefore, implementation of the Proposed Action in conjunction with other past, present, or reasonably foreseeable projects would not result in significant cumulative impacts to utilities in the ROI.

4.4.10 Socioeconomics

The long-term employment for personnel supporting the Proposed Action would be considered positive and would augment other local community businesses and industries. SpaceX and VSFB are major employers, and the presence of these employers can cause a chain of economic reactions throughout the local region. VSFB launch operations would not result in closing any public airport or so severely restricting using surrounding airspace to prevent access to an airport for extended time. Given existing closed airspace surrounding VSFB and the FAA's previous analyses related to the NAS have concluded minor or minimal impacts on the NAS from commercial space launches, the effects from airspace closures would result in insignificant socioeconomic impacts. As a result, the overall cumulative effect of the Proposed Action, when considered with other past, present, and reasonably foreseeable future actions on socioeconomics is considered beneficial and would not be significant.

4.4.11 Transportation

Impacts to the local and regional transportation network due to the Proposed Action, along with past, present, and reasonably foreseeable projects in the ROI would contribute to increased traffic volumes in the region. However, traffic volumes in the ROI are low and the roadways operate at acceptable levels of service. The Proposed Action would generate a relatively small and temporary increase in daily vehicle traffic that would not have a cumulative adverse effect on capacity. Trains that would be stopped at safety hold points for launch activities or railway crossings would only experience minor delays of short duration that are relatively infrequent. Launch windows are typically minimal (typically instantaneous or several minutes but could last a few hours) and during longer launch delays 2 ROPS/DON communicates with the UPRR POC to allow trains to move through the affected area; thereby minimizing potential impacts to train schedules. As a result, we expect no significant cumulative adverse effects to capacity to occur as a result of the Proposed Action.

4.4.12 Human Health and Safety

The Proposed Action and other concurrent projects on VSFB could result in increased risks to human health and safety. Implementing the Proposed Action and other similar actions at VSFB would slightly increase the short-term risk associated with personnel performing work at project locations. SLD 30 has developed hazardous areas that constrain project sites to ensure the health and safety of workers (Section 3.14); these hazard areas have been in use for decades' worth of launch and military activities and applied to many on-base projects. DOD and DAF emergency management readiness and response to public health and safety issues are detailed in DODI 6055.17, DODI 6200.03, AFI 10-2519, and AFI 10-2501. These DOD and DAF instructions have been established for a wide variety of DOD operations and projects and require compliance to mitigate impacts to human health and safety. Any potential contractors would be required to establish and maintain safety programs that would provide protection to their workers and limit the exposure of personnel to work hazards. The safety program would include coordination with the AFCEC MMRP manager and contact with the weapons safety specialist for SLD 30 for information on DAF and SLD 30 policies on unexploded ordnance safety for construction work at VSFB. Projects on VSFB are regulated by the same policies and processes to prevent significant impacts on human health and safety from launch activities, weapons testing, and other military actions on VSFB. By implementing the required safety measures, there would be no significant cumulative impacts resulting from the Proposed Action and other anticipated projects. Therefore, implementation of the Proposed Action, with other past, present, or reasonably foreseeable projects would not result in significant cumulative impacts on human health and safety.

4.4.13 Hazardous Materials and Waste Management

Past, present, and future projects on VSFB are subject to the same protocols and procedures for the management of hazardous materials and waste. In addition to federal, state, and local rules, installation management of any hazardous materials would occur by complying with Base-specific manuals and protocols such as the HMMP, the Hazardous Materials Emergency Response Plan, and the ISWMP. Slight variances in protocols may occur in contractors' or project proponents' project-specific Emergency Response Plan as it pertains to the unique requirements and processes of individual Proposed Actions. Additionally, EPMs like the prescribed EPMs for this Proposed Action in Appendix L, would be implemented to minimize impacts to hazardous materials or hazardous waste management from similar Proposed Actions. Impacts to hazardous materials and waste management from launch activities, weapons testing, and other military actions on VSFB are closely monitored and controlled by the same policies and procedures to ensure impacts are mitigated or minimized and do not result in significant cumulative detrimental effects to hazardous materials and waste management resources. Therefore, implementing the Proposed Action, with other past, present, or reasonably foreseeable projects would not result in significant cumulative impacts on hazardous materials and waste management.

4.4.14 Solid Waste Management

The cumulative projects listed above, including the Proposed Action, will result in an overall increase in solid waste generation produced during the increased launch operations. All operations and activities on VSFB are required to comply with all applicable federal, state, local laws, and regulations, and applicable SLD 30 plans. Local landfills have adequate capacity to process the projected temporary increases in solid waste, especially with the development of the Santa Maria Integrated Waste Management Facility. Therefore, with adhering to disposal and recycling requirements and EPMs described in Appendix L, the Proposed Action would not have a significant cumulative impact on solid waste management.

4.5 Summary and Conclusion

To ensure that no significant cumulative impacts result from projects on VSFB that occur either concurrently or sequentially with the Proposed Action or Alternative 2, SLD 30 includes environmental contract specifications and protective measures, when necessary, in all projects. Preventive measures are identified and defined by resource managers and project proponents and SLD 30 take actions during the planning process to ensure adverse impacts are minimized, or avoided all together, as projects are reviewed under NEPA. Prior projects are also considered to ensure no levels of acceptable impacts are exceeded.

All projects on VSFB are designed and implemented to fully comply with applicable statutes and regulations. SLD 30 develops EPMs in coordination with appropriate regulatory agencies throughout the NEPA process. With these practices in place, the activities included under the Alternative 2, would not result in significant cumulative impacts. However, the Proposed Action has the potential to result in significant cumulative impacts on air quality until a GCR Determination is made. That said, the impacts from the Proposed Action will be included in the upcoming increased launch EIS as a past action in the cumulative impacts analysis section to further analyze the potential impacts of the Proposed Action combined with the foreseeable future proposals.

Under the No Action Alternative, increased launch cadence on VSFB would not occur, resulting in no contributions to cumulative impacts beyond those described in the 2023 SEA.

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Brian Pownall, P.E. (SpaceX) Environmental Engineer
B.S., Civil Engineering, North Carolina State University
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5.2 List of Agencies and Persons Consulted

Aaron Allen, U.S. Army Corps of Engineers, Regulatory Division, Los Angeles District

Avenue Library, Ventura, Ca

Carly Barham, Santa Barbara Air Pollution Control District

California Environmental Protection Agency

California Native Plant Society, Channel Islands Chapter

Marzine Catherine, Office of Protected Resources, National Marine Fisheries Service

Gerry Ching, Los Padres Chapter, Sierra Club

Ana Citrin, Gaviota Coast Conservancy

Sam Cohen, Elders Council, Santa Ynez Band of Chumash Indians Elder's Council, Santa Ynez, California

Tyrone Conner, Deputy Chief, Waterways Management, Eleventh Coast Guard District

Melissa Daugherty, Central Coast Ambient Monitoring Program, Central Coast Regional Water Quality Control Board

Chris Diel, Assistant Field Supervisor, Ventura Field Office, United States Fish and Wildlife Service

Alex Economou, Santa Barbara County Air Pollution Control District

E.P. Foster Library, Ventura, CA

Rhys Evans, VSFB, Natural Resources, 30 CES/CEIEA

Leslie Grey, Office of Commercial Space Transportation, Federal Aviation Administration

Brian Halvorson, Economic & Community Development, City of Lompoc

Steve Henry, Ventura Fish and Wildlife Office, United States Fish and Wildlife Service

David A. Jorgenson, U.S. Army Corps of Engineers

Samantha Kaisersatt, Conservation Chief, 30 CES/CEIEA

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David Lackie, Santa Barbara County Planning & Development

Daniel Lawson, Long Beach Branch Chief, Protected Resource Division, National Marine Fisheries Service

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Luanne Lum, VSFB, Natural Resources, 30 CES/CEIEA

Russell Marlow, California Trout

Chris Mobley, Channel Islands National Marine Sanctuary, National Oceanic and Atmospheric Administration

National Park Service, Channel Islands National Park

NOAA - National Marine Fisheries Service, West Coast Regional Office

Office of the Governor, Office of Planning and Research, State Clearing House

Ojai Library, Ojai, CA

Julianne Polanco, California SHPO, Office of Historic Preservation, Department of Parks and Recreation, Sacramento, California

Mandy Sackett, Surfrider Foundation

Santa Barbara Public Library, Santa Barbara, CA

Santa Maria Public Library, Santa Maria, CA

Kelly Schmoker-Stanphill, California Department of Fish & Wildlife South Coast Region

LTJG Rudy Sebastian-Echevarria, Waterways Analysis & Management Systems, Eleventh Coast Guard District, U.S. Coast Guard

Amber Sellinger, Central Coast Regional Water Quality Control Board

South Oxnard Branch Library, Oxnard, CA

Theresa Stevens, U.S. Army Corps of Engineers, Regulatory Division, Los Angeles District

Superintendent, Channel Islands National Park, National Park Service

Luke Swetland, Santa Barbara Museum of Natural History

Tamarah Taaffe, La Purisima Audubon Society

Cassidy Teufel, Federal Consistency Coordinator, Energy, Ocean Resources and Federal Consistency Division, California Coastal Commission

Brian Trautwein, Environmental Defense Center

Cherridah Weigel, Economic & Community Development, City of Lompoc

Tiffany Whitsitt-Odell, Environmental Planner, Vandenberg Space Force Base, United States Space Force

Vandenberg Space Force Base Library, Vandenberg Space Force Base, California

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Darryl York, VSFB, Chief, Environmental, 30 CES/CEIEA

Nakia Zavalla, Santa Ynez Band of Chumash Indians

Stacy Zee, Office of Commercial Space Transportation, Federal Aviation Administration

6 BIBLIOGRAPHY

Air Force Civil Engineer Center (AFCEC). 2015. Vandenberg AFB to save 1.1 billion gallons of water with new privatization deal. 19 November 2015. Published by J. Echerri, AFCEC Public Affairs. Retrieved from https://www.afcec.af.mil/News/Article-Display/Article/ 871404/ vandenberg-afb-to-save-11-billion-gallons-of-water-with-new-privatization-deal/

Amtrak. 2022. Amtrak schedules. Available at: https://www.amtrak.com/

Balance Green Consulting. 2022. LEED Certifications Awarded to March ARB and VAFB – Highlights. Accessed On: 23 January 2024. Retrieved from https://www.inbalancegreen.com/ news/2020/11/10/leed-certifications-awarded-to-march-arb-and-vafb-highlights.

Benson, L.R. 2013. Quieting the boom: the shaped sonic boom demonstrator and the quest for quiet supersonic. NASA Aeronautics Book Series. National Aeronautics and Space Administration. Available at: https://www.nasa.gov/connect/ebooks/index.html.

Bolina, K., and M. Abom. 2010. Air-borne sound generated by sea waves. Journal of the Acoustical Society of America: 127.

Bradley, K.A., et al, 2018. User guides for noise modeling of commercial space operations – RUMBLE and PCBoom. Airport Cooperative Research Program Research Report 183. Produced by Wyle Laboratories, Inc., Arlington, VA and Blue Ridge Research and Consulting, LLC, Asheville, NC.

California Department of Finance. 2022. Demographics: 2020 Census. Available at: https://dof.ca.gov/forecasting/demographics/

California Department of Fish and Wildlife (CDFW). 2023. Marine Fisheries Data Explorer. Available at: https://wildlife.ca.gov/Conservation/Marine/Data-Management-Research/MFDE

CalRecycle. 2023. SWIS Facility/Site Activity Details: Santa Maria Regional Landfill (42-AA-0016) Available at: https://www2.calrecycle.ca.gov/SolidWaste/SiteActivity/Details/1253? siteID=3284.

Caltrans. 2024. Traffic Volumes AADT. Available at: https://gis.data.ca.gov/datasets/d8833219913c44358f2a9a71bda57f76/explore?location=34.650372%2C-120.494321%2C13.89.

City of Lompoc. 2014. Categorical Exclusion and Natural Environment Study – North Avenue Bridge Preventative Maintenance Project. 134 pp.

City of Lompoc. 2016. Draft Lompoc Motorsports Park Environmental Impact Report. Lompoc, CA: Meridian Consultants LLC.

City of Lompoc. 2024. Approved Private Projects. Accessed On: 23 January 2024. Available at: https://www.cityoflompoc.com/government/departments/economic-community-development/planning-division/environmental-documents/approved-private-projects

(*Ambystoma californiense* in an urban landscape. Northwestern Naturalist 87(3): 215-224.

Cromwell, G., and C.C. Faunt. 2024. Estimated Effects of a Proposed Increase in Groundwater Pumping at Vandenberg Space Force Base, Santa Barbara County, California. Prepared by the U.S. Geological

Survey California Water Science Center. Prepared for the U.S. Space Force, Vandenberg Space Force Base, California.

County of Santa Barbara Public Works. 2022. Historical Rainfall & Reservoir Information. Available at: https://www.countyofsb.org/2256/Historical-Rainfall-Reservoir-Informatio

Department of the Air Force [DAF]. 2011. Final Draft Environmental Assessment Falcon 9 and Falcon 9 Heavy Launch Vehicle Programs from Space Launch Complex 4 East, Vandenberg Air Force Base, California. U.S. Air Force, 30th Space Wing. Retrieved from: https://www.vandenberg.spaceforce.mil/Portals/18/documents/Environmental/EIAP-2011-03-1_EA_Falcon9-SLC-4E.pdf?ver=ltWVg_TKsa8haZ0zvhdM6A%3d%3d

DAF. 2015. Integrated solid waste management plan. February 2015. Vandenberg Air Force Base, CA. U.S. Air Force, 30th Space Wing.

DAF. 2016. Final Supplemental Environmental Assessment: Boost-Back and Landing of the Falcon 9 Full Thrust First Stage at Iridium Landing Area Vandenberg Air Force Base, California and Offshore Landing Contingency Option. Vandenberg Air Force Base, CA: U.S. Department of the Air Force, 30th Space Wing, Installation Management Flight. Retrieved from: https://www.vandenberg.spaceforce.mil/Portals/18/documents/Environmental/EIAP-2016-04-1_EA_Falcon9_Boost-back.pdf?ver=ICyyMrxyiTGXagCmf29TXA%3d%3d

DAF. 2018. Final Supplemental Environmental Assessment Launch, Boost-Back, and Landing of the Falcon 9 at Vandenberg Air Force Base, California and Offshore Landing Contingency Options. Vandenberg Air Force Base, CA: U.S. Department of the Air Force, 30th Space Wing, Installation Management Flight. Retrieved from: https://www.vandenberg.spaceforce.mil/Portals/18/documents/Environmental/EIAP-2018-01-31_SEA_Falcon9_Launch-Boost-back.pdf?ver=kTLZUufAucxBEFEzzsQlAw%3d%3d

DAF. 2022a. Hazardous Waste Management Plan. January 2022. Vandenberg Air Force Base, CA: U.S. Air Force, Space Launch Delta 30.

DAF. 2022b. X-37B Orbital Test Vehicle. Accessed On: 25 May 2022. Retrieved from https://www.af.mil/About-Us/Fact-Sheets/Display/Article/104539/x-37b-orbital-test-vehicle/

DAF. 2023. Final Supplemental Environmental Assessment Falcon 9 Cadence Increase at Vandenberg Space Force Base, California and Offshore landing Locations. Vandenberg Space Force Base, CA: U.S. Department of the Air Force, SLD 30, Installation Management Flight. Retrieved from: https://www.vandenberg.spaceforce.mil/Portals/18/documents/Environmental/EIAP-2023-05-1_SEA_SpaceX_Falcon9CadenceIncrease.pdf?ver=gsIu4FWj4nqnZsbyzmodpA%3d%3d

Dallas et al. 2020. The Environmental Impact of Emissions from Space Launches: A Comprehensive Review. Journal of Cleaner Production.

Department of Planning and Development Santa Barbara County. 2019. Strauss Wind Energy Project. Accessed On: 25 May 2022. Retrieved from https://www.countyofsb.org/ 912/Strauss-Wind-Energy-Project.

Dudek. 2024. Housing Impact Study Vandenberg Space Force Base.

Erwin, G. 2022. California seeks to expand commercial space launch at Vandenberg Air Force Base. Accessed On: 25 May 2022. Retrieved from https://spacenews.com/california-seeks-to-expand-commercial-space-launch-at-vandenberg-air-force-base/.

Federal Aviation Administration (FAA). 2020. Final Environmental Assessment and Finding of No Significant Impact for SpaceX Falcon Launches at Kennedy Space Center and Cape Canaveral Air Force Station. https://www.faa.gov/sites/faa.gov/files/space/environmental/nepa_docs/SpaceX_Falcon_Program _Final_EA_and_FONSI.pdf

FAA. 2024. FAA 1050.1F Desk Reference Version 2. Retrieved from: https://www.faa.gov/about/office_org/headquarters_offices/apl/environ_policy_guidance/policy/faa_nepa_order/desk_ref/media/desk-ref.pdf.

Fenton, R., and R. Methold. 2016. Mod Shoeburyness and Pendine noise and vibration study criteria for the assessment of potential building damage effects from range activities. June. Southdowns Environmental Consultants, Lewes, East Sussex, UK. 55 pp.

Fisher, T. 2008. Synopsis of Causation: Blast injury of the ear. Veterans UK and Ministry of Defense.

7

Ghoul, A., and C. Reichmuth. 2014. Hearing in the sea otter (*Enhydra lutris*): auditory profiles for an amphibious marine carnivore. Journal of Comparative Physiology. doi:10.1007/s00359-014-0943-x.

Godin, O.A. 2008. Sound transmission through water-air interfaces: new insights into an old problem. Contemporary Physics 49(2): 105-123.

Government Accountability Office. 2019. Water scarcity: DOD has not always followed leading practices to identify at-risk installations. Report to the Committee on Armed Services, U.S. Senate. November 2019. 42 pp.

GovTribe. 2019. SABER 2019. Accessed On: 23 January 2024. Retrieved from https://govtribe.com/award/federal-vehicle/vandenberg-afb-saber-construction-idiq-2014-2019

Harris, J. 2015. Personal communication via email between J. Harris (National Marine Fisheries Service) and John LaBonte (ManTech SRS Technologies, Inc.) on Guadalupe fur seal behavior, abundance, and distribution on San Miguel Island.

KBR. 2024. Falcon 9 Noise Assessment for Flight and Test Operations at Vandenberg Space Force Base. Technical Note 24-02. Prepared for Space Exploration Technologies Corporation. July 2024. 36 pp.

Kleist, G. 2018. Voluntourism Restoration Project on San Nicolas Island. Accessed On: 23 January 2024. Retrieved from https://cirweb.org/blog/2018/7/3/voluntourism-restoration-project-on-san-nicolas-island.

ManTech SRS Technologies, Inc. 2007a. Biological Monitoring of Southern Sea Otters, California Brown Pelicans, Western Snowy Plovers, and California Least Terns for the 7 June 2007 Delta II COSMO-1 Launch from Vandenberg Space Force Base, California. ManTech SRS Technologies, Inc., Lompoc, California. 24 pp.

ManTech SRS Technologies, Inc. 2007b. Biological Monitoring of California Brown Pelicans and Southern Sea Otters for the 14 December 2006 Delta II NROL-21 Launch from Vandenberg Space Force Base, California. SRS Technologies Systems Development Division, Lompoc, California. 21 pp.

ManTech SRS Technologies, Inc. 2008a. Biological Monitoring of Southern Sea Otters, California Brown Pelicans, Western Snowy Plovers, and California Least Terns for the 20 June 2008 Delta II OSTM Launch from Vandenberg Space Force Base, California. ManTech SRS Technologies, Inc., Lompoc, California. 29 pp.

ManTech SRS Technologies, Inc. 2009. Biological Monitoring of Southern Sea Otters and California Brown Pelicans for the 8 October 2009 Delta II Worldview-II Launch from Vandenberg Air Force Base, California. ManTech SRS Technologies, Inc., Lompoc, California. 22 pp.

ManTech SRS Technologies, Inc. 2017a. Biological Assessment for Launch, Boost-Back and Landing of the Falcon 9 First Stage at SLC-4, Vandenberg Air Force Base, California. ManTech SRS Technologies, Lompoc, California. 65 pp.

ManTech SRS Technologies, Inc. 2017b. Spring Canyon Riparian Mitigation and Monitoring Plan for the Falcon 9 Launch and Landing Program at SLC-4, Vandenberg Air Force Base, CA.

ManTech SRS Technologies, Inc. 2023. Spring Canyon California Red-Legged Frog Habitat Assessment – 2023, Vandenberg Space Force Base, California. Prepared for 30 CES/CEIEA. 161 pp.

ManTech SRS Technologies, Inc. 2024. Activities Pursuant to Biological Opinion 2017-F-0480 – Launch, Boost-back, and Landing of the Falcon 9 First State at Space Launch Complex-4 at Vandenberg Space Force Base, Santa Barbara County, California, 2023 Annual Report. Prepared for 30 CES/CEIEA.

National Aeronautics and Space Administration. 2011. Environmental Assessment for Launch of NASA Routine Payloads on Expendable Launch Vehicles. National Aeronautics and Space Administration, Washington, D.C. 366 pp. Retrieved from: https://www.vandenberg.spaceforce.mil/Portals/18/documents/Environmental/EIAP-2011-11_EA_ProgrammaticNASARoutinePayloads_ExpendableLaunchVehicles.pdf?ver=0YCTsNGDrYeI9uWSMoHVNQ%3d%3d

National Marine Fisheries Service (NMFS). 2007. Final Environmental Impact Statement for the Establishment of Marine Reserves and Marine Conservation Areas, Channel Islands National Marine Sanctuary. April.

National Marine Fisheries Service. 2021. ESA Section 7 Consultation Tools for Marine Mammals on the West Coast. Available online: <https://www.fisheries.noaa.gov/west-coast/endangered-species-conservation/esa-section-7-consultation-tools-marine-mammals-west>. Accessed on 12 January 2024.

National Marine Fisheries Service. 2024a. Takes of Marine Mammals Incidental to Specified Activities; Taking Marine Mammals Incidental to U.S. Space Force Launches and Supporting Activities at Vandenberg Space Force Base, Vandenberg, California. Dated 10 April 2024. Federal Register, Vol. 89, No. 70, pp 25163- 25185.

National Marine Fisheries Service. 2024b. Letter of Authorization, issued to the U.S. Space Force. Valid 10 April 2024, through 9 April 2029. Dated 10 April 2024. 9 pp.

National Oceanographic and Atmospheric Administration [NOAA]. 2024. Overpressure Levels of Concern. NOAA Office of Response and Restoration. Available at: https://response.restoration.noaa.gov/oil-and-chemical-spills/chemical-spills/resources/overpressure-levels-concern.html. As assessed on 31 January 2024.

National Park Service. 2024. Channel Islands: Current Conditions. Accessed On: 23 January 2024. Retrieved from https://www.nps.gov/chis/planyourvisit/conditions.htm.

Page, J.A., K.J. Plotkin, and C. Wilmer, C. 2010. PCBoom Version 6.6 Technical Reference and User Manual. Wyle Report WR 10-10, December 2010.

Pernell, R. 2024. Personal communication via email between R. Pernell (USSF SPOC 30 CES/CEOER), B. Pownall (SpaceX), T. Whitsitt-Odell (USSF 30 CES/CEIEA), D. Freedman (USSF SSC SLD 30/XPR), et al. regarding ability of existing septic systems to meet proposed needs at SLC-4 and SLC-6. 18 January 2024.

Plotkin, K.J. 2010. A model for the prediction of community noise from launch vehicles. (A). Journal of the Acoustical Society of America 127: 1773.

Plotkin, K., J. Page, J. Downing, and D. Reed. 1997b. Sonic boom from launch and reentry vehicles. American Institute of Aeronautics and Astronautics, Inc. https://doi.org/10.2514/6.1997-1658

Plotkin, K.J., L.C. Sutherland, and M. Moudou. 1997a. Prediction of Rocket Noise Footprints During Boost Phase. AIAA Paper 1997-1660, May 1997.

SRS Technologies, Inc. 2006a. Biological Monitoring of Southern Sea Otters, California Brown Pelicans, and Western Snowy Plovers for the 28 April 2006 Delta II Cloudsat & CALIPSO Launch from Vandenberg Space Force Base, California. SRS Technologies technical report submitted to the United States Space Force and the U.S. Fish and Wildlife Service, 11 October 2006.

SRS Technologies, Inc. 2006b. Analysis of Behavioral Responses of Southern Sea Otters, California Least Terns, and Western Snowy Plovers to the 20 April 2004 Delta II Gravity Probe B Launch from Vandenberg Space Force Base, California. SRS Technologies technical report submitted to the United States Space Force. 12 pp.

SRS Technologies, Inc. 2006c. Analysis of Behavioral Responses of California Brown Pelicans, Western Snowy Plovers and Southern Sea Otters to the 15 July 2004 Delta II AURA Launch from Vandenberg Space Force Base, California. SRS Technologies technical report submitted to the United States Space Force. 13 pp.

SRS Technologies, Inc. 2006d. Analysis of Behavioral Responses of Southern Sea Otters, California Brown Pelicans, and Western Snowy Plovers to the 20 May 2005 Delta II NOAA-N Launch from Vandenberg Space Force Base, California. SRS Technologies technical report submitted to the United States Space Force. 15 pp.

SRS Technologies, Inc. 2006e. Biological Monitoring of Southern Sea Otters, California Brown Pelicans, and Western Snowy Plovers for the 28 April 2006 Delta II Cloudsat & CALIPSO Launch from Vandenberg Space Force Base, California. SRS Technologies technical report submitted to the United States Space Force and the U.S. Fish and Wildlife Service, 11 October 2006. 18 pp.

SRS Technologies, Inc. 2006f. Analysis of behavioral responses of California brown pelicans, southern sea otters, and western snowy plovers to the 20 May 2004 Taurus ROCSAT-2 launch from Vandenberg Air Force Base, California. SRS Technologies technical report submitted to the United States Space Force. 18 pp.

SRS Technologies, Inc. 2006g. Biological monitoring of southern sea otters, California brown pelicans, and western snowy plovers, and water quality and acoustic monitoring for the 27 June 2006 Delta IV NROL-22 launch from Vandenberg Air Force Base, California. SRS Technologies technical report submitted to the United States Space Force. 44 pp.

SRS Technologies, Inc. 2006h. Biological Monitoring of Southern Sea Otters, California Brown Pelicans, Gaviota Tarplant, and El Segundo Blue Butterfly, and Water Quality Monitoring for the 4 November 2006 Delta IV DMSP-17 Launch from Vandenberg Space Force Base, California. SRS Technologies Systems Development Division, Lompoc, California. 40 pp.

Thorson, P.H., J.K. Francine, E.A. Berg, L.E. Fillmore, and D.A. Eidson. 2001. Acoustic Measurement of the 21 September 2000 Titan II G-13 Launch and Quantitative Analysis of Behavioral Responses for Selected Pinnipeds on Vandenberg Air Force Base, CA. SRS Technologies technical report submitted to the United States Air Force and the National Marine Fisheries Service.

U.S. Air Force. 2018. Final Supplemental Environmental Assessment for Launch, Boost-Back, and Landing of the Falcon 9 at Vandenberg Air Force Base, California and Offshore Landing Contingency Options. 24 January 2018.

U.S. Air Force. 2023. Final Supplemental Environmental Assessment Falcon 9 Cadence Increase at Vandenberg Space Force Base, California and Offshore Landing Locations. 18 May 2023

U.S. Environmental Protection Agency (USEPA). 1992. Procedures for Emission Inventory Preparation. Volume IV: Mobile Sources. Emission Planning and Strategies Division, Office of Mobile Sources and Technical Support Division, Office of Air Quality Planning and Standards. 240 pp.

U.S. Fish and Wildlife Service. 2017. Biological Opinion on the Launch, Boost-Back and Landing of the Falcon 9 First Stage at SLC-4 at Vandenberg Air Force Base, Santa Barbara County, California (20 17-F-0480). 12 December 2017.

U.S. Fish and Wildlife Service. 2024. Biological Opinion on the Launch, Boost-Back, and Landing of the Falcon 9 First Stage at Space Launch Complex 4 (SLC-4) with project modification to include up to 16 additional launches between October 1 and December 31, 2024, Vandenberg Space Force Base, Santa Barbara County, California. 28 August 2024.

Vandenberg Space Force Base. 2018. Vandenberg solar array project. Retrieved 23 January 2024 from: https://www.vandenberg.spaceforce.mil/News/Article-Display/Article/1490020/vandenberg-solar-array-project/

World Meteorological Organization. 2022. Scientific Assessment of Ozone Depletion. GAW Report No. 278.

APPENDIX A
U.S. Fish and Wildlife Service Consultation

Biological Assessment for

Falcon 9 Cadence Increase and SLC-6 Modifications at Vandenberg Space Force Base, California

June 2024

Prepared for

Space Launch Delta 30, Installation Management Flight Environmental Assets
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ACRONYMS AND ABBREVIATIONS

ac	acre(s)
ARTO	arroyo toad
BA	Biological Assessment
CA	California
CAGN	coastal California gnatcatcher
CDFW	California Department of Fish and Wildlife
C.F.R.	Code of Federal Regulations
CNDDB	California Natural Diversity Database
CRLF	California red-legged frog
DAF	Department of the Air Force
dB	decibel(s) unweighted
dBA	A-weighted decibel(s)
DPS	Distinct Population Segment
E	east
ESA	Endangered Species Act
°F	degrees Fahrenheit
FR	Federal Register
ft	foot or feet
ft^2	square foot or feet
HIF	Horizontal Integration Facility
INRMP	Integrated Natural Resources Management Plan
kHz	kilohertz
km^2	square kilometers
LBVI	least Bell's vireo
LETE	California least tern
MAMU	marbled murrelet
mi	mile(s)
MSRS	ManTech SRS Technologies, Inc.
OCA	other carnivores in-air
PBO	Programmatic Biological Opinion
PCE	primary constituent elements
psf	pounds per square foot
RIRA	light-footed Ridgeway's rail
RORO	roll-on-roll-off
SLC	Space Launch Complex
SLC-4E	Space Launch Complex 4 East
SLC-4W	Space Landing Complex 4 West
SLM	sound level meter
SNPL	western snowy plover
SWPT	southwestern pond turtle
TWG	tidewater goby
U.S.C.	United States Code
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UTS	unarmored threespine stickleback

VSFB	Vandenberg Space Force Base (formerly Vandenberg Air Force Base (VAFB)
W	west

1 Introduction

1.1 Background & Consultation History

The purpose of this Biological Assessment (BA) is to address the effects of a proposed increase in the annual cadence for SpaceX Falcon 9 operations at Vandenberg Space Force Base (VSFB), California and redevelopment of Space Launch Complex (SLC) 6 on federally listed (endangered and threatened) species and their Critical Habitat as required by section 7 of the Endangered Species Act (ESA) of 1973 (16 United States Code [U.S.C.] section 1536). Pursuant to section 7(a)(2) of the ESA of 1973 (16 U.S.C. section 1536), as amended, the Department of the Air Force (DAF), is required to consult with the United States Fish and Wildlife Service (USFWS) for those actions it has determined may affect ESA-listed species or their Critical Habitat. The DAF is the lead agency for the purposes of this BA.

The USFWS has previously completed four biological opinions (BO; USFWS 2010, 2011, 2014a, 2017a, 2023), two concurrence letters (USFWS 2014b, 2015a), and one email transmittal of concurrence (USFWS 2022) regarding the effects of operations performed to support this launch program at SLC-4.

In the BO dated 10 December 2010 (USFWS 2010), the USFWS consulted on the modification and operation of SLC-4 East (SLC-4E) for the new Falcon 9 and Falcon Heavy Space Vehicle Program. The USFWS concurred that modification of SLC-4E, launch noise, and visual disturbance from space vehicle launches from this facility may affect, but were not likely to adversely affect the California least tern (LETE, *Sternula antillarum browni*), western snowy plover (SNPL, *Charadrius nivosus*), or southern sea otter (*Enhydra lutris nereis*). Although Falcon Heavy at SLC-4 was included in the 2010 BO, modifying SLC-4 to support Falcon Heavy would result in multiple long-duration shutdowns of the launch pad, disrupting many contracted missions and would not meet the need to provide additional launch capacity to support SpaceX's manifest, including for Government missions. Therefore, Falcon Heavy is no longer planned to operate at SLC-4.

The DAF requested reinitiation on 25 May 2011 due to a change in the effects determination for the California red-legged frog (CRLF; *Rana draytonii*), from "no effect" to "may affect, not likely to adversely affect." In the resulting BO (USFWS 2011), the USFWS concurred that launch noise and visual disturbance from space vehicle launches from this facility may affect, but were not likely to adversely affect the CRLF, LETE, SNPL.

On 10 October 2013, the DAF informed the USFWS of potential unauthorized impacts on CRLF resulting from the discharge of water into Spring Canyon during the launch of a Falcon 9 rocket on 29 September 2013. The DAF stated that all future launches from SLC-4E would be conducted with a dry flame duct to prevent discharge to Spring Canyon. In a letter dated 29 August 2014, the USFWS concurred that launch activities at SLC-4E may affect, but were not likely to adversely affect CRLF that may occur in suitable habitat in Spring Canyon (USFWS 2014b).

In the BO dated 22 December 2014 (USFWS 2014a), the DAF consulted with the USFWS on the proposed in-flight abort test and improvements at SSLC-4 West (SLC-4W) which included constructing a 300-foot (ft) diameter concrete pad to accommodate future landings of Falcon 9 first stage, two new access roads, and a new "FireX" fire control system. The USFWS concurred that the proposed activities may affect, but were not likely to adversely affect the LETE, SNPL, or southern sea otter. The USFWS authorized incidental take of CRLF resulting from site improvements and, for frogs, capture, and relocation.

On 2 July 2015, the DAF consulted with the USFWS on Falcon 9 boost-back landing operations, which would occur up to 10 times per year at SLC-4W or at sea. The anticipated engine noise at landing would be less than the noise generated during launch, and the anticipated sonic boom overpressure would be up to a maximum of 2.0 psf. The USFWS concurred that boost-back landings of the Falcon 9 first stage at SLC-4W may affect, but were not likely to adversely affect the CRLF, LETE, SNPL, or southern sea otter (USFWS 2015a).

In the BO dated 12 December 2017 (USFWS 2017a), the DAF consulted with the USFWS on the launch of the Falcon 9 from SLC-4E, followed by first stage boost-back and landing at SLC-4W up to 12 times per year, use of up to 200,000 gallons of water in the flame duct, construction of a civil structure and retention basin to divert and retain a portion of the water expelled from the flame duct, removal of vegetation in Spring Canyon to minimize potential effects to nesting birds, and habitat enhancement to mitigate for impacts on riparian vegetation. The USFWS concurred that these activities may affect, but were not likely to adversely affect the California condor (*Gymnogyps californianus*), marbled murrelet (MAMU; *Brachyramphus marmoratus*), and southern sea otter, and may affect, and would likely adversely affect CRLF, LETE, and SNPL. The USFWS also concurred that the proposed project would not affect designated Critical Habitat for any species.

In an email communication dated 13 October 2022, the USFWS agreed that the effects from increasing the number of Falcon 9 launches from 12 to 14 in 2022 were consistent with existing analyses and reinitiation was not warranted (USFWS 2022).

As part of the Programmatic Biological Opinion (PBO) for routine operations and maintenance activities at VSFB (USFWS 2015), the impacts of maintaining the firebreaks surrounding both SLC-4E and SLC-4W and activities conducted at the harbor have been analyzed.

On 21 March 2023, the USFWS issued a BO (2022-0013990-S7-001; USFWS 2023a) to the DAF for an increase in the SpaceX Falcon 9 launch cadence from 12 to 36 launches per year at SLC-4 on VSFB. The USFWS concurred that these activities may affect, but were not likely to adversely affect MAMU, southern sea otter, California condor, unarmored threespine stickleback (UTS; *Gasterosteus aculeatus williamsoni*), and tidewater goby (TWG; *Eucyclogobius newberryi*) and would likely adversely affect CRLF, LETE, and SNPL.

This BA examines the potential effects of an increase in the SpaceX Falcon 9 launch cadence from 36 to 50 launches per year at VSFB and modifying SLC-6 to support the Falcon 9 and Falcon Heavy launches and landings on the federally listed TWG, UTS, California tiger salamander (CTS; *Ambystoma californiense*), CRLF, arroyo toad (ARTO; *Anaxyrus californicus*), MAMU, southwestern willow flycatcher (SWFL; *Empidonax traillii extimus*), least Bell's vireo (LBVI; *Vireo bellii pusillus*), SNPL, LETE, California condor, coastal California gnatcatcher (CAGN; *Polioptila californica californica*), light-footed Ridgeway's rail (RIRA; *Rallus obsoletus levipes*), southern sea otter, and Critical Habitat for these species, where designated. This BA also analyzes potential effects on the unlisted western spadefoot (*Spea hammondii*), which is under review for potential listing under the ESA, and the southwestern pond turtle (SWPT; *Actinemys pallida*), which is proposed for listing under the ESA (88 Federal Register [FR] 68370 68399). Following each launch, SpaceX would perform a boost-back and landing of the first stage booster up to 50 times, either downrange on a droneship or at SLC-4 at VSFB. SpaceX would continue to land no more than 12 first stages at SLC-4 per year.

1.2 Other Species Considered

Three additional ESA-listed species were considered during the analysis of this project but dismissed. Lompoc yerba santa (*Eriodictyon capitatum*) and beach layia (*Layia carnosa*) occur in the greater area; however, neither species were found during biological surveys of the Action Areas where ground disturbing activities would occur and physical impacts would not extend into areas occupied by these species. In addition, SpaceX does not propose to use solid rocket fuel, so there would be no potential deposition of acidic compounds on the landscape. Consequently, consideration of these species is not carried forward in this BA. Although suitable habitat for Gaviota tarplant (*Deinandra increscens* ssp. v*illosa*) exists in the Action Area where physical impacts would occur, the area was surveyed by a qualified biologist and only the common unlisted grassland tarplant (*Deinandra increscens* ssp. *increscens*) was present. Therefore, consideration of these three species is not carried forward in this BA.

2 Project Description

2.1 Project Location

VSFB occupies approximately 99,100 acres (ac) of central Santa Barbara County, California, and is approximately halfway between San Diego and San Francisco (Figure 2.1-1). VSFB occurs in a transitional ecological region that includes the northern and southern distributional limits for many plant and animal species. The Santa Ynez River and State Highway 246 divide VSFB into two distinct parts: North Base and South Base. SLC-4 is located on South Base, approximately 4.0 mi south of the Santa Ynez River and 0.9 mi east of the Pacific Ocean. SLC-4E is the existing launch facility for the Falcon 9 program and SLC-4W is the existing landing facility for the Falcon 9 program. SLC-6 is 3.6 mi south of SLC-4, approximately 1.0 mi east of the Pacific Ocean (Figure 2.1-1).

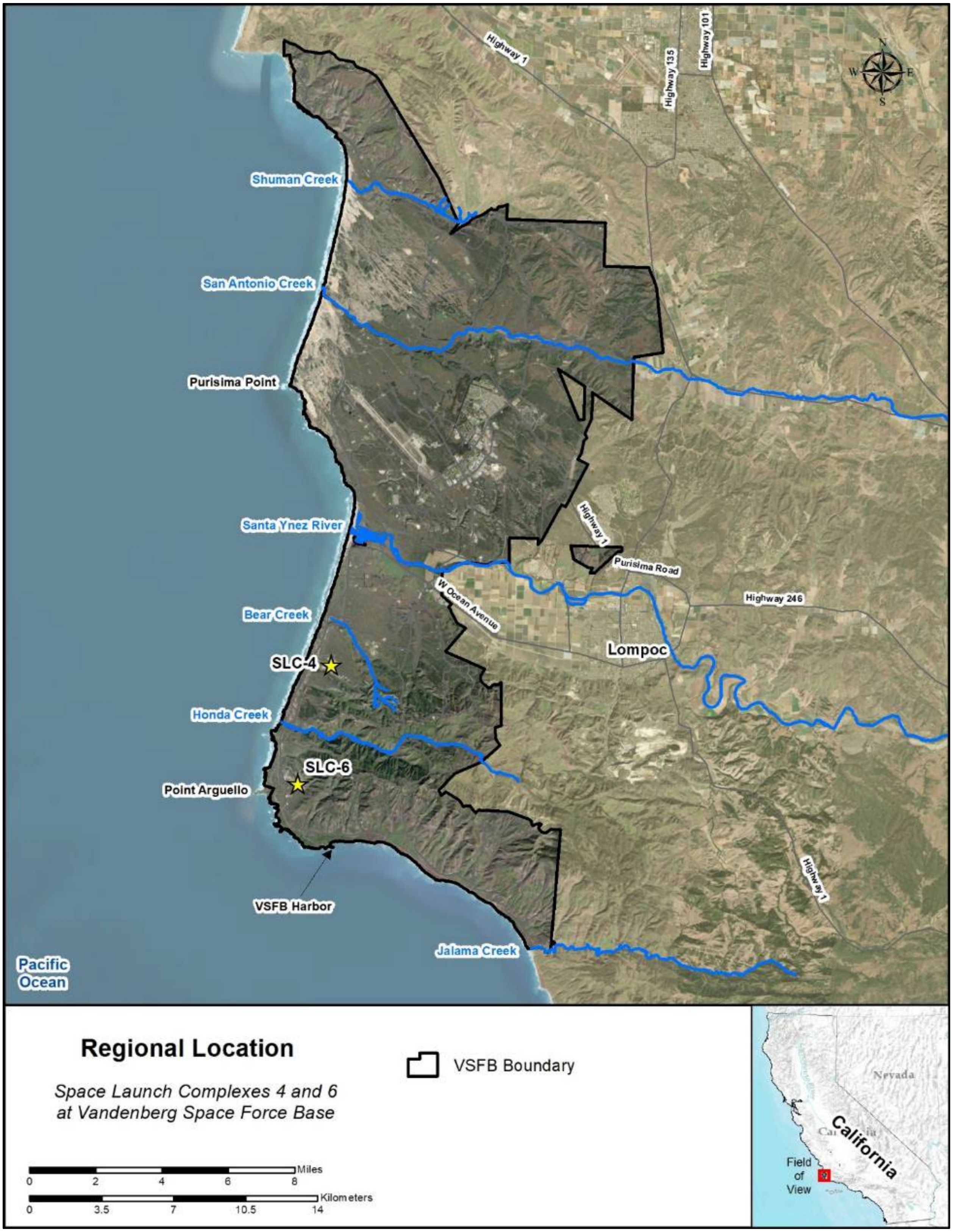

Figure 2.1-1. Regional location of SLC-4 and SLC-6.

2.2 Proposed Action

The Proposed Action is to increase the annual Falcon 9 annual launch cadence at SLC-4 and modify SLC-6 to support the Falcon launch vehicles. Under the Proposed Action, SpaceX would launch Falcon 9 up to 50 times per year from SLC-4. Following each launch, SpaceX would perform a boost-back and landing of the first stage boosters up to 50 times, either downrange on a droneship or at landing zones at VSFB. As approved in prior environmental documents, no more than 12 first stage landings would occur at SLC-4 per year. SpaceX proposes to construct landing zones adjacent to SLC-6 to support future landing operations at SLC-6. Landing operations at SLC-6 would be evaluated in future environmental reviews.

2.2.1 Launch Vehicle

A detailed description of Falcon 9 can be found in the prior 2017 and 2023 BOs (USFWS 2017a, 2023). **2.2**

2.2.2 1SLC-6 Modifications

SpaceX would modify SLC-6 (Figure 2.2-2) to support Falcon 9 and Falcon Heavy launches, including demolition of existing structures and construction of infrastructure that would support the Falcon 9 and Falcon Heavy launch vehicle programs. Demolition would be limited to structures within the SLC-6 launch complex. Demolition techniques for large structures may involve the use of heavy machinery to cut or pull down the structures or use explosives. Infrastructure would include utilities, the potential construction of a new hangar, construction of a vehicle erector system at the launch pad, and minor modification to the existing flame trench. SpaceX would construct new or improve existing power, water, wastewater, and communications utilities. Commodity storage, including rocket propellant-1, liquid oxygen, nitrogen, helium, and water, would be constructed within the existing launch complex to support launch operations. Construction may occur at any time of the day or night. Construction activities would not occur in previously undisturbed areas with potential for CRLF or SWPT occurrence until 24 hours after an actual precipitation event greater than 0.2-inch accumulating within a 24-hour period.

Table 2-1 summarizes potential noise levels from typical construction equipment and how far that sound typically propagates. Daily sound levels would vary depending on the type of activity occurring that day and equipment used, but generally sound would remain within the vicinity of SLC-6. If explosives were to be used for demolition, the exact sound level is dependent on the size of the charge and is anticipated to result in a short impulsive sound similar to those experienced during first-stage landing events at SLC-4. The duration of demolition (i.e., the number of days that noise would be produced) would depend on the methods used for demolition. Traditional demolition methods using equipment such as mechanical shears would require more time to remove the structures compared to explosives.

Table 2-1. Estimated Received Unweghted Sound Levels of Standard Construction Equipment at Various Distances*.

Estimated received Noise Levels (dB)	Distance from Shears (ft)	Distance from Jackhammer (ft)	Distance from Crane (ft)	Distance from Welder/Torch (ft)
120	3.2	1.5	--	--
110	10	4.5	1.8	--
100	32	14	5.6	2.5
90	100	45	18	7.9
80	320	140	56	25

* Source: Washington State Department of Transportation 2012

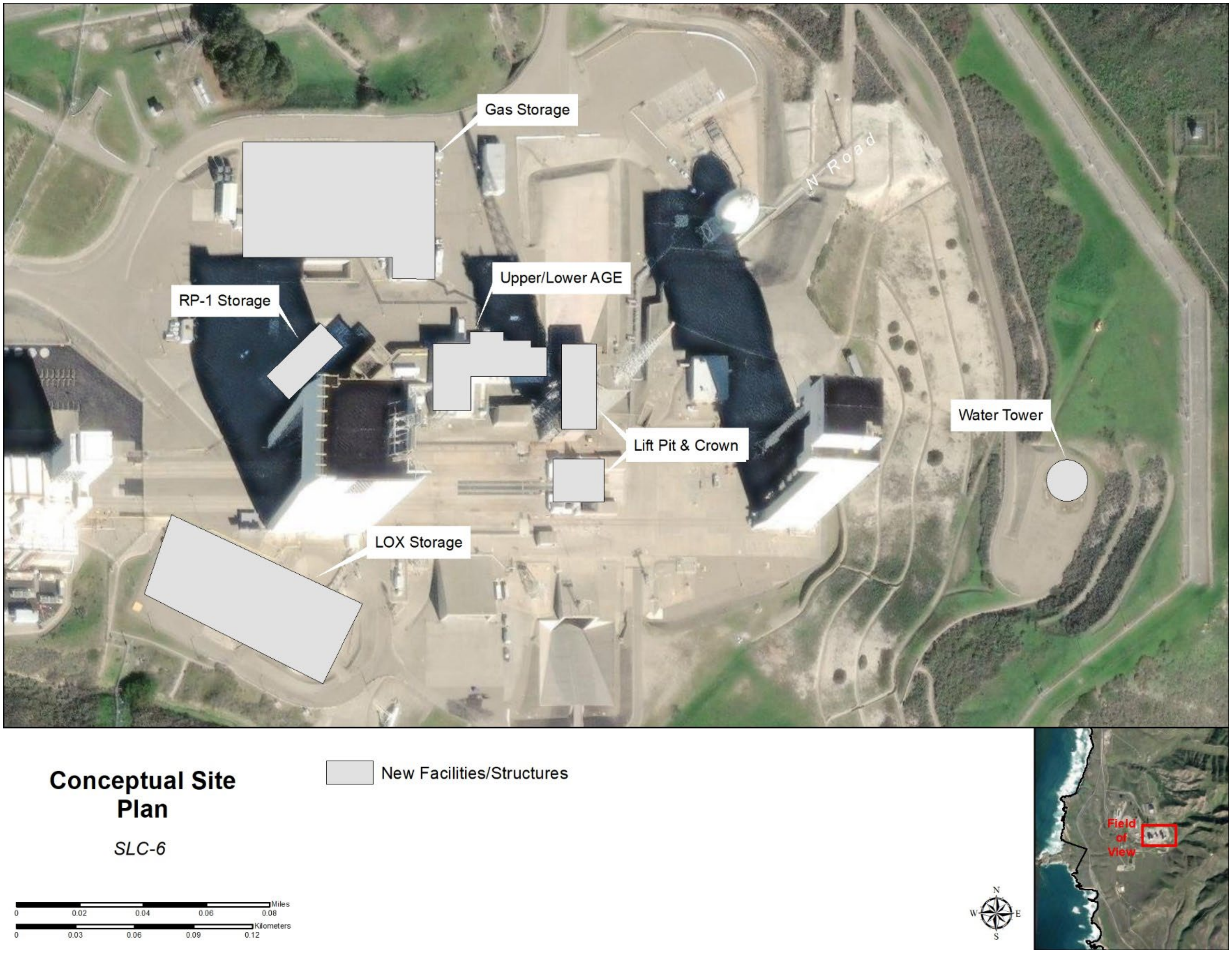

Figure 2.2-2. SLC-6 conceptual site plan; AGE = aerospace ground equipment, LOX = liquid oxygen, RP-1 = rocket propellant-1

Construction of SLC-6 Landing Zones & Firebreaks

SpaceX would construct two landing zones south of SLC-6 to support landing of first stage Falcon boosters launching from SLC-6 (Figure 2.2-3). Each landing zone would be made up of a 280-ft diameter concrete pad surrounded by a 60-ft gravel apron, for a total diameter of 400 ft. SpaceX would construct a new nitrogen gas line from SLC-6 to a fluids ground supporting equipment bay at the landing zones. A 30-ft by 30-ft pedestal would be constructed at each landing pad. Crane storage, which is a cleared area to lay down cranes when not in operation, is proposed on the western boundary. Each landing zone would have a connection to the existing road to support booster transport. Approximately 16 ac would be cleared to construct the landing zones. A new firebreak is proposed south of the landing zones. Cypress Ridge Road and N Road would also be improved for fire access. These improvements are anticipated to be within the existing roadway footprints. Proposed firebreaks are shown in Figure 2.2-4.

Any fill would be purchased from local existing off base suppliers, and/or if using any sources on-base, the fill would be obtained from preexisting, established borrow pits, which are covered under existing NEPA and related regulatory permitting.

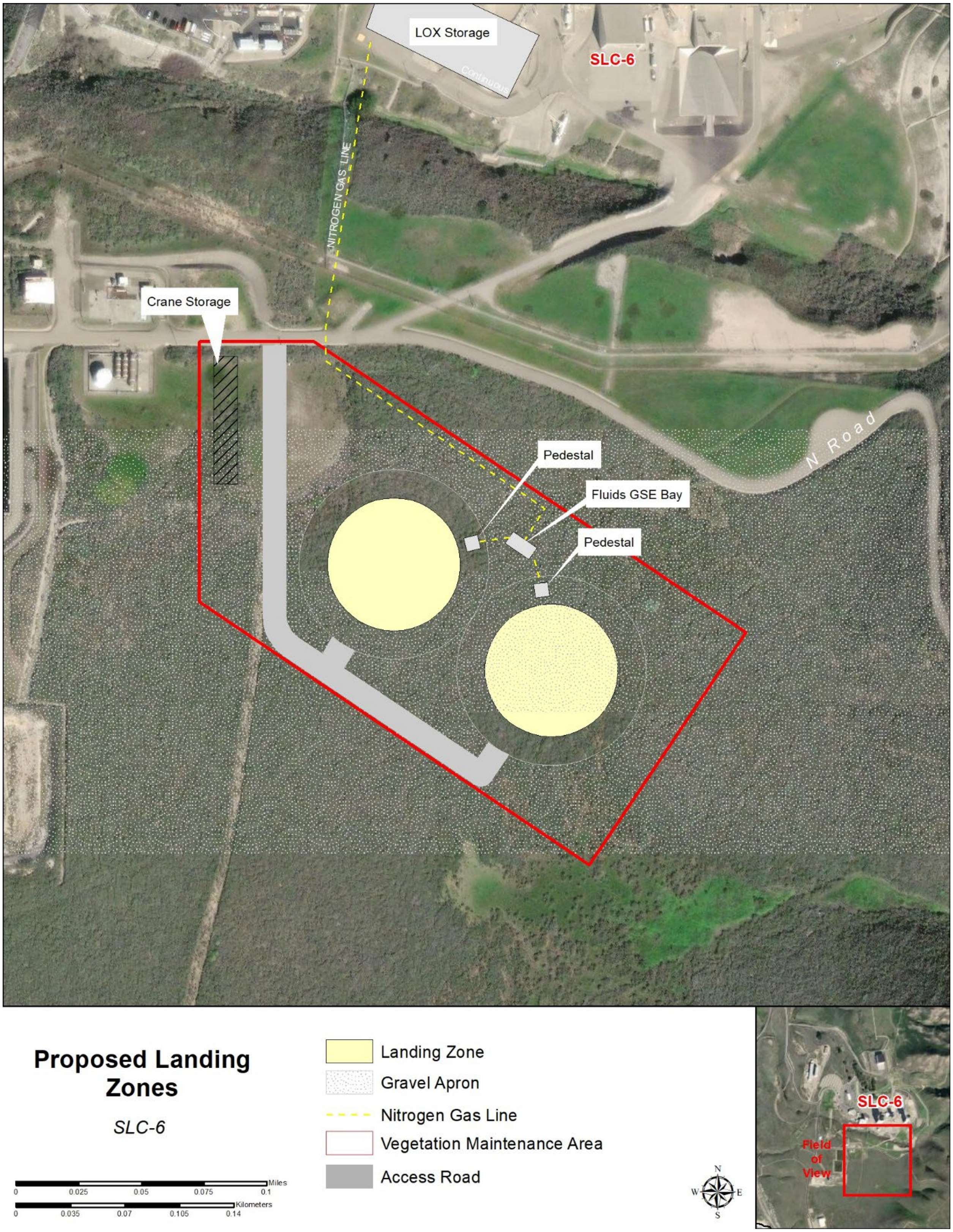

Figure 2.2-3. Conceptual site layout for construction of new landing zones.

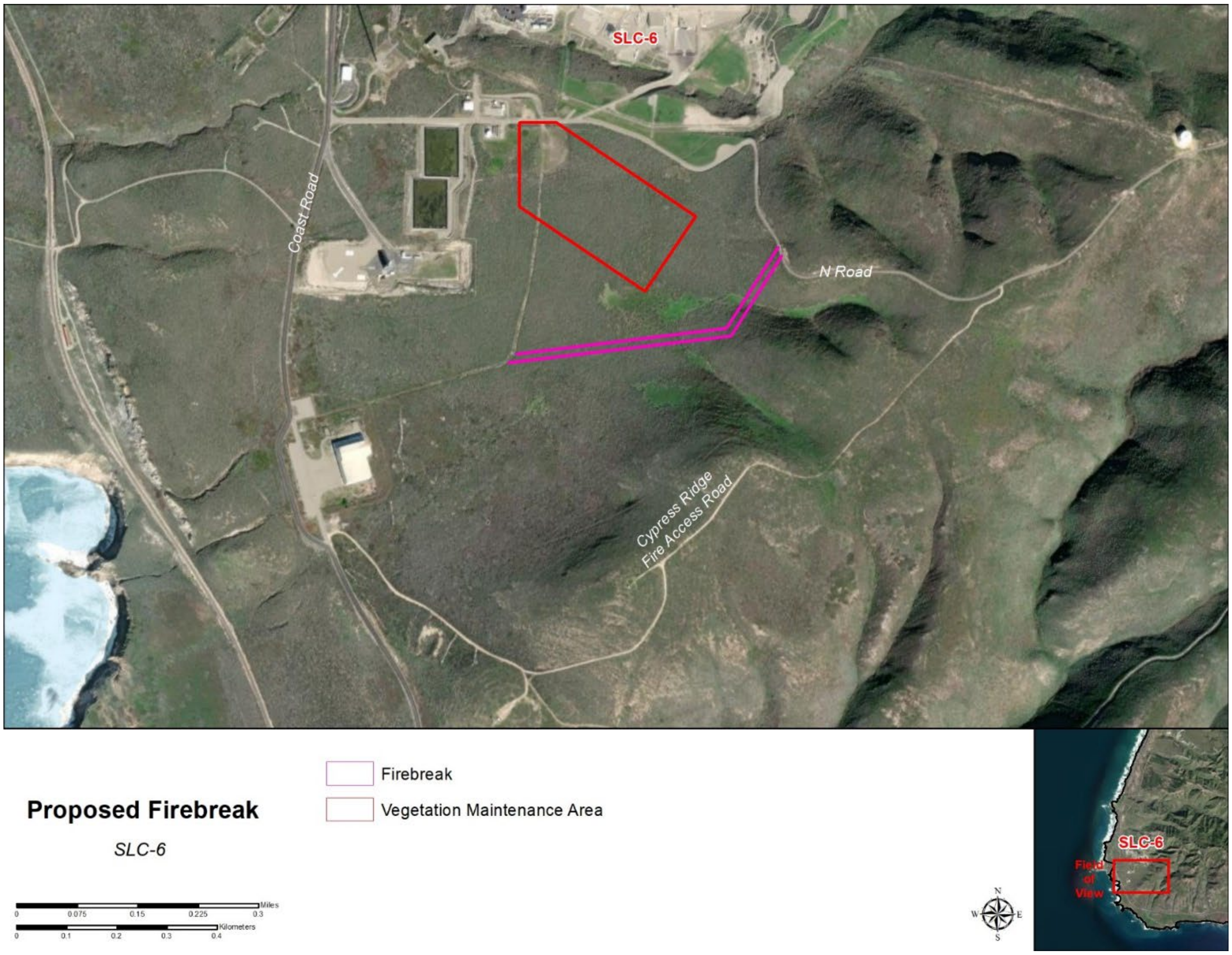

Figure 2.2-4. Proposed Firebreak.

Alternative 1 – SLC-6 with Horizonal Integration Facility

SpaceX is considering two alternative hangar locations. Under Alternative 1, SpaceX would modify the horizontal integration facility (HIF) located north of SLC-6 to support Falcon 9 and Falcon Heavy operations (Figure 2.2-5). Modifications would include interior work, construction of an approximately 5,000 square foot (ft^2) annex on the south side of the building, and construction of an approximately 42,000 ft^2 paved area north of the building to provide rear access into the hangar. SpaceX would construct rails from the hangar to the launch pad to transport Falcon. Existing culverts along this road would be maintained or modified/improved during construction of the rail system. At this time the HIF is currently leased by United Launch Alliance.

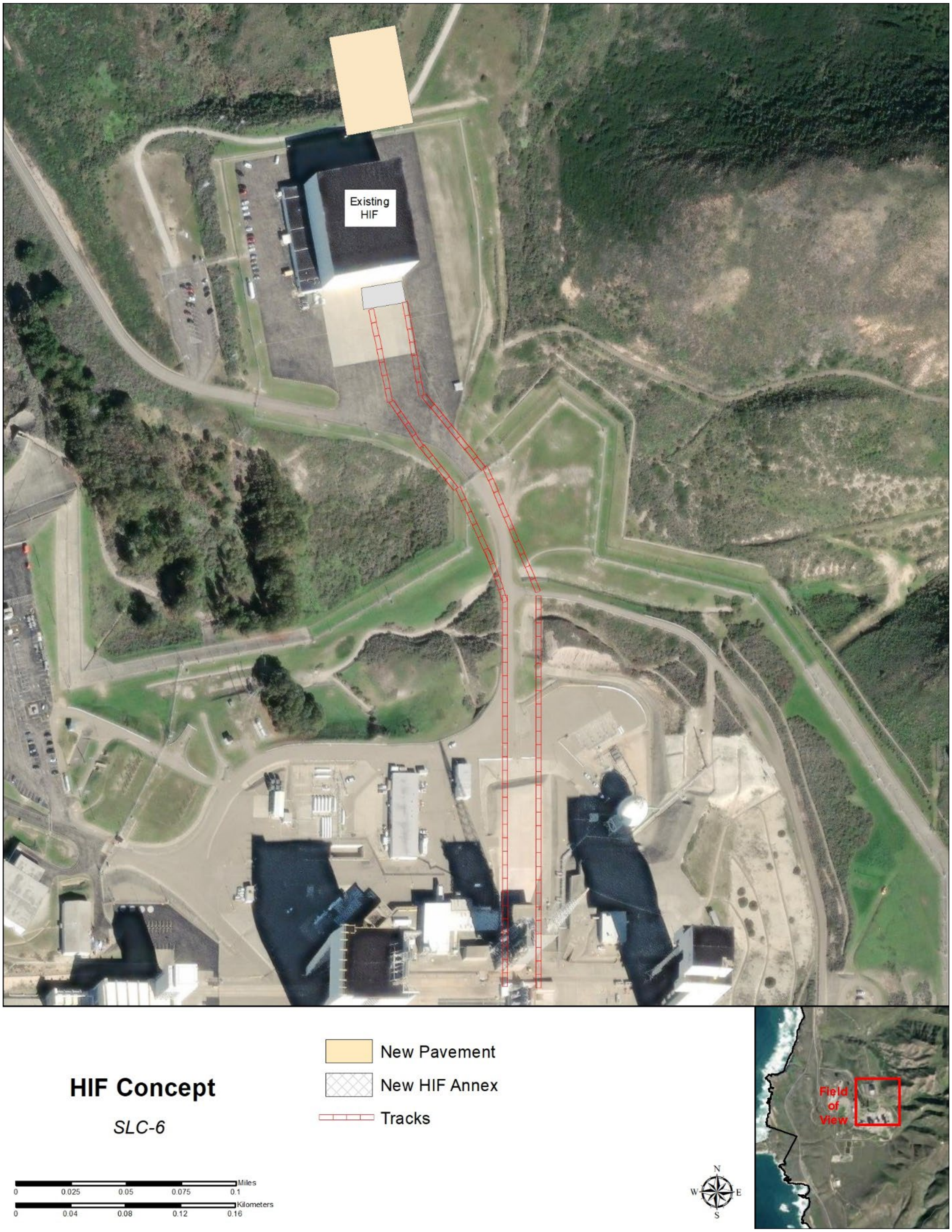

Figure 2.2-5. Alternative 1 – HIF Concept.

Alternative 2 – SLC-6 with North Hangar

Under Alternative 2, SpaceX would construct an approximately 61,250 ft^2 hangar north of the launch pad line to support Falcon 9 and Falcon Heavy integration and processing (Figure 2.2-6). Areas around the hangar would be graded to provide rear access to the hangar. SpaceX would construct rails from the hangar to the launch pad to transport Falcon. Existing culverts along this road would be maintained or modified/improved during construction of the rail system. The SLC-6 fence would be relocated and vehicular access from Luner Road to N Road would be removed. An apron would be constructed to provide rear access into the hangar.

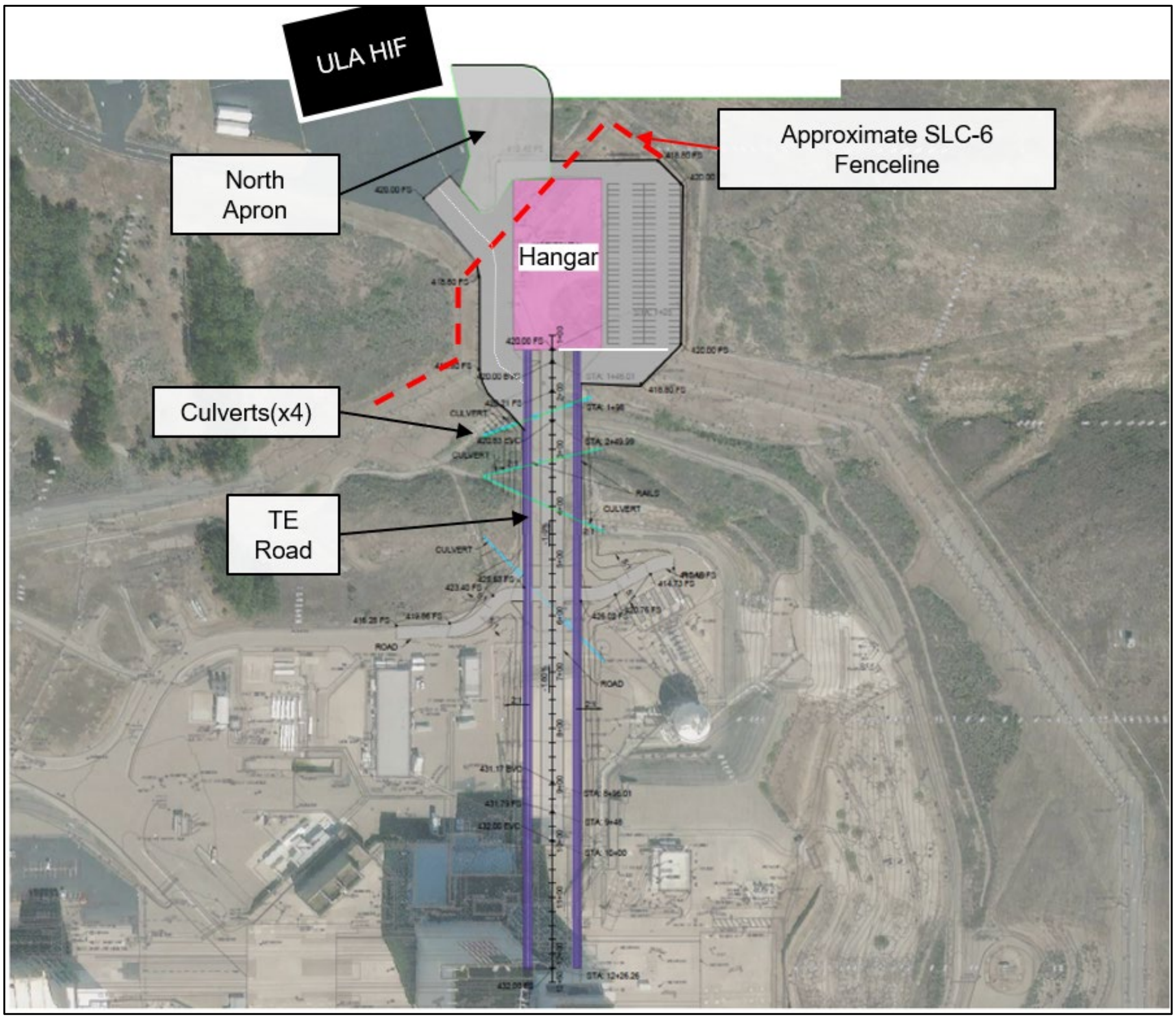

Figure 2.2-6. Alternative 2 – SLC-6 with North Hangar.

2.2.3 Launch Operations

SpaceX would conduct launch operations at SLC-4 in the same way as described in the 2023 BO (USFWS 2023). One to three days before each launch, a static fire test, which lasts a few seconds, may be conducted. The need to conduct a static fire test depends on the mission, but there would be no more than 30 static fire events per year. Launch operations would occur day or night, at any time during the year. Launches could occur frequently as every 2 days, though it is anticipated that the annual launch cadence would be spread throughout the year. SpaceX would perform a boost-back and landing of the first stage, either downrange on a droneship or at the landing zones at SLC-4. Mission objectives may occasionally require expending the first stage booster in the Pacific Ocean. If intentionally expending the first stage, it would break up upon atmospheric re-entry and there would be no residual propellant or explosion upon impact with the Pacific Ocean. The first stage remnants would sink to the bottom of the ocean.

SpaceX would utilize approximately 70,000 gallons of water per launch at SLC-4, as described in the 2023 BO (USFWS 2023). Landing operations at SLC-4 would continue to utilize approximately 40,000 gallons per landing. In addition, a maximum of 1.37 million gallons (4.20 ac-ft) per year would be required to support the personnel and operational activities at SLC 4, a maximum of 1.19 million gallons (3.64 ac-ft) per year to support personnel at Buildings 398 and 520. Therefore, at maximum cadence, the Proposed Action would use up to 6.54 million gallons (20.07 ac-ft) of water per year.

Trajectories from SLC-4 would remain within the previously analyzed azimuth range of 140 to 325 degrees. SpaceX would land first stage boosters launched from SLC-4E at SLC-4W or downrange on a droneship as described in the 2017 and 2023 BOs (USFWS 2017a, 2023). SpaceX would land up to 12 boosters at SLC-4 annually.

SpaceX would utilize the same downrange area previously considered in the 2023 BO (USFWS 2023). The droneship would then transport the booster to the Port of Long Beach as described in the 2023 BO (USFWS 2023). SpaceX would continue to transport first stage boosters and fairings from the Port of Long Beach to the VSFB harbor via a "roll-on-roll-off" barge, as described in the 2023 BO (USFWS 2023). The Proposed Action would include up to 50 events per year utilizing roll-on-roll-off operations.

2.2.4 Launch and Landing Noise

Engine noise was modeled using RNoise. This sophisticated model incorporates numerous components, including the acoustic power of the rocket engine source, forward flight effects, the angle from the source to the receiver (directivity), Doppler effect, propagation between the source and receiver (ray path), atmospheric absorption, and ground interference to estimate received noise levels. RNoise assumes the surface of the earth is flat and therefore does not account for attenuation due to landforms. Therefore, the estimates of engine noise levels below are conservative for areas shielded by hills, bluffs, or other features, such as buildings or dense vegetation.

Figures depicting launch modeling results are included in Chapter 4 under relevant species accounts. During Falcon 9 launches from SLC-4, engine noise produced during launches would be audible across VSFB and the surrounding areas. Engine noise during Falcon 9 first stage landings at SLC-4 would impact a smaller area, between Purisima Point and Point Conception along the coast and inland to Lompoc. Landing noise follows launch and associated launch engine noise by approximately 5 to 7 minutes and typically occurs slightly before the sonic boom impacts land. Static fire engine tests, which typically occur 1 to 3 days prior to launch and last up to 7 seconds per event, would also generate noise across VSFB and off base areas, including the Santa Rita Hills and Gaviota Coast.

During ascent, a sonic boom (overpressure of impulsive sound) with a peak of approximately 3.0 to 5.0 pounds per square foot (psf) would be generated. Depending on the launch trajectory, the sonic boom may or may not impact the surface of the earth. Since 2017, approximately 25 percent of Falcon 9 launches from SLC-4 have not produced sonic booms that impact the surface of the earth because the ascent of the rocket was too steep. When the sonic booms do impact the earth's surface, they primarily impact the Pacific Ocean, but may overlap the Northern Channel Islands (NCI; see example shown in Figure 4.11-3). Since 2017, of the launches that produced sonic booms that impacted the surface of the earth, approximately 30 percent have impacted the NCI. Sonic boom modeling determined that launches with these northerly mission profiles will only impact the ocean's surface with no impacts to land.

For easterly trajectories, sonic booms may impact southeastern Santa Barbara County, Ventura County, and Los Angeles County on the mainland (Figure 2.2-7). The vast majority of the sonic booms that would impact these areas would be less than 1.0 psf. Even with identical trajectories, atmospheric conditions create considerable variation in sonic booms locations and intensities. To account for this variation, PCBoom can utilize meteorological parameters in the model that effect where and at what level a sonic boom may impact the surface of the earth. In the late 1990's, SRS Technologies, Inc. assembled a series of daily meteorological profiles across 10 years (1984-1994, one per day for 10 years) from radiosonde data for weather balloons released by the VSFB weather squadron. The data include pressure, temperature, wind speed, and wind direction along an elevational profile from ground, every 1,000 feet (ft), to 110,000 ft. Figure 2.2-7 depicts the overlaid output from sonic boom modeling software (PCBoom) for four actual SpaceX easterly trajectories, each trajectory run between 29 and 34 times, each run representing 1 of between 29 and 34 randomly selected meteorological profiles that capture potential weather conditions throughout the year (125 model outputs total) overlaid in the image. Meteorological conditions were sampled with removal to avoid repeated model runs for each trajectory. 15% of model runs predicted any impacts in eastern Santa Barbara County; 50% of these sonic boom levels were less than 0.25 psf, 87% were less than 1.0 psf, and 0.3% were greater than 2.0 psf. The highest level predicted for eastern Santa Barbara County was 2.13 psf. 97% of the model runs predicted sonic boom impacts within Ventura County; 65% were less than 0.25 psf, 86% were less than 1.0 psf, and 0.04% were greater than 2.0 psf. The highest predicted boom level predicted for Ventura County 2.03 psf. 94% of model runs predicted impacts in western Los Angeles County; 95% were less than 0.25 psf, and 100% were less than 0.75 psf.

During first stage descent for landings at SLC-4, a sonic boom would also be generated. Falcon 9 missions conducted with first stage landing at SLC-4W have had a maximum modeled sonic boom of between 2 and approximately 8 psf. Although unlikely, sonic booms up to 3.1 psf may also impact the NCI during landing events at SLC-4 or on droneships in offshore areas near VSFB. However, during the majority of downrange droneship landings in the proposed landing areas, sonic booms would be directed entirely at the ocean surface without impacting any land.

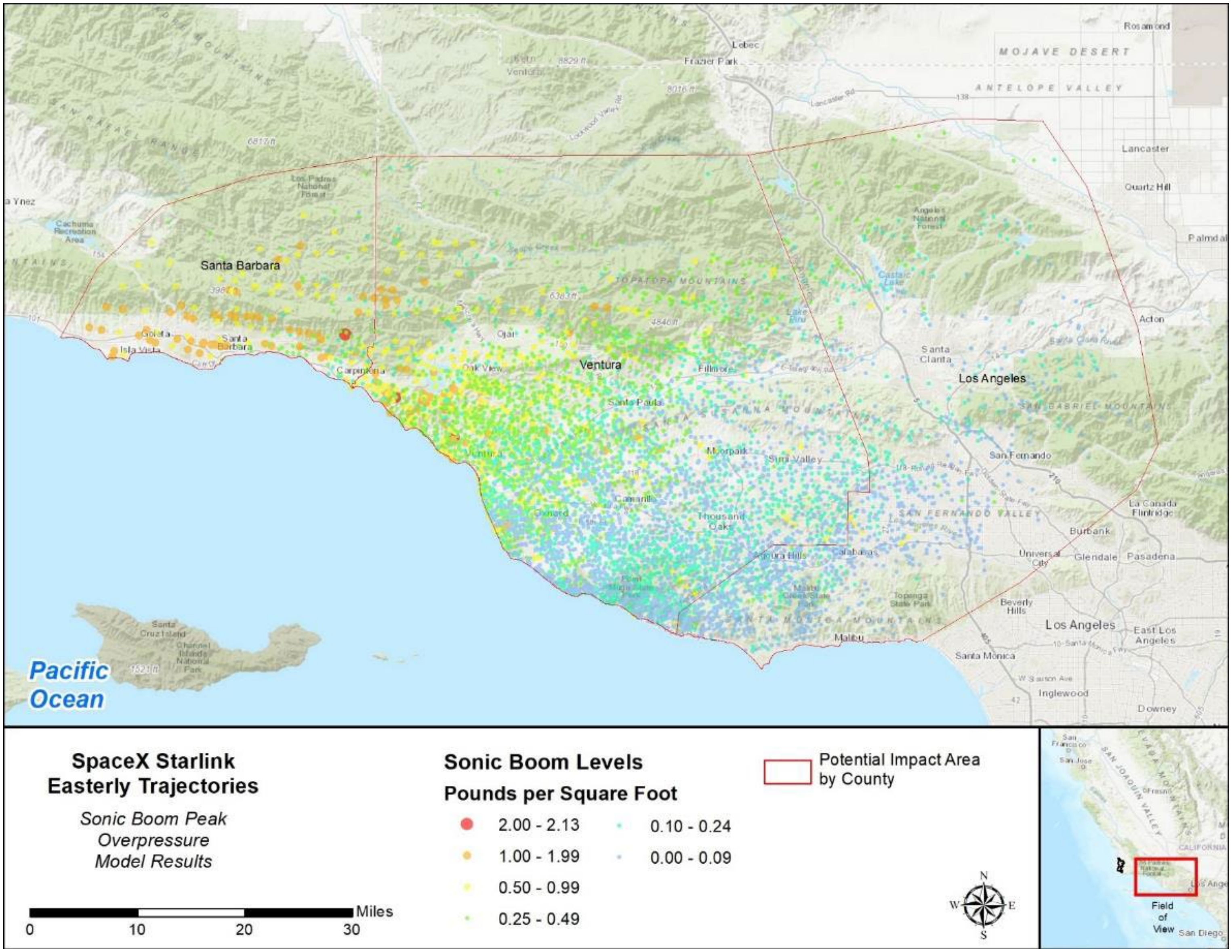

Figure 2.2-7. Potential sonic boom impact areas in eastern Santa Barbara, Ventura, and Los Angeles Counties.

2.3 Avoidance, Minimization, Monitoring, and Mitigation Measures

The minimization and monitoring measures listed below would be implemented to avoid, minimize, or characterize the effects of the Proposed Action on the CRLF, SWPT, SWFL, LBVI, SNPL, LETE, MAMU, California condor, and southern sea otter. There are no minimization or monitoring measures proposed for TWG, UTS, CTS, or western spadefoot. There are no feasible methods to minimize the intensity of the sonic boom or engine noise; however, the estimates of noise levels are conservatively high, since the modeling does not consider attenuation due to landforms.

Avoidance and minimization measures included in this BA require various levels of biological competency from personnel completing specific tasks, as defined below:

- Permitted Biologist: Biologist with a valid and current USFWS section 10(a)(1)(A) Recovery Permit or specifically named as an approved biologist in a project-specific Biological Opinion (BO) or the VSFB PBO. The DAF will coordinate with the USFWS prior to assigning permitted biologists to this project.
- USFWS Approved Biologist: Biologist with the expertise to identify listed species and species with similar appearance. The DAF will review and approve the qualifications or authorization forms from each individual, and then submit a request to the USFWS for review and approval no less than 15 days prior to the start of the Proposed Action. Each resume will list their experience and qualifications to conduct specific actions that could potentially affect listed species and their habitats. A USFWS approved biologist could train other biologists and personnel during surveys and project work; in some cases, a USFWS approved biologist could also provide on-site supervision of other biologists.
- Qualified Biologist: Biologist trained to accurately identify specific federally listed species and their habitats by either a permitted or USFWS approved biologist. This person could perform basic project monitoring but would need to have oversight from a permitted or USFWS approved biologist. Oversight will require a permitted or USFWS approved biologist to be available for phone/email consultation during the surveys and to have the ability to visit during monitoring/survey activities if needed.

2.3.1 General Environmental Protection Measures

The following protection and monitoring measures would apply to all aspects of the Proposed Action to protect and minimize effects on biological resources:

- Qualified biological monitors, approved by USFWS and 30 CES/CEIEA, shall be present to monitor activities at all times deemed necessary by the DAF throughout the length of the project to minimize impacts on these species. The biological monitors shall be responsible for delineating areas where special-status species are located or concentrated and inspecting equipment and equipment staging areas for fluid leaks. Prior to the onset of maintenance activities, qualification submittals of biologist(s), who would conduct the monitoring, surveying, and other biological field activities shall be submitted by 30 CES/CEIEA to the USFWS for approval.
- USFWS Approved Biologists would relocate special-status species in jeopardy of being killed or injured by construction, including CRLF and SWPT.

- Qualified biologists shall brief all project personnel prior to participating in project implementation activities. At a minimum, the training would include a description of the listed species and sensitive biological resources occurring in the area, the general and specific measures and restrictions to protect these resources during project implementation, the provisions of the ESA and the necessity of adhering to the provisions of the ESA, and the penalties associated with violations of the ESA.
- Disturbances shall be kept to the minimum extent necessary to accomplish project objectives.
- All erosion control materials used (i.e., gravel, sand, fill material, wattles, etc.) would be from weed-free sources. Only nonplastic, 100 percent biodegradable erosion control materials (e.g., erosion blankets, wattles) would be left in place following project completion.
- Portable toilets would only be placed over paved surfaces or within staging areas.
- All human-generated trash at the project site shall be disposed of in proper containers and removed from the work site and properly secured in a suitable trash container at the end of each workday. Special attention will be paid to ensure any food waste is properly contained. All construction debris and trash shall be removed from the work area upon completion of the project.
- A qualified biologist shall inspect any equipment left overnight prior to the start of work. Equipment would be checked for presence of special-status species in the vicinity and for fluid leaks.
- The DAF would continue to remove nonnative, invasive predators encountered during survey efforts (i.e., bullfrogs [*Lithobates catesbeianus*]).
- To avoid transferring disease or pathogens between aquatic habitats during the course of surveys and handling of amphibians, the biologist(s) shall follow decontamination procedures described in the Declining Amphibian Population Task Force's Code of Practice (USFWS 2002a).
- Prior to construction activities, wildlife and special-status species, including CRLF, shall be removed from an exclusion area within the project site and relocated, to the nearest suitable habitat location at least 500 ft away to decrease the likelihood of recapture through the process described below. These activities would be accomplished prior to the start of construction and only under the direct supervision of a USFWS Approved Biologist.
- Exclusion Area. An exclusion area (or potentially multiple separate exclusion areas) would be established in all areas requiring the removal of vegetation, placement of fill, and removal/exclusion of sensitive species.
    - Under direction of a qualified biologist, the exclusion area would be encircled with minimum 3-ft-high silt fencing, anchored with metal T-posts, and buried along the bottom edge to the best extent possible to prevent terrestrial wildlife, including CRLF and SWPT, from entering the site.
    - Following completion of the installation of exclusion fencing, qualified biologists would survey the exclusion area for wildlife and special-status species, including

CRLF and SWPT. A USFWS Approved Biologist would capture all CRLF and SWPT to the nearest suitable habitat outside of the exclusion area and released.

  - All animals would be held in 5-gallon buckets until release. All animals held would be segregated by size and species such that predation would be unlikely. The holding time would be minimized to the greatest extent feasible and the health of all held animals would be continuously monitored to evaluate the need for additional measures to protect the animals, such as aeration of water in holding buckets.
  - The exclusion fencing would be inspected twice daily by qualified biologists. Prior to the start of work each day, fencing would be inspected for any breaches that may have been created overnight and allowed terrestrial wildlife to enter the exclusion area. At the end of each workday, the fencing would be inspected again to identify any areas that may need repair prior to nightfall. Compromised fence would be repaired immediately. If significant breaks are discovered during the morning inspection, a survey would be conducted that night to detect and remove any CRLF or SWPT that may have entered the site.
  - The exclusion fencing would be removed at the completion of construction activities.
- Any open holes or trenches will be covered with plywood or metal sheets and supplied with an escape ramp if left overnight to minimize the risk of entrapment of CRLF, SWPT, or other wildlife.
- Precipitation Events: Construction activities will not occur in previously undisturbed areas with potential for CRLF or SWPT occurrence until 24 hours after an actual precipitation event greater than 0.2-inch accumulating within a 24-hour period.
- No overnight staging of equipment or supplies would occur within 0.10 mi of CRLF or SWPT aquatic habitat. Measures would be implemented that preclude CRLF or SWPT from accessing the staging area (e.g., drift fence barrier installed).
- A qualified biologist will survey the areas of the construction site with potential CRLF or SWPT occurrence, including any open holes or trenches, each day prior to initiation of work.
- To avoid potential project-related impacts on nesting migratory birds, if vegetation clearing is initiated during avian nesting season (15 February through 15 August), a qualified biologist would conduct nesting bird surveys within 250 ft of the Action Area prior to project initiation and vegetation-clearing activities. If nesting migratory birds are found within the Action Area, a buffer of adequate size to prevent disturbance from project-related activities (to be determined by the biological monitor) would be marked with flagging tape to avoid disturbance. The nest would be monitored to determine impacts, if any, from project-related disturbance. In addition to ensuring compliance with the Migratory Bird Treaty Act, this measure would ensure any undetected ESA-listed birds are not present during vegetation removal. If work occurs during nesting season, a qualified biologist would conduct bird nest surveys prior to project activities.
- The DAF will continue to sample water quality in lower Spring Canyon once annually when ponded water is present to ensure no project-related byproducts (i.e., launch combustion

residue, operations-related run-off, etc.) have entered the waterway in a manner not previously considered in this analysis. The DAF will continue to perform sampling a minimum of once a year until 2026, as required under BO 2022-0013990-S7-001 (USFWS 2023a). The DAF will design water quality sampling to detect potential project related byproducts and any resulting associated changes in aquatic habitat (i.e., salinity, pH, etc.). Sampling will consider and utilize the most recent applicable advances in water quality sampling technology. The DAF will include maps depicting sampling locations during annual reporting. The DAF will collect and clearly present data including any associated chemical and nutrient presence, dissolved oxygen, water temperature, turbidity, and any other pertinent observations regarding ecosystem condition for purposes of annual comparison. If the DAF finds that project related water contamination occurs, the DAF will coordinate with the USFWS, address sources of input, and remediate.

- The DAF will establish a pre-project baseline for hydrodynamic data within San Antonio Creek. During project operations the DAF will collect hydrodynamic data annually using consistent data collection methodologies for purposes of comparison against the established baseline. The DAF will use this data to ensure that the proposed project's water extraction, when viewed in addition to the unknown total water extraction amount of permitted launch projects, is not measurably affecting flow rate or water level within San Antonio Creek.
- SpaceX will prepare a Lighting Management Plan for SLC-4 to reduce potential visual impacts associated with facility lighting. The Lighting Management Plan will be submitted to the DAF for approval and USFWS for reference.
- SpaceX will prepare a Lighting Management Plan for SLC-6 prior to operation of the site. The Lighting Management Plan will be submitted to the DAF for approval and USFWS for reference.

2.3.2 California Red-legged Frog

- The DAF will maintain exhaust ducts and associated v-ditch at SLC-4 and SLC-6 to be free of standing water to the maximum extent possible between launches to help minimize the potential to attract CRLF to SLC-4 and SLC-6.
- The DAF will continue to require that a biologist survey the SLC-4 v-ditch feature for CRLF prior to any maintenance activities and relocate any encountered individuals.
- Vegetation Management Area
    - One day prior to vegetation removal from Spring Canyon, a qualified biologist will conduct surveys for CRLF within the area to be mowed. A USFWS Approved or Permitted biologist will capture any CRLF present, if possible, and release them at the nearest suitable habitat within Spring Canyon outside of the vegetation management area, as determined by the biologist. The biologist will also be present during vegetation removal to capture and relocate CRLF to the extent that safety precautions allow. In addition, this biologist will search for injured or dead CRLF after vegetation removal to document take.
    - A qualified biologist will perform one CRLF survey annually during peak breeding season in Spring Canyon when individuals are most likely to be present and detectable. If CRLF are not encountered at the time of this survey, no subsequent

pre/post launch surveys would occur. If CRLF are found to be present during the annual survey, pre- and post-launch surveys and relocation of any CRLF encountered would occur for each subsequent launch event.

- CRLF Baseline and Launch Monitoring:
  - The DAF will implement long-term monitoring of annual population and distribution trends associated with CRLF populations within Jalama Creek, Honda Creek, Bear Creek, and the Santa Ynez River. The DAF will develop a monitoring plan that adequately addresses potential short- and long-term project effects that may result from sensory pollutants. The DAF will coordinate with the USFWS during plan development and provide the USFWS the monitoring plan for review and approval within three months of project implementation to ensure that potential project related short and long-term effects are detectable and clearly defined.
    - The monitoring plan will clearly establish a pre-project baseline of the CRLF average population level within each impacted breeding feature (Jalama Creek, Honda Creek, Bear Creek, and Santa Ynez River) and clearly define the survey area and methodology. Following project implementation, the DAF will conduct annual surveys utilizing the same methodology within each impacted breeding feature during the breeding season when CRLF are most likely to be encountered.
    - The monitoring plan will include passive bioacoustics monitoring (Wildlife Acoustics Song-Meter 4 or similar technology) and will establish frog calling behavior baseline within each impacted breeding feature (Jalama Creek, Honda Creek, Bear Creek, and Santa Ynez River) and any necessary appropriate control sites for purposes of signal characteristic comparison. CRLF calling behavior baseline will include applicable call characteristics (e.g., changes in signal rate, call frequency, amplitude, call timing, call duration, etc.). The DAF will ensure that bioacoustic monitoring conducted is designed to best address confounding factors in order to appropriately characterize impacts of launch, static fire, and landing events on calling behavior. Results will be analyzed in conjunction with long term population data to ensure any observed changes in signal characteristics are not resulting in observable declines in population.
  - The DAF will conduct quarterly night surveys for CRLF and spring or early summer tadpole surveys of Jalama Creek, Honda Creek, Bear Creek, and the Santa Ynez River to compare baseline CRLF occupancy data collected over the past 10 years and assess if there are any changes in CRLF habitat occupancy, breeding behavior (calling), and breeding success (egg mass and tadpole densities) within these sites. The following will be recorded and measured during the surveys:
    - CRLF detection density (number of frogs per survey hour), following the same survey methods conducted previously at these sites and throughout VSFB.
    - CRLF locations and breeding evidence (e.g., calling, egg masses).

        - Environmental data during surveys (temperature, wind speed, humidity, and dewpoint) to determine if environmental factors are affecting CRLF detection or calling rates.
        - Annual habitat assessments to measure flow rates, stream morphology, depths, and sediment to determine if any changes in CRLF metrics are associated with other environmental factors, such as drought.
    - Bioacoustic monitoring would be conducted annually during CRLF breeding season (typically November through April, depending on rainfall) to characterize the noise environment and determine if there are changes in calling behaviors as the Proposed Action commences. Passive noise recorders and environmental data loggers (temperature, relative humidity, dew point) would be placed at up to two suitable breeding locations within Jalama Creek, Honda Creek, Bear Creek, and the Santa Ynez River. Passive bioacoustic recording would occur throughout the entirety of the breeding season using the Wildlife Acoustics Song-Meter 4 (or similar technology) with software that enables autodetection of CRLF calling. The DAF will use bioacoustic monitoring to characterize and analyze impacts of launch, static fire, and landing events on calling behavior during the breeding season to assess whether Falcon noise events affect CRLF calling frequency.
    - To address potential population declines that may be a result of the Proposed Action, the specified threshold criteria are described below:
        - CRLF occupancy, calling rate, or tadpole densities decline from baseline by 15 percent or more and,
        - The 15 percent decline from baseline is maintained for two consecutive years.
    - If any of these threshold criteria are met and cannot confidently be attributed to other natural- or human-caused catastrophic factors, not related to the Proposed Action, that may eliminate or significantly degrade suitable habitat (see potential scenarios described below), the DAF will mitigate these impacts as discussed under CRLF Mitigation section below. Examples of potential catastrophic scenarios include the following:
        - Fire, unrelated to project activities or launch operations, that directly impacts Jalama Creek, Honda Creek, Bear Creek, or the Santa Ynez River and is demonstrated to degrade or eliminate breeding habitat.
        - Landslides or significant erosion events, unrelated to project activities or launch operations, in Jalama Creek, Honda Creek, Bear Creek, or the Santa Ynez River that results in the elimination or degradation of CRLF breeding habitat.
        - Drought or climate impacts that quantifiably reduce available aquatic habitat further than what was available during existing baseline.
        - Flash flood events during the breeding season that are more significant than what was documented during the existing baseline.
    - The DAF will review the purported cause of decline with the USFWS and reach agreement. If cause of declines is determined to be inconclusive, the DAF will implement proposed mitigation.

- CRLF Mitigation
    - The DAF will create new CRLF breeding habitat at a 2:1 ratio (habitat enhanced: habitat affected) for adverse effects to occupied CRLF habitat, as determined above, at the San Antonio Creek Oxbow Restoration Area, an established wetland mitigation site on VSFB. Historically occupied by riparian vegetation, restoration efforts will focus on enhancing this abandoned tract of agricultural land to improve sensitive species habitat in San Antonio Creek and expand breeding habitat for CRLF. Surveys were conducted in February 2024 in the portion of this site that have already undergone restoration documented 10 adult and 2 juvenile CRLF utilizing the restored area, in addition to one egg mass, showing that the enhanced site is suitable for CRLF breeding.
    - Additional restoration will be conducted in the "expansion area" adjacent to the existing restoration area (where restoration has already been conducted in support of other projects). Restoration will involve digging a channel that reaches ground water. Spoils generated during excavation will be used to create a berm bordering the channel that will be planted with willows. This method is already being used at this site and has been proven to successfully create deep water aquatic habitat, that supports CRLF reproduction, bordered by riparian woodland. The restored habitat mirrors naturally occurring high-flow channels in San Antonio Creek.
    - Actions taken within this area will include site preparation via herbicide application, plowing, container plant installation, seeding, willow pole planting (via water jet, hand-held power auger, or manually driving a steel rod into the ground), and watering via water truck. The mitigation actions for CRLF are included under the existing USFWS PBO (8-8-12-F-49R) and all applicable avoidance, minimization, and monitoring measures required under the PBO would be implemented.

2.3.3 Southwestern Pond Turtle

- SWPT Baseline Monitoring:
    - The DAF will implement long-term monitoring of annual population and distribution trends associated with SWPT populations within Jalama Creek, Honda Creek, Bear Creek, and the Santa Ynez River. The DAF will develop a monitoring plan that adequately addresses potential short- and long-term project effects that may result from sensory pollutants. The DAF will coordinate with the USFWS during plan development and provide the USFWS the monitoring plan for review and approval within three months of project implementation to ensure that potential project related short and long-term effects are detectable and clearly defined.
        - The monitoring plan will clearly establish methods to estimate average population levels within each impacted breeding feature (Jalama Creek, Honda Creek, Bear Creek, and the Santa Ynez River) and clearly define the survey area and methodology. Mark-recapture techniques will be used to monitor population sizes and movements of individuals.

- Annual habitat assessments to measure flow rates, stream morphology, depths, and sediment to determine if any changes in SWPT metrics are associated with other environmental factors, such as drought.
- To address potential declining trends that may be a result of the proposed project, the specified threshold criteria are described below:
  - SWPT population estimates decline by 15 percent or more and,
  - The 15 percent decline from baseline is maintained for two consecutive years.
- If any of these threshold criteria are met and cannot confidently be attributed to other natural- or human-caused catastrophic factors, not related to the Proposed Action, that may eliminate or significantly degrade suitable habitat (see potential scenarios described below), the DAF will mitigate these impacts as discussed under SWPT Mitigation section below. Examples of potential catastrophic scenarios include the following:
  - Fire, unrelated to project activities or launch operations, that directly impacts Jalama Creek, Honda Creek, Bear Creek, or the Santa Ynez River and is demonstrated to degrade or eliminate breeding habitat.
  - Landslides or significant erosion events, unrelated to project activities or launch operations, that result in the elimination or degradation of SWPT habitat.
  - Drought or climate impacts that quantifiably reduce available aquatic habitat further than what was available during existing baseline.
  - Flash flood events during the breeding season that are more significant than what was experienced during the existing baseline.
- The DAF will review the purported cause of decline with the USFWS and reach agreement. If cause of declines is determined to be inconclusive, the DAF will implement proposed mitigation.

- SWPT Mitigation
  - The DAF will create new SWPT habitat at a 2:1 ratio (habitat enhanced: habitat affected) for adverse effects to occupied SWPT habitat, as determined above, at the San Antonio Creek Oxbow Restoration Area, an established wetland mitigation site on VSFB. Historically occupied by riparian vegetation, restoration efforts will focus on enhancing this abandoned tract of agricultural land to improve San Antonio Creek and provide habitat for SWPT.
  - Additional restoration will be conducted in the "expansion area" adjacent to the existing restoration area (where restoration has already been conducted in support of other projects). Restoration will involve digging a channel that reaches ground water. Spoils generated during excavation will be used to create a berm bordering the channel that will be planted with willows. This method is already being used at the site and has proven successful at creating deep water aquatic habitat, suitable for SWPT, with adjacent riparian woodland that simulates naturally occurring high-flow channels.
  - Actions taken within this area will include site preparation via herbicide application, plowing, container plant installation, seeding, willow pole planting

(via water jet, hand-held power auger, or manually driving a steel rod into the ground), and watering via water truck. The mitigation actions for SWPT are included under the existing USFWS Programmatic Biological Opinion (PBO 8-8-12-F-49R) and all applicable avoidance, minimization, and monitoring measures required under the PBO would be implemented.

2.3.4 Marbled Murrelet

- Annual MAMU population surveys would continue to be conducted at the current levels performed by the DAF to monitor the frequency and distribution of marbled murrelet within the action area.

2.3.5 Southwestern Willow Flycatcher

- The DAF will require that a Qualified Biologist conduct point-count surveys for SWFL on VSFB and at potential breeding habitats at the Santa Ynez River adjacent to Buellton, California during the breeding season (15 May through 15 August) concurrent with routine riparian bird surveys on VSFB, conducted once every three years. The DAF will require that Permitted Biologists conduct any required protocol level surveys.

2.3.6 Least Bell's Vireo

- The DAF will require that a Qualified Biologist conduct point-count surveys for LBVI on VSFB and at potential breeding habitats at the Santa Ynez River adjacent to Buellton, California during the breeding season (15 May through 15 August) concurrent with routine riparian bird surveys on VSFB, conducted once every three years. The DAF will require that Permitted Biologists conduct any required protocol level surveys.

2.3.7 Western Snowy Plover

- The DAF will implement long-term monitoring of annual population and distribution trends associated with SNPL along Surf Beach. The DAF will develop a monitoring plan that adequately addresses potential short- and long-term project effects that may result from sensory pollutants. The DAF will coordinate with the USFWS during plan development and provide the USFWS the monitoring plan for review and approval within three months of project implementation to ensure that potential project related short and long-term effects are detectable and clearly defined. The SNPL monitoring plan will include a clear, established baseline annual variation and decline threshold that would trigger proposed mitigation (see below).
    - The DAF will augment the current SNPL monitoring program on VSFB by performing acoustic monitoring and geospatial analysis of nesting activity on South Surf Beach to assess potential adverse effects from Falcon noise events.
    - The current Base-wide SNPL monitoring program estimates breeding effort, nest fates, and fledging success while recording patterns of habitat use through the season. This program will be augmented for the Proposed Action by placing sound level meters (SLMs) immediately inland of South Surf Beach to characterize the noise environment and any related launch and landing associated disturbance.

- The DAF will perform geospatial analysis annually to identify declines in the SNPL population, nesting activity, and reproductive success that may result from cumulative effects of multiple Falcon launches and landings from SLC-4.
- To address potential declining trends that may be a result of the Proposed Action, the specified threshold criteria are described below.
    - Geospatial analysis shows a statistically significant decline (defined as a decline greater than the baseline annual variation in these variables over the past 10 years at South Surf Beach) in population or reproductive success, and
    - the decline from baseline maintains over two consecutive years within the areas impacted by noise from the Falcon program.
- If any of these threshold criteria are met and cannot confidently be attributed to other natural- or human-caused catastrophic factors, not related to the proposed action, that may eliminate or significantly degrade suitable habitat (see potential scenarios described below), the DAF will mitigate for these impacts as discussed under the SNPL Mitigation section below. Examples of potential catastrophic scenarios include the following:
    - Significant correlation of tidal activity, predation, etc. as compared with the existing baseline and demonstrable across remainder of base population.
    - Avian disease responsible for demonstrable population decline across the recovery unit.
    - Separate work activities (i.e., restoration efforts) not related to project.
- The DAF will review the purported cause of decline with the USFWS and reach agreement. If the cause of declines is determined to be inconclusive, the DAF will implement proposed mitigation.
- Motion triggered video cameras will be used during the breeding season (1 March through 30 September) to determine nest fates and potential impacts to nests due to launches and landings to reduce disturbance associated with human activity within breeding habitat.
    - The DAF will monitor active nests at South Surf Beach with motion triggered video cameras during the breeding season at whichever of the following is greater within the modeled 4.0 psf zone to assess potential novel effects that may result from frequent launching: (i) 10 percent of active SNPL nests, or (ii) 4 active SNPL nests. The DAF will monitor at whichever the following is greater within the modeled 3.0 to 4.0 psf zone: (iii) 10 percent of active SNPL nests, or (iv) 2 active SNPL nests. The DAF will monitor at whichever the following is greater within the modeled 2.0 to 3.0 psf zone: (v) 5 percent of active SNPL nests, or (vi) 4 active SNPL nests.
    - Cameras will be placed in a manner to minimize disturbance to nesting plovers; this will be determined in the field based on the best judgement of a permitted biologist.
    - The DAF will employ camera technology that is capable of long-term recording and time marking the moment of disturbance events.

- The DAF will implement landscape level camera monitoring in conjunction with individual nest cameras to document SNPL response to launch and sonic boom noise and overpressures. The landscape level camera(s) will be capable of long-term recording, time marking the moment of disturbance events, and deployed adjacent to areas of highest density nesting to best capture population level reaction. The DAF will coordinate camera installation and placement with a USFWS approved biologist to ensure no additional effects would occur (i.e., perching for raptors).
    - The DAF will review SNPL nest camera recordings as soon as possible after potential disturbance events.
- The DAF will rescue any SNPL eggs abandoned on Surf Beach during disturbance events. The DAF will develop and/or fund a program to incubate any rescued abandoned eggs and release fledglings.
- SNPL Mitigation
    - The DAF will increase predator removal efforts to include the non-breeding season, particularly focusing on raven removal at and adjacent to VSFB beaches.
    - Given that all available SNPL nesting habitat on VSFB has already or will soon (under current planning) be restored, the biggest factor reducing nest success is predation with significant impacts from ravens. Ravens, which have historically been absent to rare in the region, are now common, and the population has increased substantially over the past two decades. Raven population increases are due to human activities which have allowed their numbers to increase and range to expand each year. Off-season raven control efforts will help reduce the population on Base prior to the breeding season which should increase nest success.
    - Predator control actions will include trapping, shooting, and tracking SNPL predators from VSFB beaches and surrounding areas on Base. The mitigation actions for SNPL are permitted under an existing USFWS BO (8-8-12-F-11R; USFWS 2015a) and all applicable avoidance, minimization, and monitoring measures required under BO 8-8-12-F-11R will be implemented. CEIEA also maintains a USFWS depredation permit.

2.3.8 California Least Tern

- The DAF will implement long-term monitoring of annual population and distribution trends associated with LETE at Purisima Point. The DAF will develop a monitoring plan that adequately addresses potential short- and long-term project effects that may result from sensory pollutants. The DAF will coordinate with the USFWS during plan development and provide the USFWS the monitoring plan for review and approval within three months of project implementation to ensure that potential project related short and long-term effects are detectable and clearly defined. The LETE monitoring plan will include a clear, established baseline annual variation and decline threshold that would trigger proposed mitigation (see below).

- The DAF will augment the current LETE monitoring program on VSFB by performing acoustic monitoring and geospatial analysis of nesting activity at the Purisima LETE colony to assess potential adverse effects from Falcon 9 noise events.
    - The current Base-wide LETE monitoring program estimates breeding effort, nest fates, and fledging success while recording patterns of habitat use through the season. This program will be augmented for the Proposed Action by placing SLMs immediately inland of the LETE colony at Purisima Point to characterize the noise environment and any related launch and landing associated disturbance.
    - The DAF will perform geospatial analysis annually to identify declines in the LETE population, nesting activity, and reproductive success that may result from cumulative effects of multiple launches and landings from SLC-4.
- To address potential declining trends that may be a result of the Proposed Action, the specified threshold criteria is described below.
    - Geospatial analysis shows a statistically significant decline (defined as a decline greater than the baseline annual variation in these variables over the past 10 years at Purisima Point) in population or reproductive success, and
    - the decline from baseline maintains over two consecutive years within the areas impacted by noise from the Falcon program.
- If any of these threshold criteria are met and cannot confidently be attributed to other natural- or human-caused catastrophic factors, not related to the Proposed Action, that may eliminate or significantly degrade suitable habitat (see potential scenarios described below), the DAF will mitigate for these impacts as discussed under the LETE Mitigation section below. Examples of potential catastrophic scenarios include the following:
    - Significant correlation of predation, lower prey availability, etc. as compared with the existing baseline and demonstrable across remainder of base population.
    - Avian disease responsible for demonstrable population decline across the recovery unit.
    - Separate work activities (i.e., restoration efforts) not related to project.
- The DAF will review the purported cause of decline with the USFWS and reach agreement. If the cause of declines is determined to be inconclusive, the DAF will implement proposed mitigation.
- Motion triggered video cameras will be used during the breeding season (typically 15 April to 15 August) to determine nest fates and potential impacts to nests due to launches and landings to reduce disturbance associated with human activity within breeding habitat.
    - The DAF will monitor at whichever of the following is greater within the Purisima Point colony: (i) 10 percent of active LETE nests, or (ii) 4 active LETE nests.
    - Cameras will be placed in a manner to minimize disturbance to nesting terns; this will be determined in the field based on the best judgement of a permitted biologist.
    - The DAF will employ camera technology that is capable of long-term recording and time marking the moment of disturbance events.

- The DAF will implement landscape level camera monitoring in conjunction with individual nest cameras to document LETE response to launch and sonic boom noise and overpressures. The landscape level camera(s) will be capable of long-term recording, time marking the moment of disturbance events, and deployed adjacent to areas of highest density nesting to best capture population level reaction. The DAF will coordinate camera installation and placement with a USFWS approved biologist to ensure no additional effects would occur (i.e., perching for raptors).
  - The DAF will review LETE nest camera recordings as soon as possible following disturbance events.
- The DAF will rescue any LETE eggs abandoned at the Purisima Point colony during disturbance events. The DAF will develop and/or fund a program to incubate any rescued abandoned eggs and release fledglings.
- LETE Mitigation
  - The DAF will increase predator removal efforts to include the non-breeding season, particularly focusing on raven removal at and adjacent to VSFB beaches.
  - One factor reducing nesting success is nest predation. Off-season predator control will help reduce the population on Base prior to the breeding season which should increase nest success.
  - Predator control actions will include trapping, shooting, and tracking LETE predators from VSFB beaches and surrounding areas on Base. The mitigation actions for LETE are permitted under an existing USFWS BO (8-8-12-F-11R; USFWS 2015a) and all applicable avoidance, minimization, and monitoring measures required under BO 8-8-12-F-11R will be implemented. CEIEA also maintains a USFWS depredation permit.

2.3.9 California Condor

- The DAF will coordinate with the USFWS on a quarterly basis to determine if any California condors are present at VSFB. The DAF will contact the USFWS if California condors appear to be near or within the area affected by a launch from SLC-4. In the unlikely event that a California condor is nearby, qualified biologists will monitor California condor movements in the vicinity of VSFB and coordinate with the USFWS to analyze data before, during, and after launch events to determine whether any changes in movement occur.
- The DAF will coordinate with current USFWS personnel, including Arianna Punzalan, Supervisory Wildlife Biologist (arianna_punzalan@fws.gov, (805) 377-5471); Joseph Brandt, Wildlife Biologist (joseph_brandt@fws.gov, 805-677-3324 or 805-644-1766, extension 53324), or Steve Kirkland, California Condor Field Coordinator, USFWS California Condor Recovery Program (steve_kirkland@fws.gov, 805-644-5185, extension 294).

2.3.10 Southern Sea Otter

- A USFWS-approved biologist would monitor southern sea otters for landing events at SLC-4W whenever a sonic boom of 2 psf or greater is predicted to be generated by the boost-back that would impact southern sea otter habitat. The monitoring location would be selected based on where pressure waves greater than 2 psf are predicted to impact and the relation of these locations to occupied sea otter habitat, which is commonly Sudden Flats on south VAFB. However, no monitors are allowed within the "Impact Limit Line" during launch or boostback. If otter counts by the United States Geological Survey, or other non-related survey efforts, show the establishment of new populations within the action area, new survey locations would be considered for boost-back and landing events.

  - A USFWS-approved biologist would conduct daily counts of sea otters at the selected monitoring location beginning 3 days before and continuing 3 days after the boost-back and landing. The monitor would note any mortality, injury, or abnormal behavior observed during these counts. Weather permitting; the counts would be conducted between 09:00 AM and 12:00 PM when otters are most likely to be rafting to help maintain daily consistency in detectability. Monitors would use both binoculars (10X) and a high-resolution 50—80X telescope to conduct counts; and
  - Acoustic recording equipment would be deployed at or near the monitoring location to document and quantify sonic boom levels.

- If no long term effects on sea otter populations are observed after three years of full launch cadence the monitoring will be discontinued after review of data and concurrence of the USFWS.

2.3.11 Annual Report

- A written report will be submitted by 31 March for each fiscal year (October through September) that activities are conducted. The annual report will include documentation of the analysis of impacts of the proposed activities on federally listed species; monitoring results; documentation of the number of individuals of federally listed species harassed (e.g., flushed or relocated from an area), captured, or injured or killed; the date, time, and location of any form of take; approximate size and age of those individuals taken; a description of relocation sites for captured individuals; the acreages of habitat for the federally listed species that were restored/enhanced; and requests for modifying or discontinuing any of the monitoring or mitigation measures.

3 Methods and Action Area

The USFWS's regulations define the "Action Area" as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action" (50 Code of Federal Regulations [C.F.R.] section 402.02). Impacts on listed species were considered for all areas potentially impacted by the forseeable disturbances caused by launch activities, including visual impacts (including light emisisons), engine noise, sonic booms, and water use from launches and increased number of personnel to support launch activities. The current water source for VSFB is four water wells located within the San Antonio Creek Basin. There is an existing connection between State water and the VSFB water supply system; however, during annual maintenance that lasts two to three weeks, VSFB utilizes four water wells in the San Antonio Creek Basin. Listed species known to occur within San Antonio Creek were also considered due to water extraction requirements to support SLC-4.

The action area is defined as areas expected to receive 100 decibels (dB) unweighted (Lmax) from engine noise or greater than 1 psf sonic boom during launch or landing, whichever is greater. Not every launch would result in a sonic boom that impacts the surface of the earth, thus for some missions the action area is only the 100 dB Lmax noise contour. It should be noted that launches and landing may occur upon different trajectories, thus the area potentially receiving a sonic boom would vary from mission to mission. Launches with the same trajectory may also result in different sonic boom impacts, as sound propagation is influenced by atmospheric conditions at the time of the noise event as discussed in Section 2.2.4.

The primary stressor inherent in the Proposed Action is noise. Noise impacts may induce startle and alert responses in individuals. Responses to noise vary, based largely upon individual circumstances and psychological factors unrelated to the intensity of the sound. It is, therefore, difficult to generalize the anticipated behavioral reactions to various noise levels across species. Available studies and data as well as personal observations by qualified biologists in the field were used as the basis for determining what noise levels were likely to produce a significant behavioral response or damage to hearing sensitivity. In most cases, however, no directly applicable studies exist. Therefore, reasonable conclusions were deduced from similar species as proxy to the extent possible and by examining evidence of impacts from other types of noise (e.g., aircraft noise, space vehicle launch noise).

Biological surveys of the area surrounding SLC-4 were performed as part of the 2017 biological assessment (ManTech SRS Technologies, Inc. [MSRS] 2017a). There was no need to perform additional field surveys at SLC-4 for this BA because the Proposed Action does not require any construction-related ground disturbance at this location, the maximum number of first stage landings (12) at SLC-4W would not change from what was described in the 2023 BO (USFWS 2023), and recent survey data are available for all relevant species in the areas potentially impacted at that location. Biological surveys of the proposed construction areas at SLC-6 were performed during October and November 2023. A qualified biologist performed meandering surveys throughout the areas where construction is proposed, mapping any federally listed species encountered and assessing habitat for suitability and potential occurrence of these species. Existing special status species monitoring data, survey reports, and California Natural Diversity Database (CNDDB) records were reviewed to assess the potential occurrence, distribution, and habitat use of federally listed species around SLC-6 and within the broader Action Area.

4 Status of the Species

4.1 Tidewater Goby (Federally Listed Endangered Species)

4.1.1 Status

The TWG was listed as endangered on 7 March 1994 (59 FR 5494). On 24 June 1999, the USFWS proposed to remove the populations occurring north of Orange County, California, from the endangered species list (64 FR 33816). In November 2002, the USFWS withdrew this proposed delisting rule and retained the TWG's listing as endangered throughout its range (67 FR 67803). The USFWS published a Recovery Plan for the TWG in 2005 (USFWS 2005). In January 2014, USFWS proposed to reclassify the TWG from endangered to threatened (79 FR 14340-14362). In addition, the USFWS is considering a proposed taxonomic split between northern and southern populations of this species, with an expectation to delist the northern population (including all individuals at VSFB). A decision on this proposal has not been made.

4.1.2 Life History

The TWG is a small, bottom-dwelling fish found in California's coastal estuaries, wetlands, lagoons, and lower reaches of coastal streams and rivers. It is an annual species, with individuals typically not living for more than a year. TWG population size is heavily influenced by environmental conditions. In years experiencing high rains, when lagoons are breached, TWG numbers fall as fish are washed out to sea. Individuals able to access refugia, such as that provided by vegetation in littoral marshes, are able to survive flood events. These surviving individuals breed after the lagoons close, allowing populations to rebound the following summer (Swift et al. 1989). Breeding may occur year-round (Swenson 1999), with peak spawning activity usually occurring during the spring and a second peak during the late summer (Swift et al. 1989).

The key threat to TWG is the degradation of coastal lagoons as a result of diversion of water (dewatering streams affects marsh habitat extent, and alters temperature and salinity within the marshes), pollution from agricultural and sewage effluents, siltation (often through sediment generated during cattle overgrazing and feral pig activity), and coastal development. In addition, introduced predatory fish (especially centrarchids and channel catfish [*Ictalurus punctatus*], crayfish [*Procambarus clarkii*], and mosquito fish [*Gambusia affinis*]) pose a direct threat to TWG populations through predation of eggs, young, and adults.

4.1.3 Occurrence within the Action Area

TWG have been reported in all the major drainages on VSFB, including Shuman Creek, San Antonio Creek, the Santa Ynez River, Honda Creek, and Jalama Creek (Swift et al. 1997). TWG typically favor areas within the fresh-saltwater interface with salinities of less than 12 parts per thousand (Swift et al. 1989). However, this species will range into fresh water and has been recorded up to 7.5 mi upstream from the ocean in the Santa Ynez River (Swift et al. 1997).

Potential habitat for TWG within the Action Area includes Honda Creek, the Santa Ynez River, Jalama Creek, and San Antonio Creek. TWG were first found in the Honda estuary lagoon in 1995 (Lafferty et al. 1999). The species was again documented in 2001; however, seine net surveys conducted in Honda Creek in 2008 indicated that TWG were no longer present (MSRS 2009a). Seine net surveys were again conducted in Honda Creek in 2015 and 2016 with no TWG present (MSRS 2016a, 2018a). Despite being easily detectable in shallow water with a flashlight during night frog surveys, no TWG were observed during night CRLF surveys of the Honda Creek estuary for SpaceX launch monitoring activities in January 2022 (J. LaBonte, pers. obs.).

In 2013, the Honda Creek estuary lagoon dried and stayed dry through 2016 before rehydrating in the winter of 2016–2017 (MSRS 2018a). Since 2017, the lagoon has been subject to drying during late summer months, making any longer-term occupancy by fish dependent on being able to establish in areas east of Coast Road, but the narrowness and shallowness of the creek in this area makes this unlikely. Occurrence within Honda Creek would be dependent on TWG recolonizing the lagoon if it fills and breaches in response to winter rains. Unless environmental conditions return to a consistently wetter regime conducive to perennial water in the Honda lagoon, any TWG occupancy is likely to be of short duration.

On VSFB, TWG currently occur in the Santa Ynez River from the estuary to 13th Street Bridge and San Antonio Creek, being mostly concentrated in the San Antonio Creek lagoon as compared to its channel (Swift 1997, 1999; MSRS 2018b). TWG also occur in Jalama Creek (MSRS 2016a). To the southeast of VSFB, in the region potentially impacted by sonic booms during missions with easterly trajectories (Figure 2.2-8), TWG occur in most coastal streams, bays, and estuaries in southeastern Santa Barbara, Ventura, and southwestern Los Angeles Counties (California Department of Fish and Wildlife [CDFW] 2024).

4.1.4 Critical Habitat

The USFWS issued a final rule for designation of Critical Habitat for the TWG on 6 February 2013 (78 FR 8745-8819). VSFB was exempted from Critical Habitat designation under Section 4(a)(3) of the ESA. USFWS has adopted VSFB's Integrated Natural Resources Management Plan (INRMP; U.S. Air Force 2021), prepared under section 101 of the Sikes Act (16 U.S.C. 670a). The potential sonic boom footprint from missions with easterly trajectories overlaps Critical Habitat Units SB-8, 9, 10, 11, and 12, VEN-1, 2, 3, and 4, and LA-1, 2, 3, and 4 (Figure 4.1-1).

The primary constituent elements (PCE) include the following:

> (1) Persistent, shallow (in the range of approximately 0.3 to 6.6 ft) still-to-slow-moving lagoons, estuaries, and coastal streams with salinity up to 12 parts per thousand, which provide adequate space for normal behavior and individual and population growth that contain one or more of the following:
>
> > (a) Substrates (e.g., sand, silt, mud) suitable for the construction of burrows for reproduction;
> >
> > (b) Submerged and emergent aquatic vegetation, such as *Potamogeton pectinatus*, *Ruppia maritima*, *Typha latifolia*, and *Scirpus* spp., that provides protection from predators and high flow events; or

(c) Presence of a sandbar(s) across the mouth of a lagoon or estuary during the late spring, summer, and fall that closes or partially closes the lagoon or estuary, thereby providing relatively stable water levels and salinity.

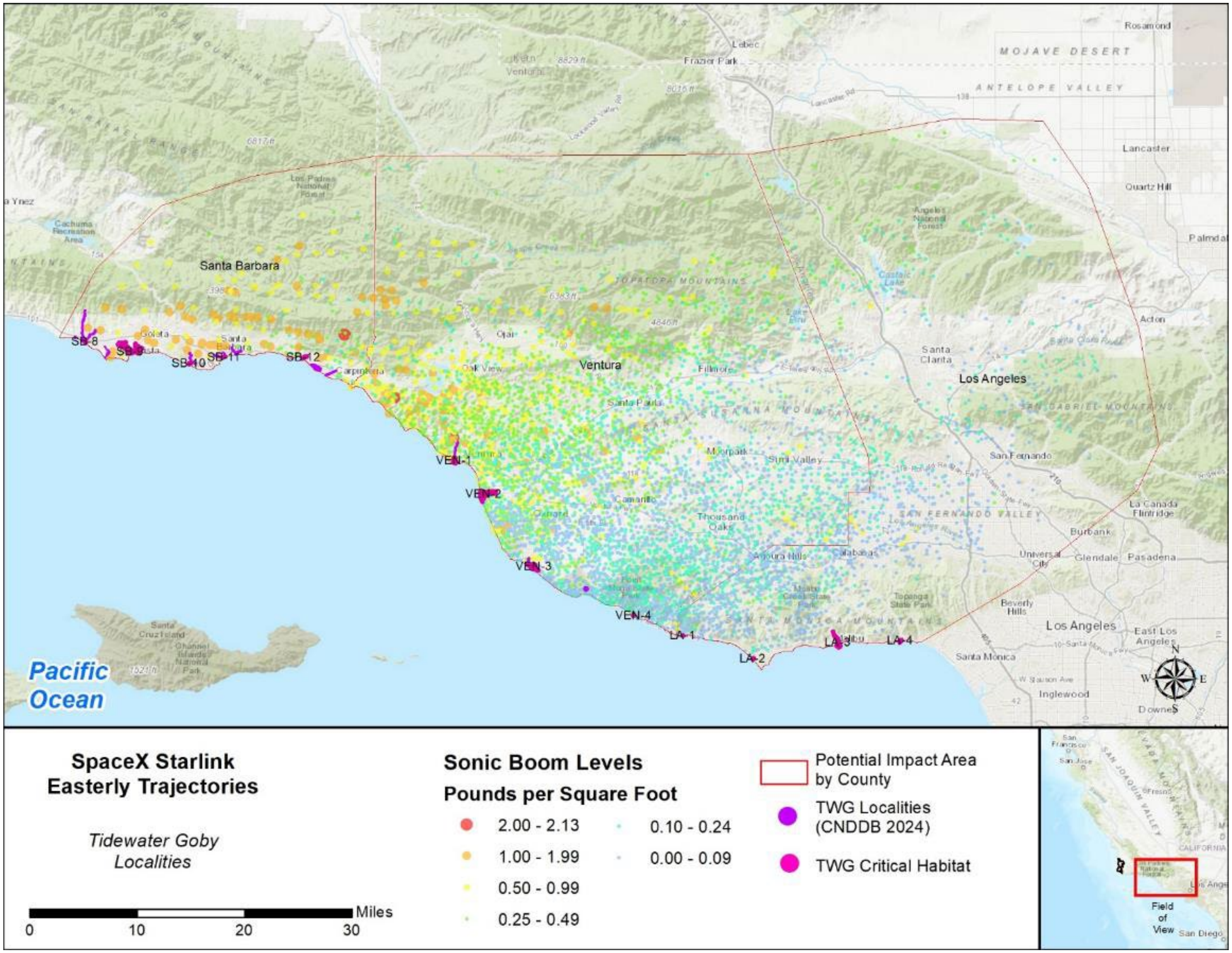

Figure 4.1-1. TWG localities, Critical Habitat, and potential sonic boom impact areas in eastern Santa Barbara, Ventura, and Los Angeles Counties.

4.2 Unarmored Threespine Stickleback (Federally Listed Endangered Species)

4.2.1 Status

The UTS was listed as endangered in 1970 (35 FR 16047-16048). A Recovery Plan was issued in 1985 (USFWS 1985a).

4.2.2 Life History

UTS are small fish (approximately 6 centimeters) that are short-lived (i.e., rarely surviving 2–3 years; USFWS 1985a). UTS reproduce throughout the year with highest recruitment noted from May to September (USFWS 1985a). These fish are opportunistic feeders and primarily feed on invertebrates and aquatic insects (USFWS 1985a). In San Antonio Creek, UTS coexist with other native and introduced species, many of which likely prey on UTS.

4.2.3 Occurrence in the Action Area

UTS were abundant throughout the Los Angeles basin but were reported to be extirpated by 1942. As of 1985, UTS was generally restricted to the Santa Clara River drainage in Ventura and Los Angeles Counties and the San Antonio Creek drainage in Santa Barbara County (USFWS 1985a, CDFW 2024). On VSFB, UTS have been found in San Antonio Creek from Barka Slough to the lagoon with UTS primarily occupying the creek channel (ManTech 2009a, Swift 1999).

UTS were introduced into Honda Creek, south of SLC-5, in 1984 (MSRS 2009a). Extensive aquatic surveys conducted in 2008, 2016, and 2017 did not detect any fish in the creek (MSRS 2009a, 2016a, 2018a). Additionally, between 2008 and 2022, Honda Creek has gone through multiple cycles of drying and rehydration, which would preclude occupancy by and persistence of fish.

4.2.4 Critical Habitat

Critical Habitat for the UTS was proposed in 1980 (45 FR 76012-76015) but has not been finalized.

4.3 California Tiger Salamander (Federally Listed Endangered Species)

4.3.1 Status

The USFWS lists the CTS Santa Barbara Distinct Population Segment (DPS) as federally endangered on 21 September 2000 (65 FR 57242). The USFWS finalized a recovery plan for the Santa Barbara DPS in 2016 (USFWS 2016).

4.3.2 Life History

CTS is a large, stocky salamander that inhabits low-elevation (under 1,500 ft) seasonal ponds and grasslands. Man-made livestock and other ponds have become an important component of the specie's habitat. The species spends most of its life underground in small mammal burrows. Outside of the breeding season, CTS are typically found in burrows at depths between 0.2 m and 1.36 m underground, where it is believed that they remain active year-round (Barry and Shaffer 1994). CTS occupied burrows are typically within 1 mi of their breeding ponds. (Barry and Shaffer 1994; Nafis 2023).

Winter rain events trigger CTS to emerge from burrows to seek breeding ponds, usually between November and January, depending on timing of heavy rain events (Loredo & Van Vuren 1996;

Trenham et al. 2000; Cook et al. 2006; USFWS 2016). CTS may migrate up to a mile or more before reaching a breeding pond. Males typically arrive before females and remain aboveground longer than females. After mating, the salamander returns to its burrow. Eggs, which are laid underwater on features such as blades of grass and twigs, typically hatch 10 to 28 days after deposition. Although larvae development can be delayed during periods of persistent cold weather, CTS typically emerge as terrestrial metamorphic salamanders between May and August and disperse into upland subterranean habitat.

CTS larvae prey on a variety of invertebrates, including zooplankton and crustaceans, as well as aquatic insects. Larger larvae also eat tadpoles. Adults may eat small invertebrates and vertebrates (USFWS 2016).

4.3.3 Occurrence within the Action Area

The Santa Barbara County Distinct Population Segment (DPS) of CTS is the southernmost extent of the species. USFWS has identified six metapopulation areas within this DPS and estimates that there are 60 known breeding ponds within these metapopulation areas scattered through the Santa Maria Valley, south to the Santa Rita Hills (Figure 4.3-1 and Figure 4.3-2). The nearest CTS breeding pools are approximately 14 mi east of SLC-4 in the Santa Rita Hills. CTS have not been detected on VSFB during regular protocol surveys of suitable habitat since 2006 (Collins 2006; Sweet et al. 2008, 2010; MSRS 2016b, 2020, 2022a).

4.3.4 Critical Habitat

The USFWS designated Critical Habitat for the Santa Barbara County DPS on 24 November 2004 (69 FR 68568) and does not include VSFB.

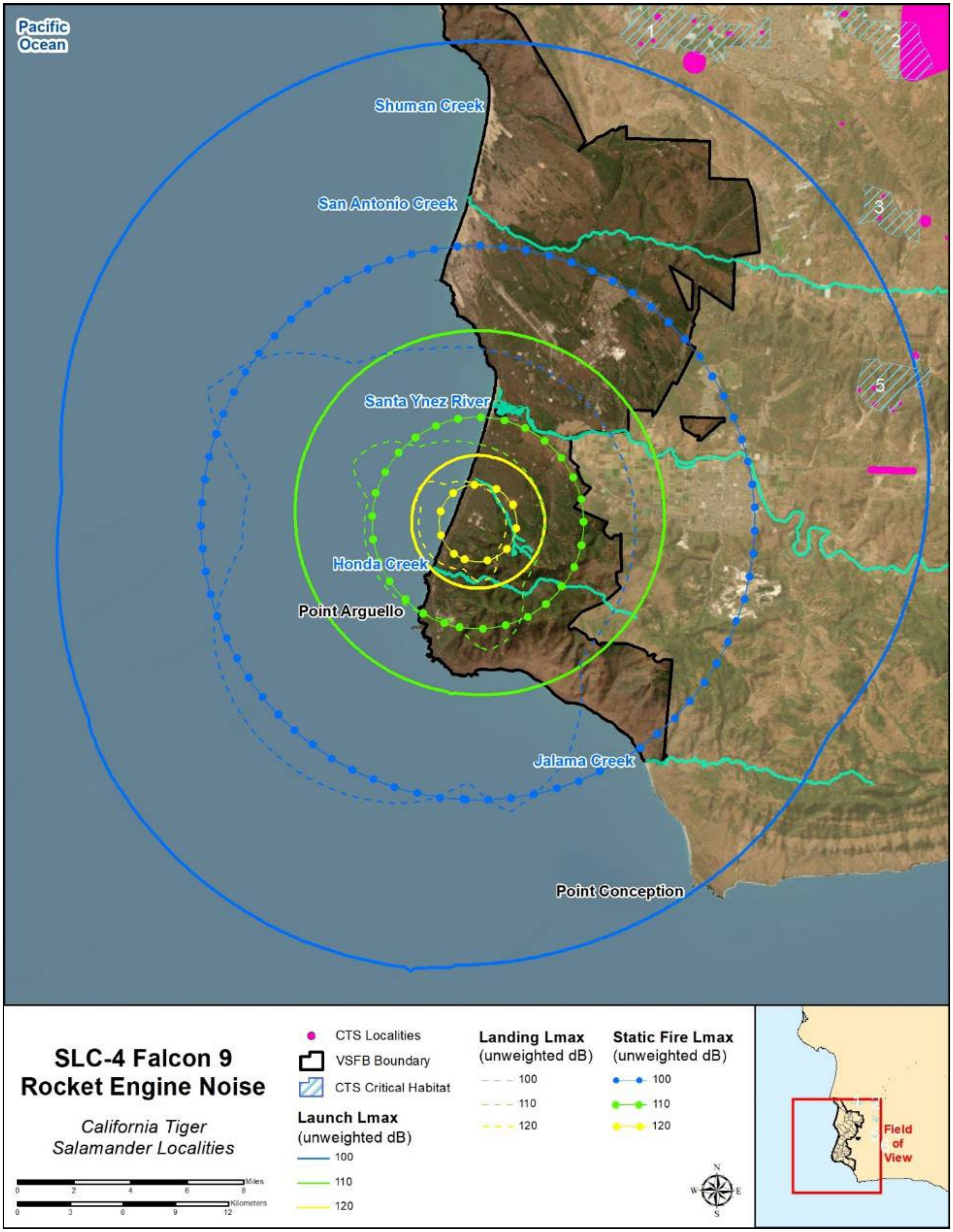

Figure 4.3-1. California tiger salamander localities, Critical Habitat, and Falcon 9 SLC-4 static fire, launch, and landing rocket engine noise.

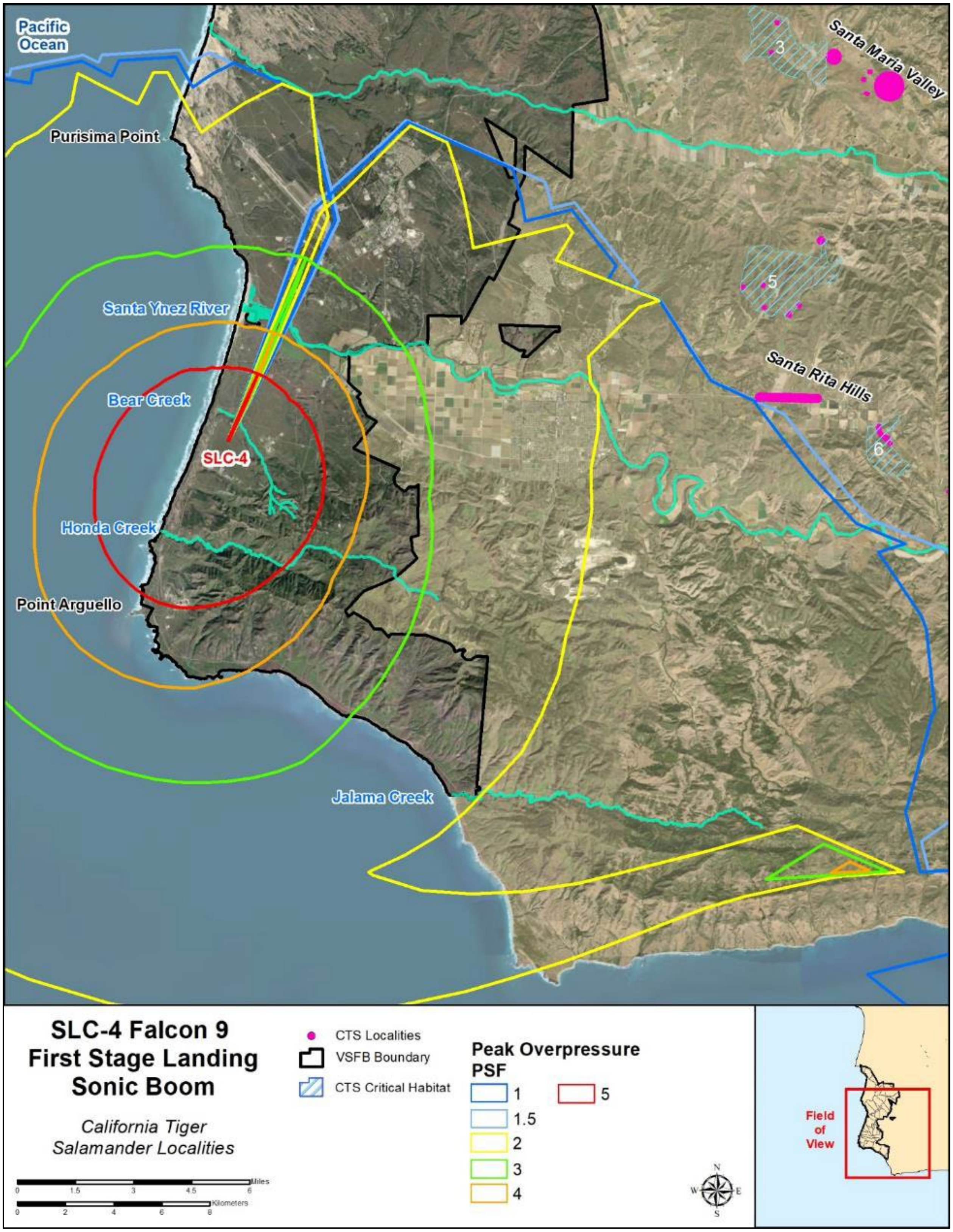

Figure 4.3-2. California tiger salamander localities, Critical Habitat, and sample SLC-4 landing sonic boom impact areas.

4.4 California Red-Legged Frog (Federally Listed Threatened Species)

4.4.1 Status

The UFSWS listed the CRLF as threatened on 23 May 1996 (61 FR 25813-25833). In 2002, USFWS issued a Recovery Plan to stabilize and restore CRLF populations (USFWS 2002b).

4.4.2 Life History

The CRLF is a member of the family Ranidae and is California's largest native frog. In order to breed, CRLF require water bodies with sufficient hydroperiods and compatible salinity levels to accommodate larval and egg development. Breeding typically takes place from November through April with most egg deposition occurring in March. Eggs require 7 to 28 days, depending on water temperature, to develop into tadpoles. Tadpoles typically require 11 to 20 weeks to develop into terrestrial frogs (USFWS 2002b), although some individuals may overwinter in the tadpole stage (Fellers et al. 2001; A. Abela, pers. obs.).

Adult CRLF have been documented traveling distances of over 1.0 mi (1.6 km) during the wet season and spending considerable time in terrestrial riparian vegetation (Tatarian 2008). Christopher (2018) found that 90 percent of the CRLF observations at VSFB within the dry season occurred within 197 ft of riparian or other aquatic habitats. It is thought that riparian vegetation provides good foraging habitat, as well as good dispersal corridors, due to canopy cover and presence of adequate moisture (USFWS 2002b).

Habitat loss and degradation, combined with over-exploitation and introduction of exotic predators, were important factors in the decline of CRLF in the early to mid-1900s. Continuing threats to CRLF include direct habitat loss due to stream alteration and loss of aquatic habitat through drought and groundwater declines, and indirect effects of expanding urbanization, competition, or predation from non-native species including the bullfrog, catfish (*Ictalurus* spp.), bass (*Micropterus* spp.), mosquitofish, and crayfish. Chytrid fungus (*Batrachochytrium dendrobatidis*) is a waterborne fungus that can decimate amphibian populations and is considered a threat to CRLF populations.

4.4.3 Occurrence within the Action Area

CRLF have been documented in nearly all permanent streams and ponds on VSFB as well as most seasonally inundated wetland and riparian sites (Figures 4.4-1 through 4.4-6; Christopher 2002). CRLF have been consistently documented in Honda Creek (Christopher 2002; MSRS 2009a, 2016a, 2018a, 2021a) and during SpaceX launch monitoring activities in January 2022 (MSRS 2022b). The Santa Ynez River, San Antonio Creek, Shuman Creek, Bear Creek, Canada del Jolloru, and Jalama Creek, have CRLF populations and suitable breeding habitat (Christopher 2002; MSRS 2009b, 2014a, 2018a). CRLF have also been documented in isolated natural wetlands on south VSFB (Christopher 2002; MSRS 2018a). CRLF were consistently found in three decommissioned wastewater treatment pools approximately 0.5 mi west of SLC-6 in the late 1990's up to 2001 (Figure 4.4-3; Christopher 2002); however, these pools have been almost completely dry for the past 20 years (A. Abela, M. Ball, and J. LaBonte, pers. obs.). These ponds were assessed in February 2024 and the northern pond was completely dry; the southern pond had shallow standing water that would not support anything more than temporary transitory habitat Figure 4.4-3; A. Abela, pers. obs.). One adult CLRF was observed in 2001 at the Industrial Wastewater Treatment Ponds, approximately 0.4 mi southwest of SLC-4 (Figure 4.4-3); however, that was likely a transient as these two ponds rarely contain water, and when water is present it is shallow (less than 3 inches) and evaporates quickly. When they were assessed in February 2024, the they had standing water that would not support anything more than temporary transitory habitat.

Two drainages border SLC-6, one to the north and one to the south (Figure 4.4-3). These drainages were assessed for CRLF habitat in February and March 2024. Although some surface water was observed, there was no deep pool habitat suitable for supporting breeding CRLF. Adjacent to SLC-6, they were determined to hold surface water flow inconsistently in response to seasonal storms that would only serve as temporary transitory habitat for CRLF. At the southwestern corner of SLC-6, the southern drainage transitions to potential aquatic, non-breeding habitat (Figure 4.4-3). Open water and flow were observed, which was determined to likely be long-lived during seasons with average to above average rainfall. Although open water, suitable aquatic and riparian vegetation, and refugia were observed, there was no deep pool habitat (> 0.7 meters) that could support CRLF breeding. Therefore, the drainage could likely serve as a suitable site for temporary occupation by CRLF. No visual or auditory evidence of CRLF presence was observed.

During the February and March 2024 CRLF habitat assessment, two areas within the SLC-6 fenceline were observed holding enough water to be potentially attractive habitat to CRLF: a “vault” structure and the “flame trench” (Figure 4.4-4 and Figure 4.4-5). Due to the lack of maintenance of the site since 2022, these structures have collected water during rainstorms and were determined to be “attractive nuisances.” The volume of water in both structures could be attractive to transiting frogs. The flame trench is sloped; thus animals could enter and exit. The vault presents an entrapment hazard since it has steep walls with no escape ladder. A temporary escape mechanism has been placed at the vault to reduce potential for entrapment. No visual or auditory evidence of CRLF presence was noted. Neither site has elements such as vegetation or shelter that would make them suitable for long-term occupancy, and no suitable breeding habitat was observed.

Spring Canyon is an ephemeral drainage located approximately 200 ft south of SLC-4. Spring Canyon has no definable channel through the majority of the drainage and minimal evidence of potential pooling or flow of surface water (MSRS 2014b). Depending on annual rainfall levels, several small areas of Spring Canyon may constitute suitable habitat for CRLF during wet periods when adequate surface water is present; however, in July 2017, after an above-average rain year, a USFWS-permitted biologist reassessed the drainage in support of this 2017 Falcon 9 BA (MSRS 2017a) and found no significant changes from the habitat assessment conducted in 2013, including no suitable breeding habitat within the vegetation removal area or downstream. Since 2017, across 11 survey efforts to perform minimization measures associated with the 2017 BO, no suitable habitat has been found, likely a result of the protracted drought conditions in Santa Barbara County. It is, therefore, unlikely that CRLF occupy this area on a regular basis, other than as transitory habitat (MSRS 2023a).

Approximately 2 mi south of SLC-4, suitable CRLF breeding habitat is found in Honda Creek, along with scattered CRLF localities in minor wetlands and drainages, across south VSFB, including Bear Creek located 1.0 mi northeast of SLC-4 (Christopher 2002; MSRS 2009b, 2014a). Suitable upland dispersal habitat exists throughout VSFB between the various riparian zones and ponds on Base but, as noted above, dispersal into these upland habitats on VSFB is limited. CRLF also occur throughout San Antonio Creek on VSFB from Barka Slough to the estuary (MSRS 2009a, 2009b, 2016a).

CRLF on the south coast of Santa Barbara County, including Gaviota Creek, Arroyo Honda, Arroyo Quemado, and other nearby creeks and tributaries are also within the Action Area due to noise impacts. Additionally, within the areas potentially impacted by sonic boom from missions with easterly trajectories, the CNDDB lists observations of CRLF from San Antonio Creek in Ojai, Las Virgenes Creek near Calabasas, and the Ventura River near Casitas Springs, from 2000 to 2016 (CDFW 2024).

4.4.4 Critical Habitat

The USFWS issued a final rule revising the CRLF's Critical Habitat on 16 March 2010 (75 FR 12816–12959). The USFWS excluded VSFB from CRLF Critical Habitat designation pursuant to Section 4(b)(2) of the ESA. Off-base, the Action Area includes STB-2, STB-4, STB-5, and STB-6 as a result of noise impact areas from Falcon 9 launch and landing activities at SLC-4 (Figure 4.4-1 and Figure 4.4-2). The potential sonic boom footprint from missions with easterly trajectories overlaps STB-7, VEN-1, VEN-2, VEN-3, and LOS-1 (Figure 4.4-6).

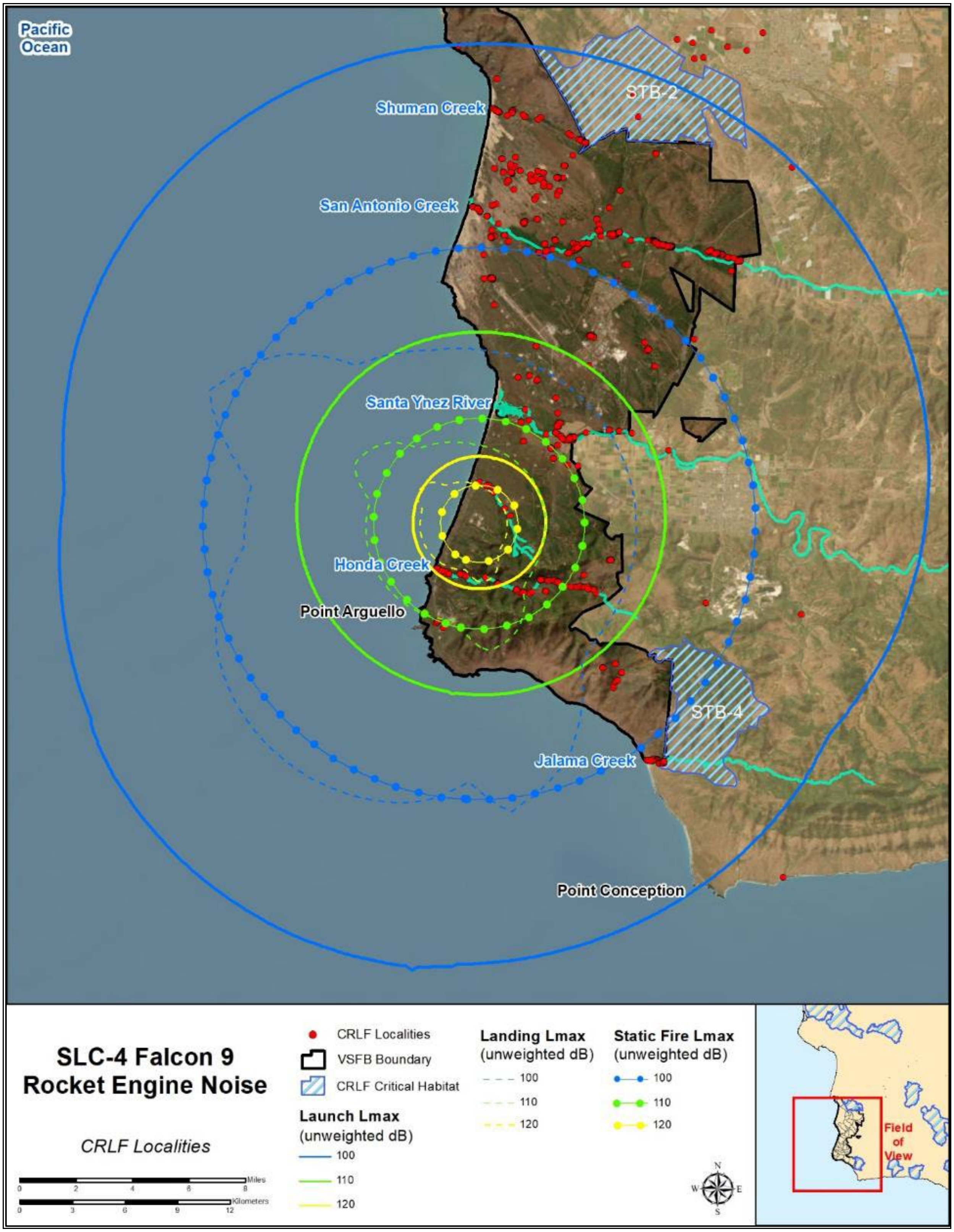

Figure 4.4-1. California red-legged frog localities, Critical Habitat, and Falcon 9 SLC-4 static fire, launch, and landing rocket engine noise.

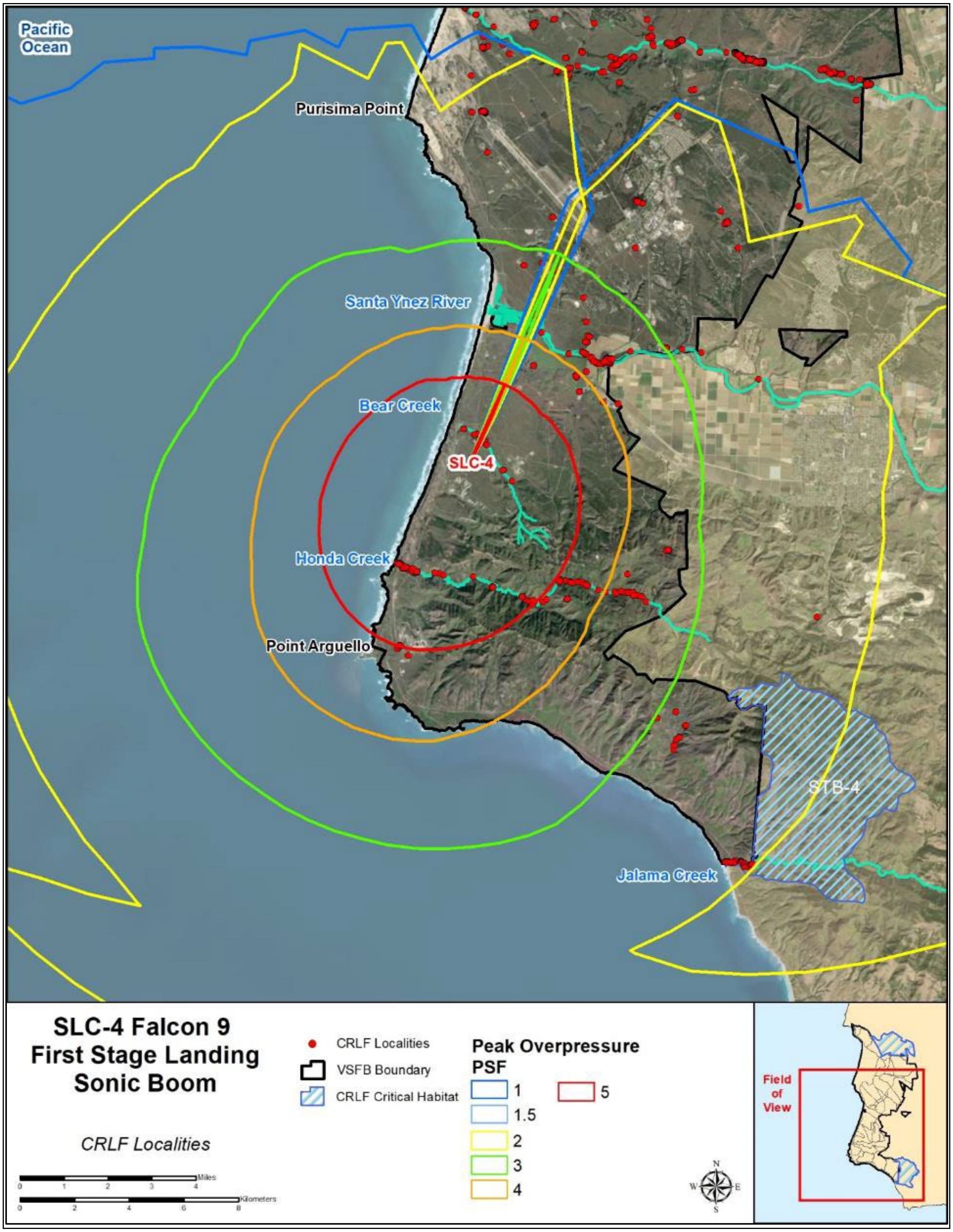

Figure 4.4-2. California red-legged frog localities, Critical Habitat, and sample SLC-4 landing sonic boom impact areas.

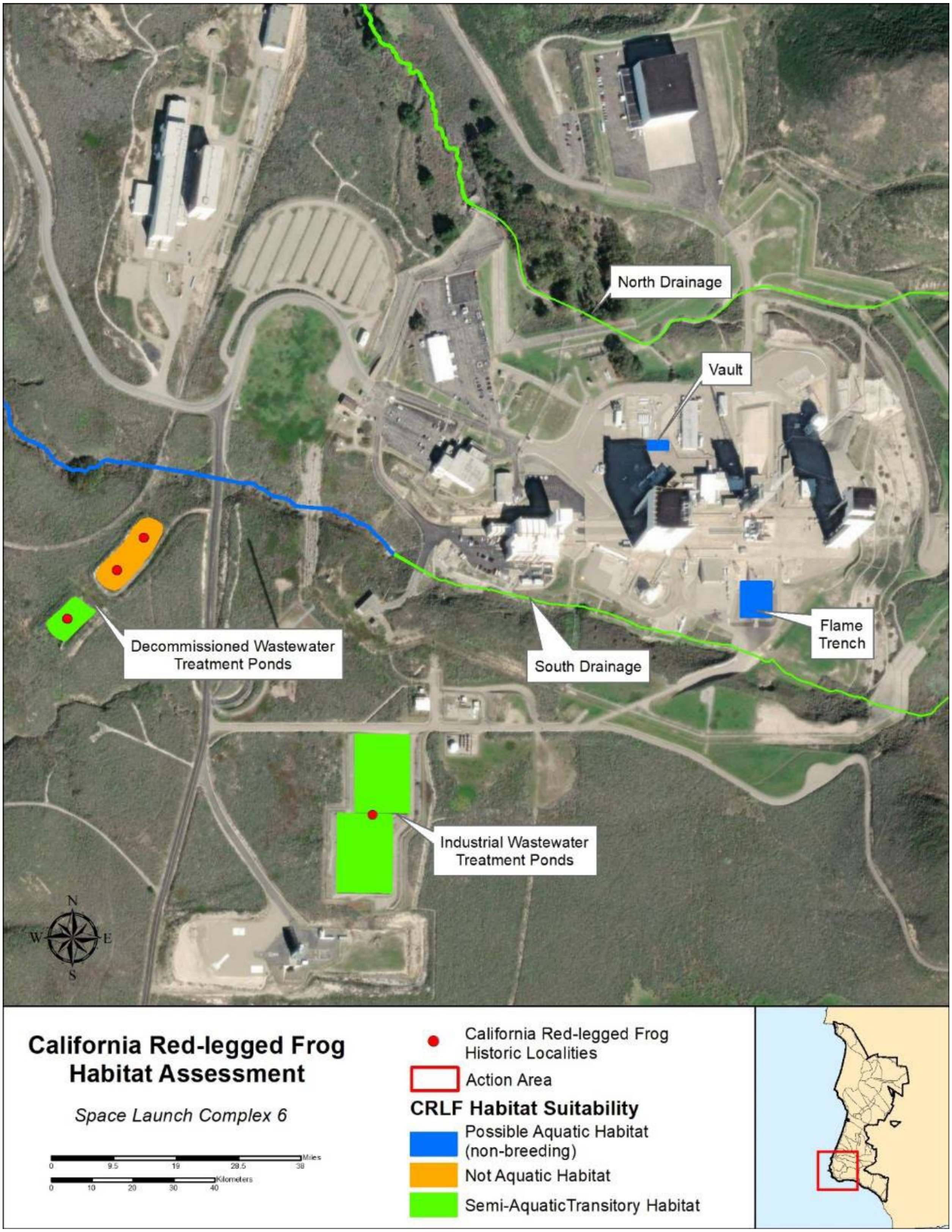

Figure 4.4-3. California red-legged frog habitat assessment of SLC-6.

Figure 4.4-4. Vault structure at SLC-6.

Figure 4.4-5. Flame trench at SLC-6.

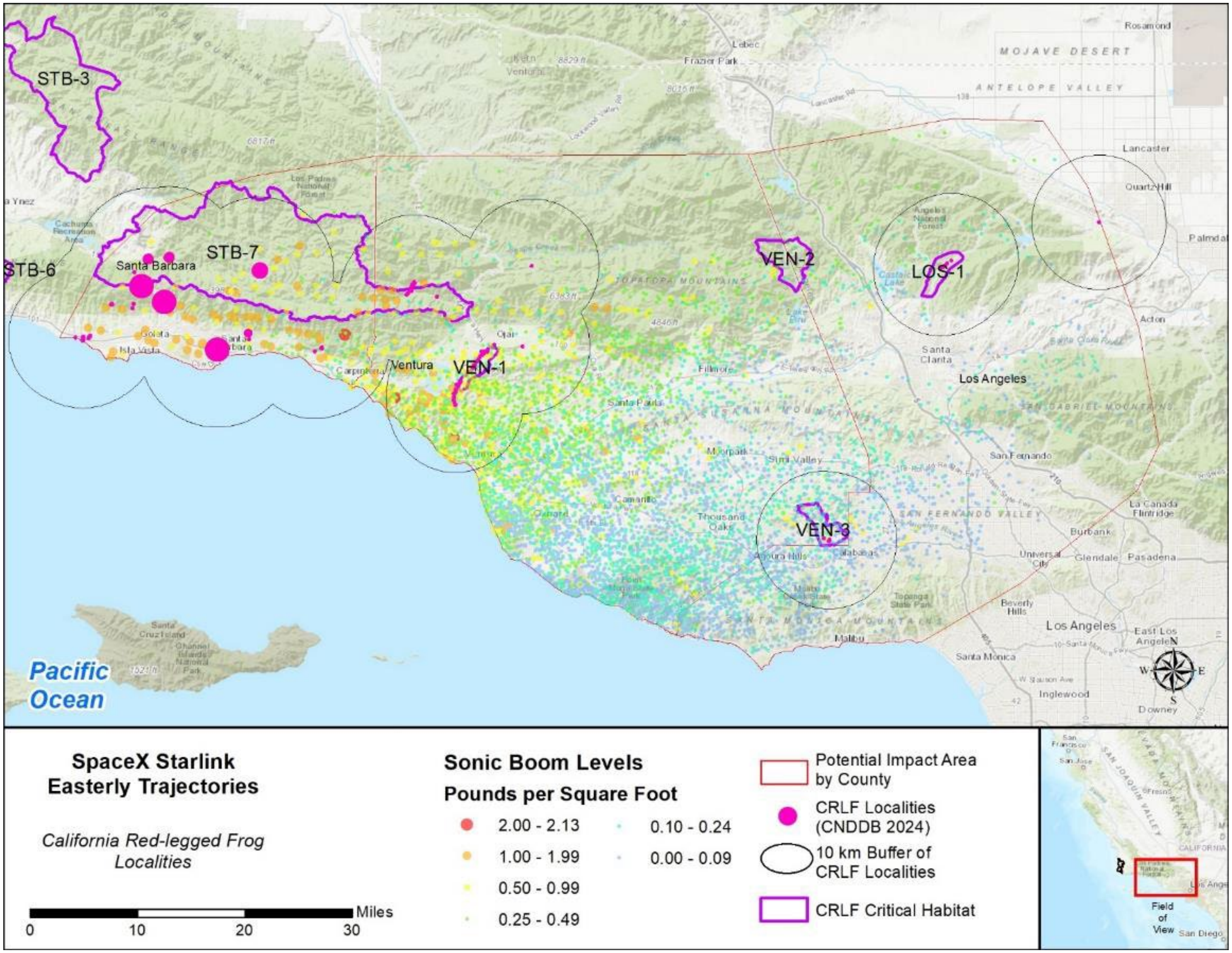

Figure 4.4-6. CRLF localities, critical habitat, and potential sonic boom impact areas in eastern Santa Barbara, Ventura, and Los Angeles Counties.

4.5 Arroyo Toad (Federally Listed Endangered Species)

4.5.1 Status

The UFSWS listed the ARTO as endangered on 16 December 1994 (59 FR 64859-64867). The USFWS published a recovery plan for the ARTO in 1999 (USFWS 1999).

4.5.2 Life History

ARTO are relatively small toads that are typically found in shallow pools and sandy or gravely streams and creeks with sandy terraces with oaks, cottonwoods, or willows. Breeding occurs from February through July at open stretches with gravel or sandy substrates. Eggs hatch within four to six days and larvae require up to 85 days to develop into toads. Juveniles and adults burrow and overwinter on sandy terraces. ARTO's primary prey are native ant species, but may forage on a variety of invertebrates.

4.5.3 Occurrence within the Action Area

ARTO occur within the region potentially impacted by sonic booms during missions with easterly trajectories spadefoot occurs (Figure 4.5-1). Specifically, these areas include the upper Santa Ynez River, Sespe Creek, Piru Creek, and the upper Santa Clara River.

4.5.4 Critical Habitat

The USFWS issued a revised designation of Critical Habitat for the ARTO in 2011 (76 FR 7245-7467).

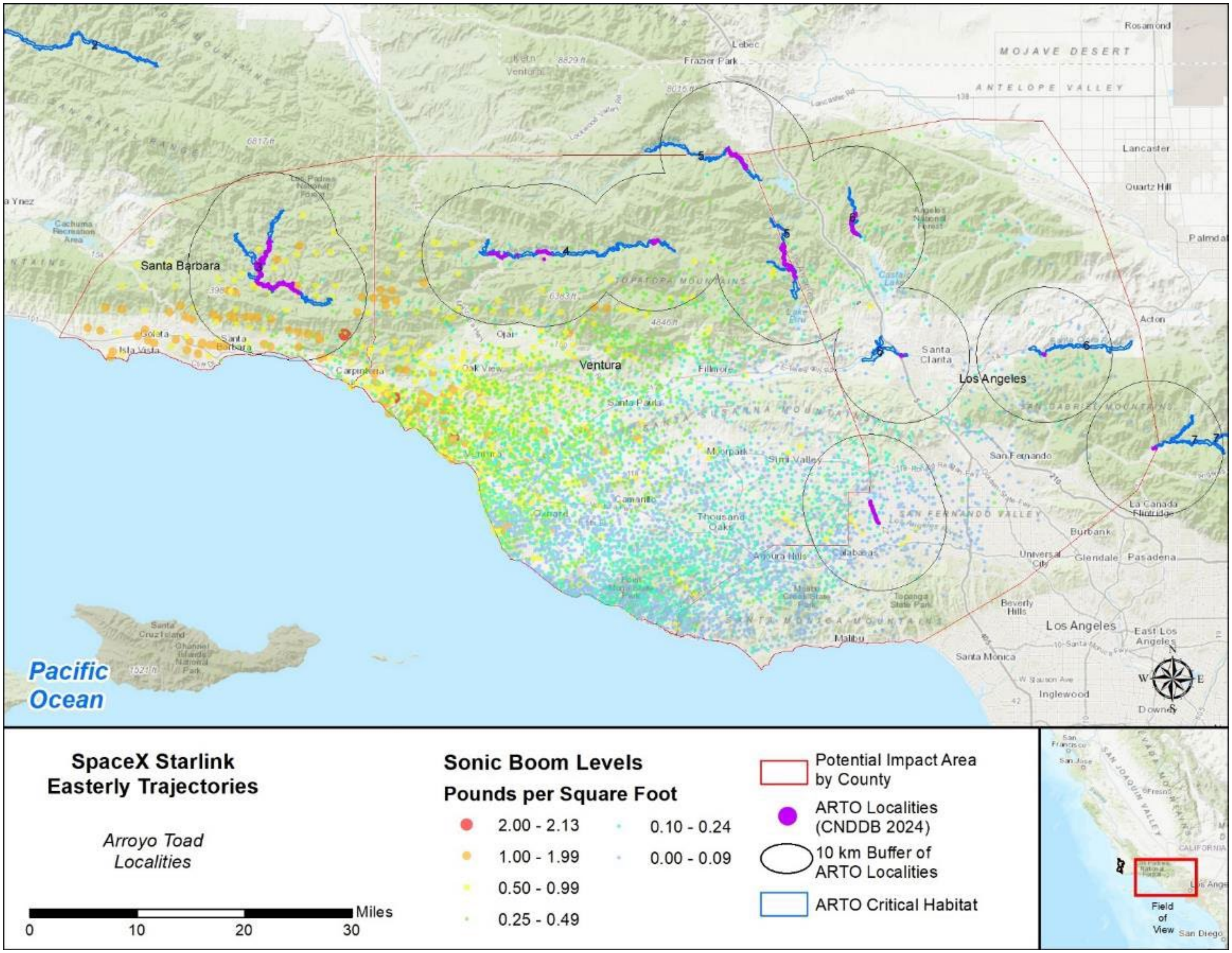

Figure 4.5-1. ARTO localities, critical habitat, and potential sonic boom impact areas in eastern Santa Barbara, Ventura, and Los Angeles Counties.

4.6 Western Spadefoot (Proposed Federal Listing as Threatened)

4.6.1 Status

On 5 December 2023, the USFWS proposed to list the northern DPS of the western spadefoot (occurring in central and northern California), and the southern DPS of the western spadefoot (occurring in southern California and northwestern Mexico), as threatened DPSs under the ESA (88 FR 84252).

4.6.2 Life History

The western spadefoot ranges in size from 1.5 to 2.5 inches snout to vent length (Stebbins and McGinnis 2012). They are dusky green or gray on their backs and usually have four irregular light-colored stripes, with the central pair of stripes sometimes distinguished by a dark, hourglass-shaped area. Adult western spadefoot forage on a variety of small invertebrate prey, including grasshoppers, true bugs, moths, ground beetles, predaceous diving beetles, ladybird beetles, click beetles, flies, ants, and earthworms (Morey and Guinn 1992).

Western spadefoots are primarily terrestrial and inhabit underground burrows, approximately 3 ft below the ground to avoid temperature extremes and desiccation (Stebbins and McGinnis 2012). Spadefoots emerge from their burrows to breed following seasonal rains in winter and spring (Dimmitt and Ruibal 1980; Jennings and Hayes 1994). Most western spadefoot surface activity is nocturnal to reduce water loss and avoid predation. Surface active post-metamorphic western spadefoots are primarily observed during the November through June period, which coincides with the adult breeding season and metamorph dispersal period. However, surface active western spadefoot have been documented year round and likely emerge from their burrows to forage whenever conditions are suitable (iNaturalist 2023; A. Abela, M. Ball, J. LaBonte pers. obs.).

Little is known regarding the land surface types western spadefoot are able to traverse or the distances that western spadefoot may travel from aquatic resources for dispersal. A study in Orange County, California found that the mean distance moved away from breeding pools was 131.36 ft, with the longest movement of an individual being 859.55 ft (Baumberger 2013). Western spadefoot habitat is primarily open grasslands, scrub, and mixed woodland where aquatic breeding habitat is available (Stebbins and McGinnis 2012). The species requires both aquatic and terrestrial habitat components, in close proximity, to meet its life history requirements.

Western spadefoots use aquatic habitat for breeding and developing larvae. Suitable aquatic habitat typically includes seasonal pools, sand or gravel washes, and small streams that are often seasonal (Stebbins and McGinnis 2012). However, eggs and larvae of western spadefoot have been observed in a variety of permanent and temporary wetlands, both natural and altered, including rivers, creeks, artificial ponds, livestock ponds, sedimentation and flood control ponds, irrigation and roadside ditches, roadside puddles, tire ruts, and borrow pits, indicating a degree of ecological plasticity (CNDDB 2023).

Western spadefoot breeding and oviposition occurs from January to May, depending on temperature and annual rains (Stebbins 1985). Age of sexual maturity is unknown but individuals may require as long as 2 years to mature (Jennings and Hayes 1994). Eggs hatch in 0.6 to 6 days depending on the temperature (Brown 1967). Larval development can be completed in 3 to 11 weeks depending on food resources and temperature, and development must be completed before the pools dry (Burgess 1950; Feaver 1971; Morey 1998). Metamorphosing frogs may leave the water and move toward suitable terrestrial burrowing habitat (Storer 1925).

4.6.3 Occurrence Within the Action Area

In the late 1990s and early 2000s, western spadefoots were documented in seasonal pools in and near the cantonment area of VSFB (Chistopher 1996; CNDDB 2023). However, spadefoots have not been detected within these pools over the past 6 years, during annual surveys for vernal pool fairy shrimp (*Branchinecta lynchi*). Although fairy shrimp are the primary survey target, pool sampling is thorough and all amphibians (egg, larva, and/or adult) detected during surveys are identified to the species level (MSRS 2016c, 2017b, 2018c, 2019, 2021b, 2022c, 2022d). A focused eDNA survey in this area in 2020 also did not detect spadefoot (MSRS 2020).

The range of this species on VSFB appears to have contracted significantly since the late 1990s when it was first documented (Christopher 1996), likely as a result of drought. Currently, the only known extant populations of spadefoot on VSFB are adjacent to the northern portion of the airfield, in the pastures north of San Antonio Creek (MSRS 2016b), and a disjunct VSFB property north of Lompoc (MSRS, unpubl. data; Figure 4.6-1 and Figure 4.6-2). Off-base, spadefoot are found in the Santa Rita Hills east of Lompoc and the Santa Maria Valley (CDFW 2024). Spadefoot have never been detected on south VSFB or south of the Santa Ynez River in Santa Barbara County. In the region potentially impacted by sonic booms during missions with easterly trajectories spadefoot occurs in eastern Ventura and western Los Angeles Counties (Figure 4.6-3; CDFW 2024).

4.6.4 Critical Habitat

In the proposed rule, the USFWS concluded that the designation of Critical Habitat for the western spadefoot northern DPS is not determinable at this time (88 FR 84252).

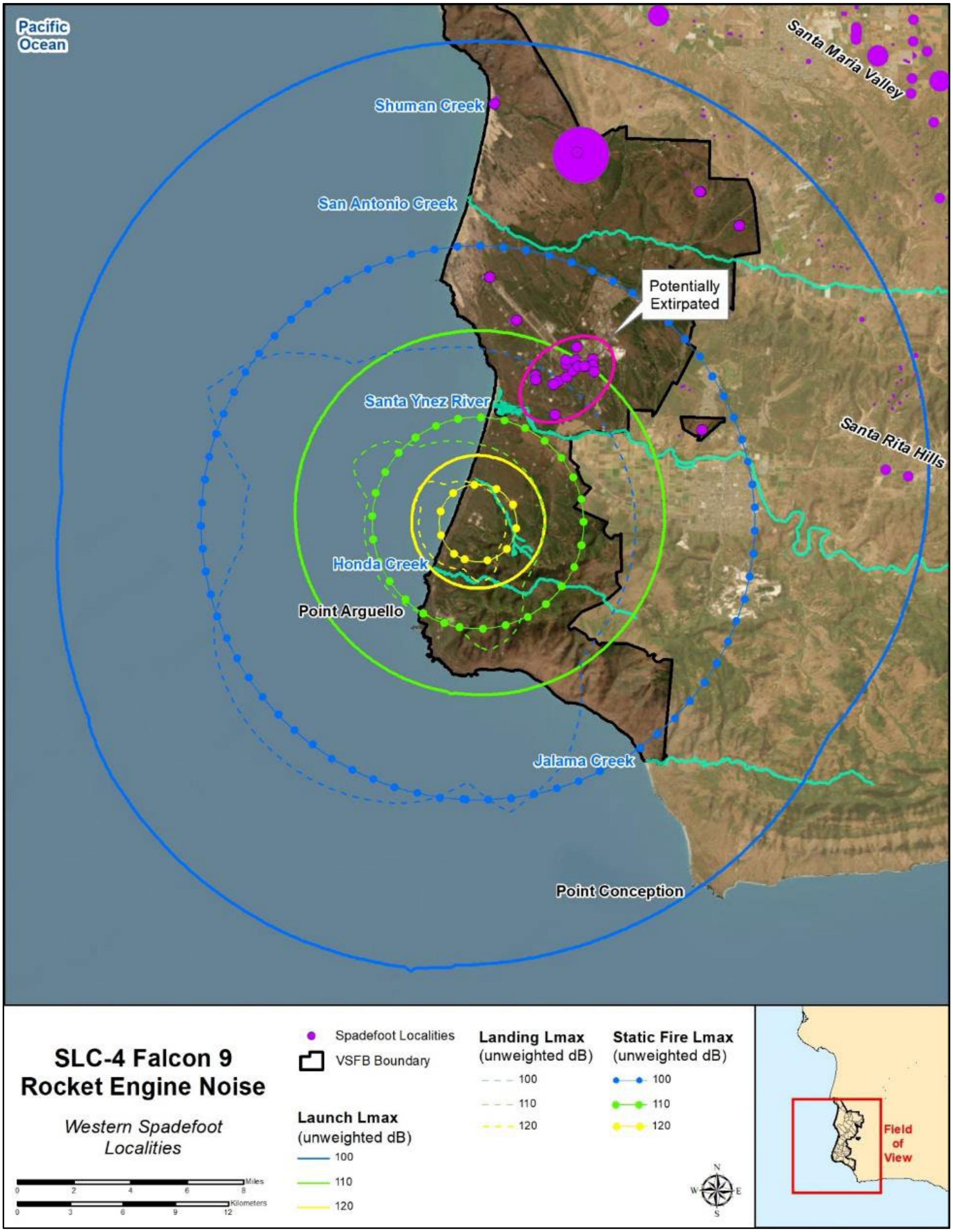

Figure 4.6-1. Western spadefoot localities and Falcon 9 SLC-4 static fire, launch, and landing rocket engine noise.

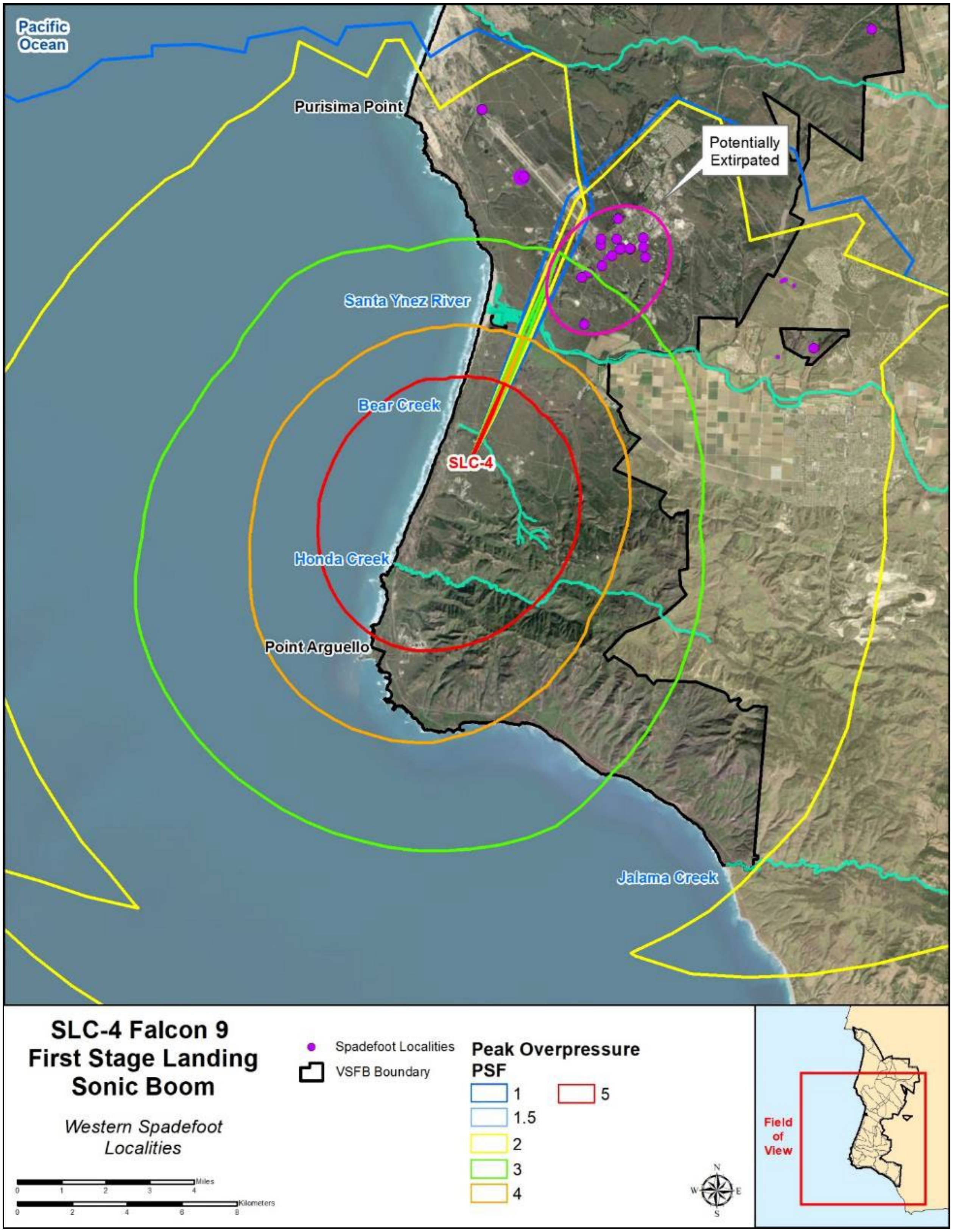

Figure 4.6-2. Western spadefoot localities and SLC-4 landing sonic boom impact areas.

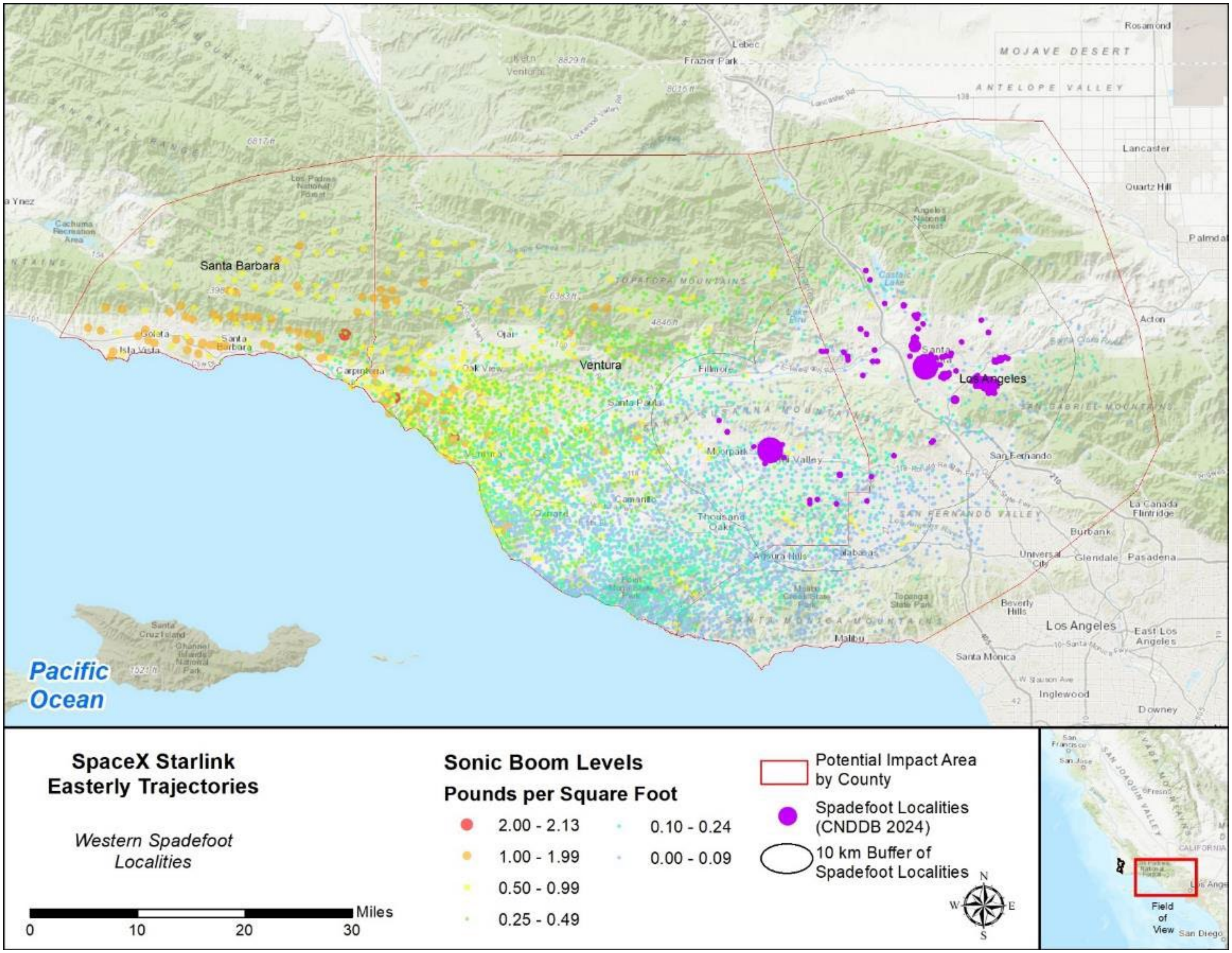

Figure 4.6-3. Western spadefoot localities and potential sonic boom impact areas in eastern Santa Barbara, Ventura, and Los Angeles Counties.

4.7 Southwestern Pond Turtle (Proposed Federal Listing as Threatened)

4.7.1 Status

The UFSWS proposed to list the SWPT as threatened under the ESA on 3 October 2023 (88 FR 68370).

4.7.2 Life History

The SWPT is approximately 4 to 7 inches in length. This species is found in permanent to semi-permanent ponds, lakes, and streams where it feeds, breeds, and shelters. This turtle utilizes bank sides, islands, rocks, logs, and floating debris to bask. SWPT also uses surrounding upland terrestrial habitat to lay eggs in underground nests, disperse, overwinter, and aestivate (Reese and Welsh Jr. 1997). SWPT have been documented aestivating in terrestrial habitats for up to 7 months during dry periods (Belli 2015). Females require upland nesting habitat in close proximity to aquatic habitat to lay their eggs (Holland 1991). Eggs are typically laid from May through July and require approximately 75 to 134 days to incubate (Holland 1991; Geist et al. 2015).

The primary threats to SWPT are habitat degradation, loss, and fragmentation, predation, competition with non-native species, disease, road mortality, over-collection, water contamination, fire, drought, and flood events (USFWS 2023b).

4.7.3 Occurrence Within the Action Area

SWPT have been found across VSFB, including Shuman Creek, San Antonio Creek, Lake Canyon, Santa Ynez River, Honda Creek, Jalama Creek, and various ponds and wetlands (Figure 4.7-1 and Figure 4.7-2; MSRS 2014a, 2014b, 2018a, 2022, CNDDB 2023; VSFB, unpublished data). Off-base, SWPT are documented throughout Santa Barbara County in various ponds, creeks, and rivers (CDFW 2023). In the region potentially impacted by sonic booms during missions with easterly trajectories spadefoot occurs in eastern Ventura and western Los Angeles Counties (Figure 4.7-3; CDFW 2024).

4.7.4 Critical Habitat

In the proposed rule, the USFWS concluded that the designation of Critical Habitat for the SWPT is not determinable at this time due to a lack of data sufficient to perform required analyses (88 FR 68370).

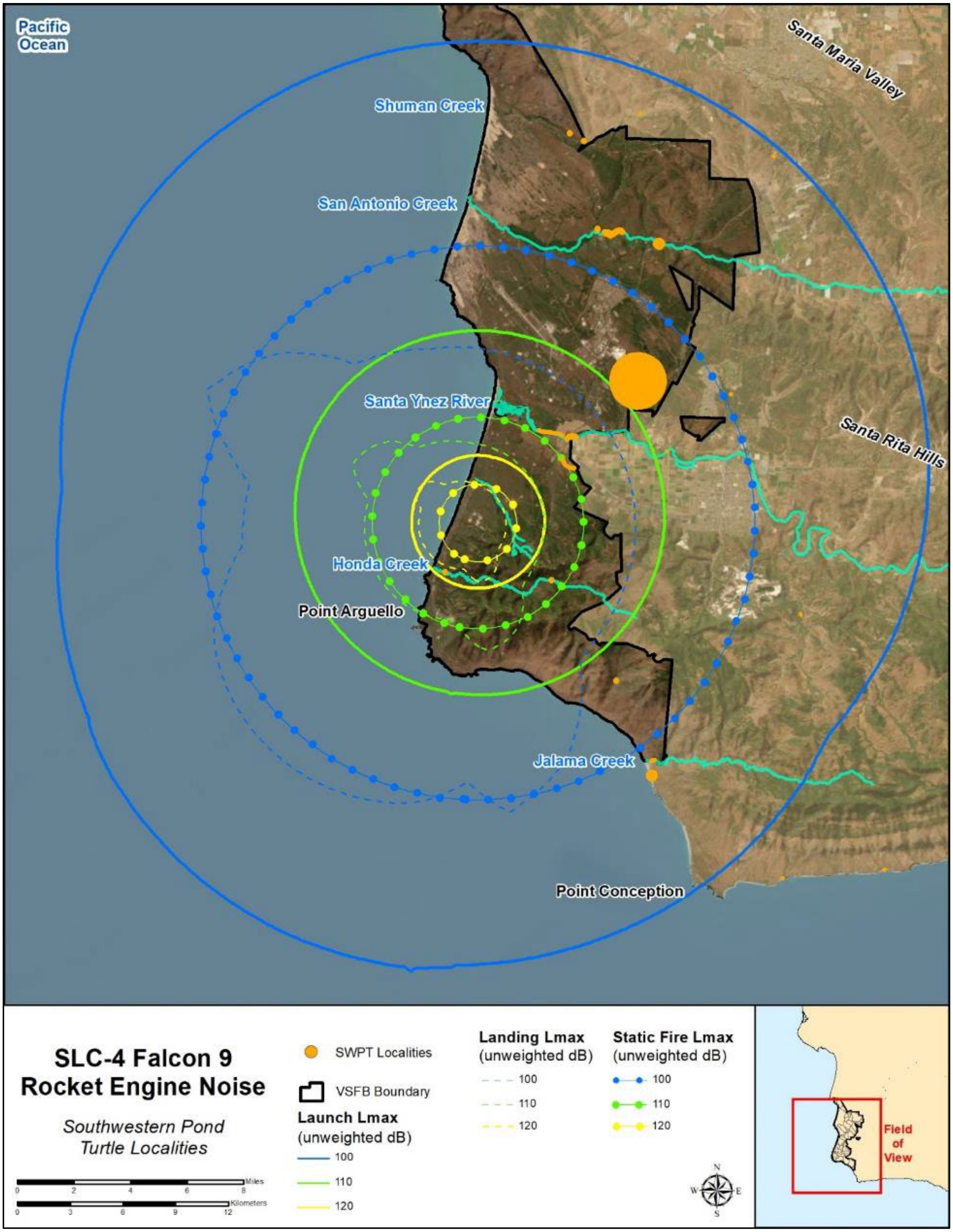

Figure 4.7-1. Southwestern pond turtle localities and Falcon 9 SLC-4 static fire, launch, and landing rocket engine noise.

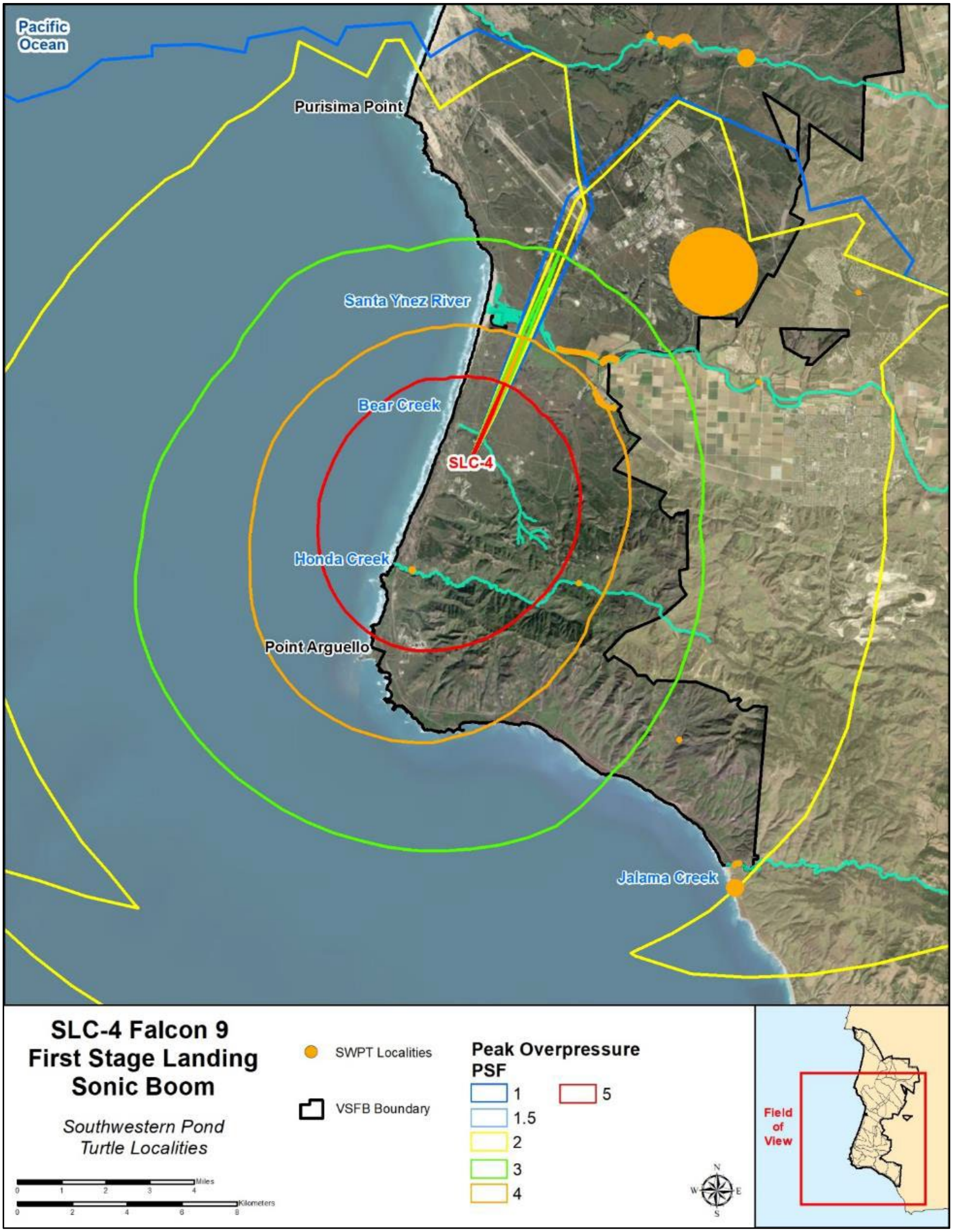

Figure 4.7-2. Southwestern pond turtle localities and sample SLC-4 landing sonic boom impact areas.

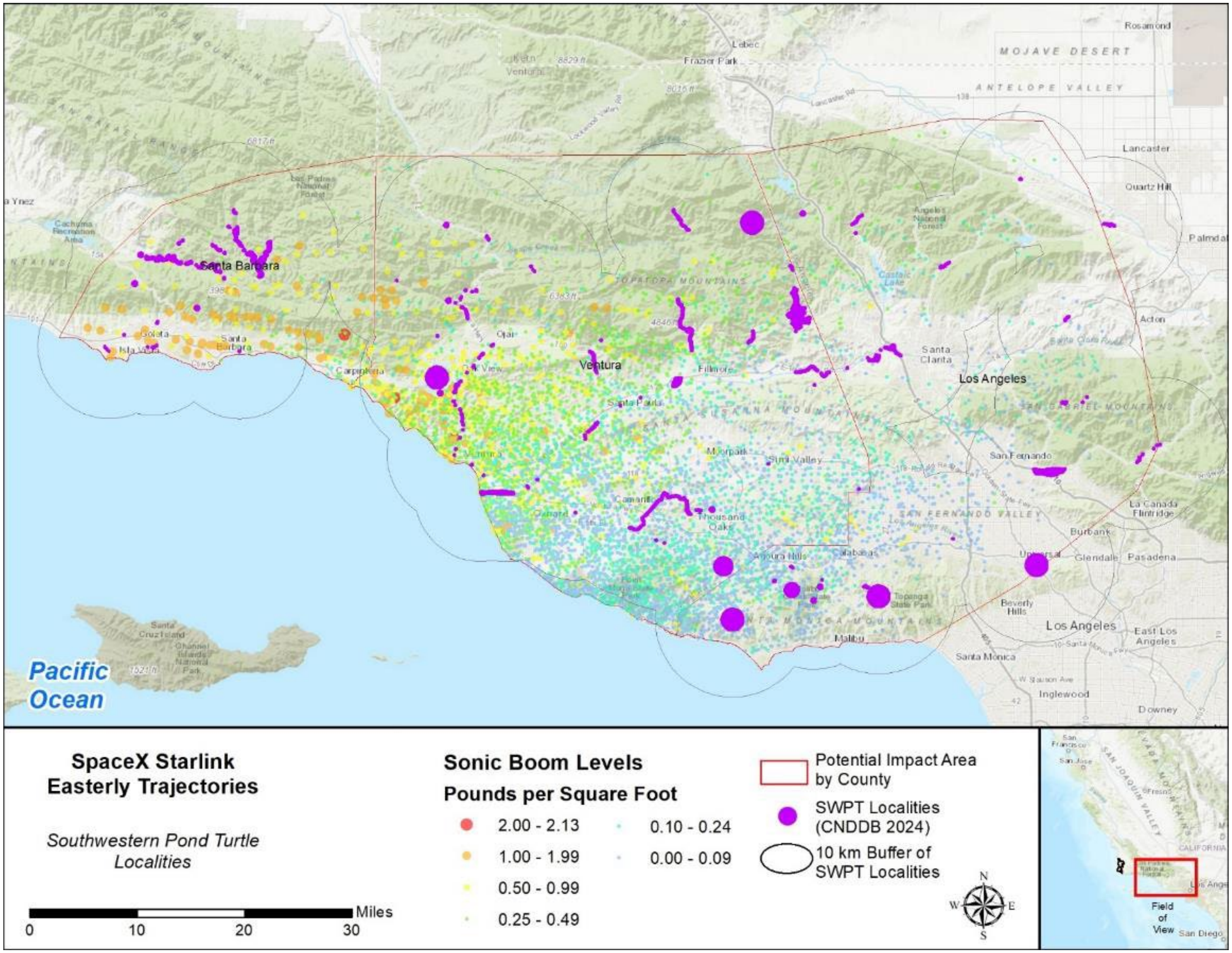

Figure 4.7-3. Southwestern pond turtle localities and potential sonic boom impact areas in eastern Santa Barbara, Ventura, and Los Angeles Counties.

4.8 Marbled Murrelet (Federally Listed Threatened Species)

4.8.1 Status

The USFWS listed the MAMU as threatened on 1 October 1992 (57 FR 45328) and published a Recovery Plan for the species in 1997 (USFWS 1997). The USFWS completed a 5-year review of the species in 2009 (USFWS 2009).

4.8.2 Life History

The MAMU is a small seabird that breeds along the Pacific coast. It forages in nearshore marine waters on small fish and invertebrates, and flies inland to breed. The species requires abundant prey within foraging habitat. Among alcids, the species is unique because it uses old-growth coniferous forests and mature trees for nesting (USFWS 1997). MAMU are wing-pursuit divers.

Although little was historically known about the MAMU movement and home range, more information is becoming available. The first MAMU nest was not documented until 1974. Since then, the MAMU's home range has been determined to be 253 square miles (mi^2) for non-nesters and 93 mi^2 for nesters within California. In addition, at-sea resting areas have also been observed an average of 3.2 mi from the mouths of drainages. MAMU spend nighttime hours resting in the ocean in these at-sea resting areas and commute to foraging areas during the day. Nests have been observed from sea level to 5,020 ft (USFWS 2009).

4.8.3 Occurrence Within the Action Area

MAMU range from Alaska to California and may occur as far south as Baja California. The species is considered rare to very rare much of the year in Santa Barbara County. However, the species may be somewhat regular north of VSFB in the late summer and would be considered casual in the spring (Lehman 2020; eBird 2023). There is no known or suitable breeding habitat for MAMU on VSFB. As such, only non-breeding individuals would occur within portions of the Action Area subject to noise impacts (Figures 4.8-1 through 4.8-5).

MAMU have been observed semi-regularly off the coast in nearshore waters between the Santa Maria River and offshore of VSFB from on-land observation sites (Figure 4.8-1 and Figure 4.8-2; eBird 2022). Specifically, one individual was observed at an unreported distance offshore from an observation site located approximately 0.5 mi west of SLC-4 in 2011 (eBird 2023). Two separate sightings were also documented in 1995 offshore of Purisima Point (eBird 2023). MAMU has never been documented breeding on VSFB, nor is any old-growth coniferous forest present on VSFB or in the Action Area.

4.8.4 Critical Habitat

The USFWS designated Critical Habitat for the MAMU on 24 May 1996 (61 FR 26257) and revised this designation on 4 August 2016 (81 FR 51348–51370). There is no designated Critical Habitat for this species within or adjacent to the Action Area. The nearest Critical Habitat is over 160 mi to the north near Santa Cruz, California.

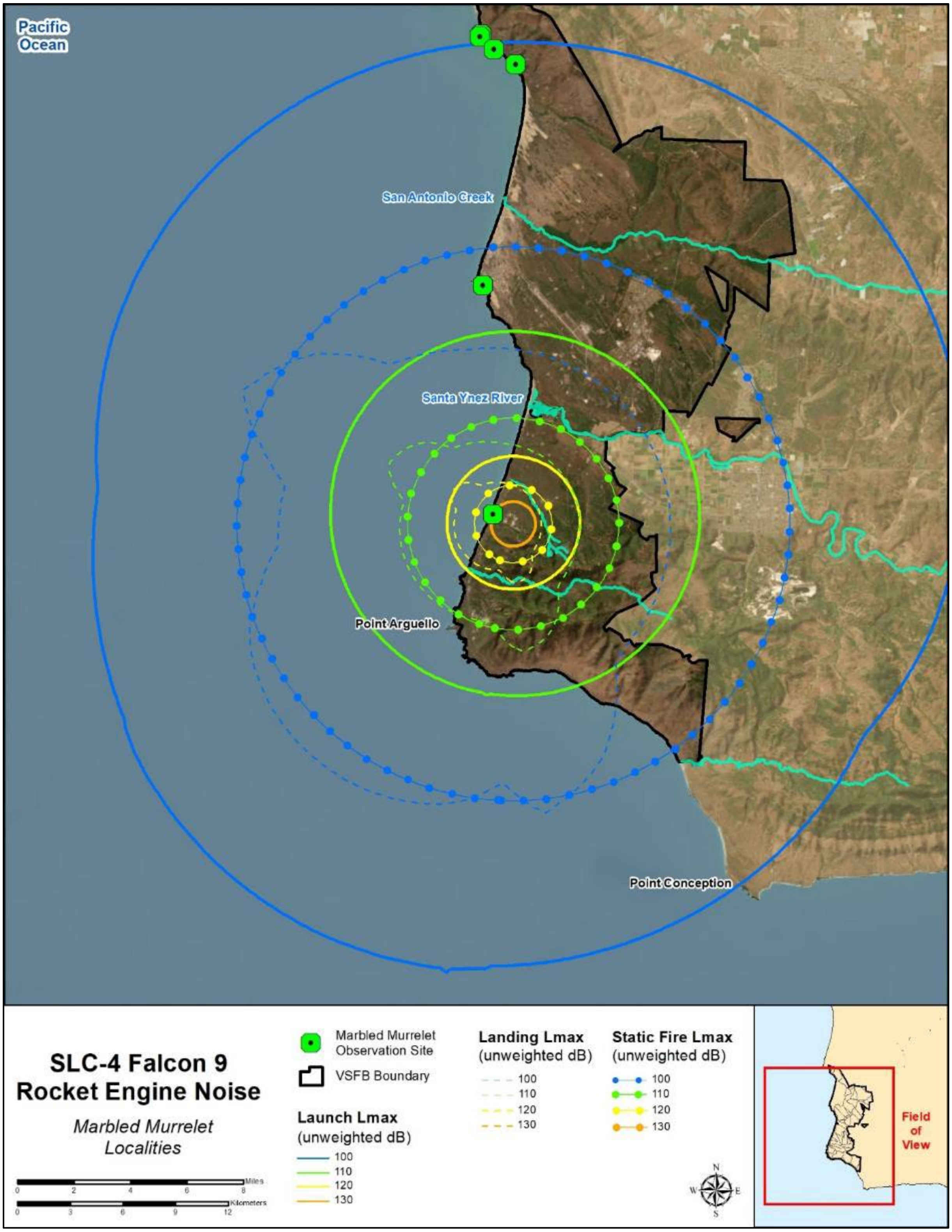

Figure 4.8-1. Marbled murrelet observation sites and Falcon 9 SLC-4 static fire, launch, and landing rocket engine noise (Note: birds were observed at an unrecorded distance offshore of these observation sites).

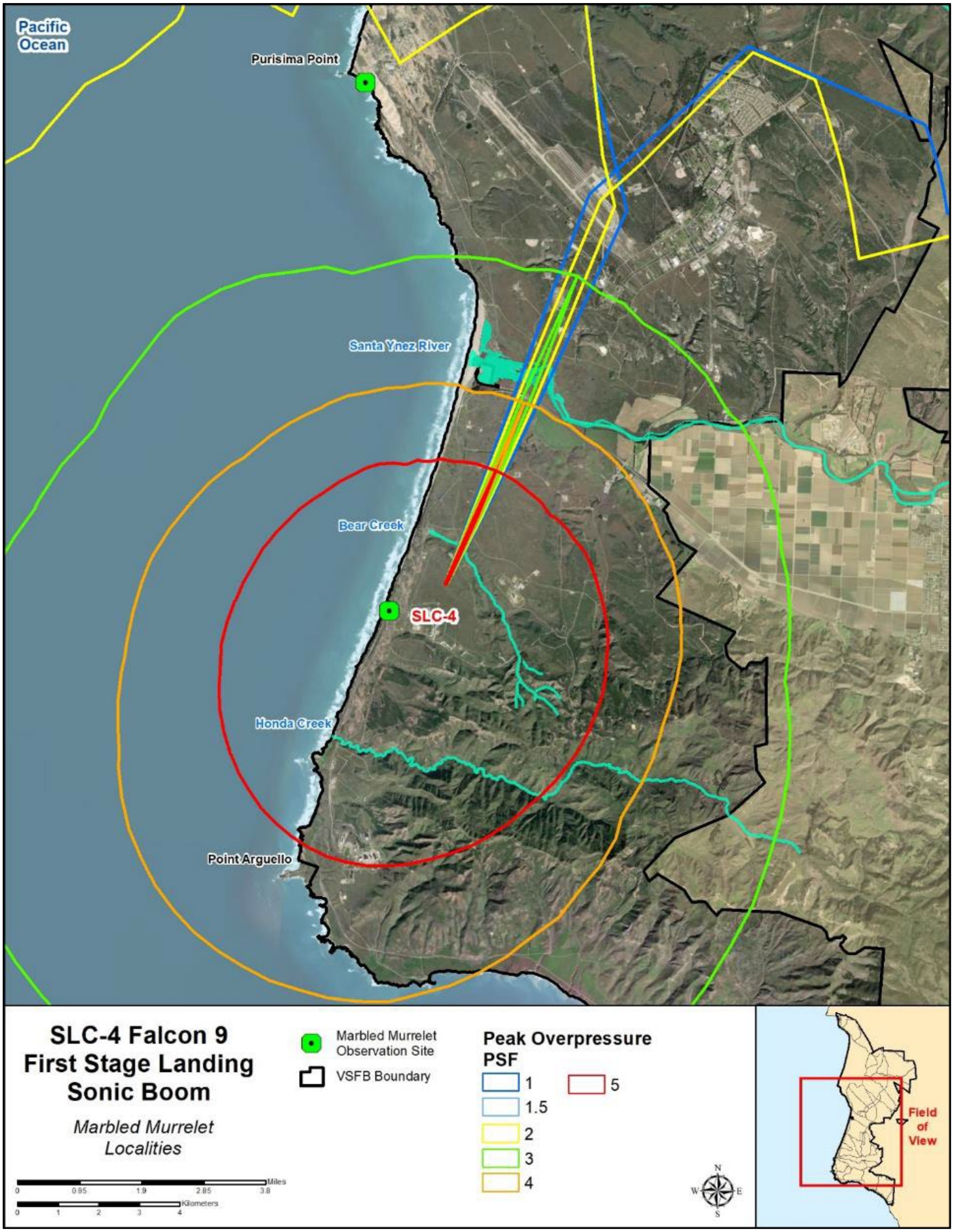

Figure 4.8-2. Marbled murrelet observation sites and sample sonic boom model results for SLC-4 landing events (Note: birds were observed at an unrecorded distance offshore of these observation sites).

4.9 Southwestern Willow Flycatcher (Federally Listed Endangered Species)

4.9.1 Status

The UFSWS listed the SWFL as endangered on 27 February 1995 (60 FR 10695-10715). In 2002, USFWS issued a Final Recovery Plan to stabilize and restore SWFL populations (USFWS 2002b).

4.9.2 Life History

SWFL, in California, are spring and summer residents of willow thickets in riparian habitats. SWFLs typically arrive at breeding grounds in early May and depart in August after breeding has been completed. SWFL are closely tied to dynamic riparian habitats featuring an overlapping mosaic of dense willows, wetlands, and open water. SWFL historically bred along the Santa Ynez River on VSFB west of the 13th Street Bridge, but progressive changes to habitat in this area has largely eliminated favored SWFL breeding habitat on VSFB.

4.9.3 Occurrence in the Action Area

The first documented SWFL breeding territory on the Santa Ynez River on VSFB was found at the Miguelito Wetland in 1992 (Figure 4.9-1 and Figure 4.9-2; Ball et al. 2012). This site is approximately 3.9 mi north of SLC-4, but it has not been occupied since 1994 (Ball et al. 2012). A small population of between one and six SWFL was consistently found from 1995 to 2003 further east along the Santa Ynez River at two sites: an area immediately west of the 13th Street Bridge and the Wildlife Natural Resources Area. The 13th Street Bridge territory included a nest site near the 13th Street Bridge (Holmgren & Collins 1999) where breeding was documented in 1998 (Farmer et al. 2003). SWFL were last seen at this site in 2000, which was subsequently destroyed by high water flow events during the winter storms of 2000-2001 (Farmer et al. 2003). SWFL were last documented at the Wildlife Natural Resources Area in 2003 (Farmer et al. 2003), and have not been re-documented during subsequent surveys.

Riparian point count surveys conducted on the Santa Ynez River on VSFB from 2004 to 2011 did not detect SWFL in the vicinity of the 13th Street Bridge (Seavy et al. 2012). SWFL were also not detected during targeted surveys of the Santa Ynez River for SWFL in 2003, 2004, 2012, and 2017 (SRS Technologies, Inc. 2004; Ball et al. 2012; Southern Sierra Research Station 2017). In addition, four surveys in the riparian forest on VSFB along the Santa Ynez River during the 2011 breeding season did not detect the species (DiGaudio et al. 2011). If SWFL were to be present on VSFB during a launch event, they would likely be migrating or foraging and present for a short period of time.

Historic modifications to the Santa Ynez River, including the installation of the former 35th Street Bridge and the bridges at 13th Street and Floredale Avenue have resulted in increased straightening and channelization of flow. The historic impacts contributed to the progressive down-cutting of the Santa Ynez River and lead to a gradual separation of the river elevation from riparian habitat (ESA PWA 2010). As the level of the channel dropped, much of the riparian habitat on the upper terrace of the floodplain was cut off from regular inundation (ESA PWA 2010). Consequently, aging riparian trees were not being replaced and interstitial wetlands have disappeared, rendering this habitat unsuitable for SWFL occupancy. The riparian habitat along the incised channel is largely confined to narrow banks and lacks complexity. This progressive deterioration of the floodplain has likely contributed to the absence of SWFL from the Santa Ynez River on VSFB in recent years and future SWFL breeding on VSFB is unlikely. Both the 13th Street Bridge and Floredale Bridges have been re-designed and replaced in recent years to allow more river movement, but effects on downstream habitats have yet to be determined.

One territorial male SWFL was incidentally detected at the Santa Ynez River adjacent to Buellton, approximately 24.5 mi east of SLC-6, in 2022; pairing was suspected but not confirmed (Griffith Wildlife Biology 2022). This area was historically occupied, with the most recent prior documented detections in 2017 (Southern Sierra Research Station 2017).

In the region potentially impacted by sonic booms during missions with easterly trajectories, SWFL occur in the upper Santa Ynez River and the Santa Clara River drainage in Ventura and Los Angeles Counties (Figure 4.9-3; CDFW 2024).

4.9.4 Critical Habitat

The USFWS issued a final rule on SWFL Critical Habitat on 3 January 2013 (78 FR 344-534). The USFWS excluded VSFB from SWFL Critical Habitat designation pursuant to under section 4(a)(3) of the ESA, based on the implementation of an INRMP (U.S. Air Force 2021). Off-base, Critical Habitat has been designated along the Santa Ynez River from Lompoc to Buellton (Figure 4.9-3). In the region potentially impacted by sonic booms during missions with easterly trajectories, Critical Habitat has been designated in the upper Santa Ynez River, the Ventura River, and the Santa Clara River drainage in Ventura and Los Angeles Counties (Figure 4.9-3).

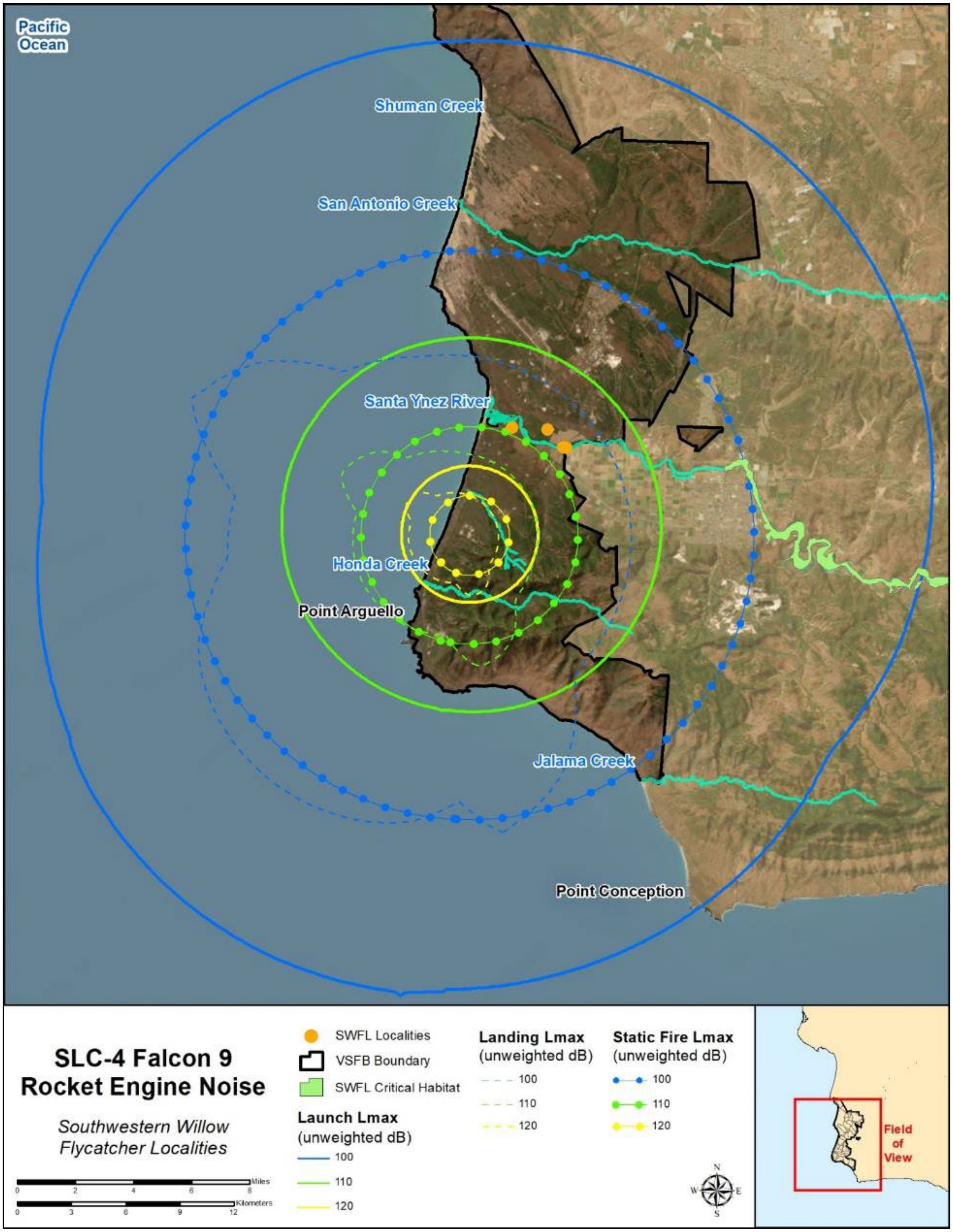

Figure 4.9-1. Southwestern willow flycatcher localities and Falcon 9 SLC-4 static fire, launch, and landing rocket engine noise.

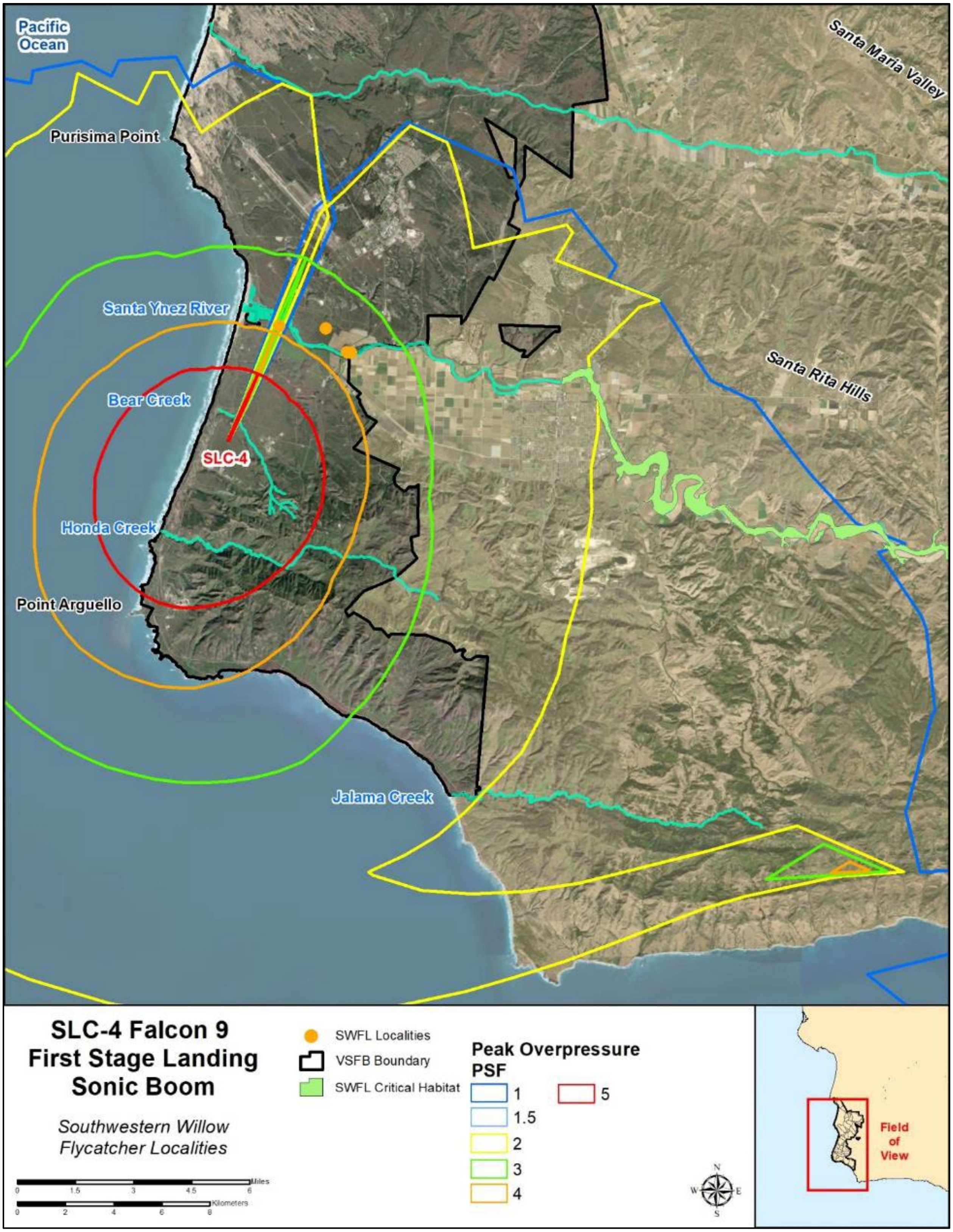

Figure 4.9-2. Southwestern willow flycatcher localities and SLC-4 landing sonic boom impact areas.

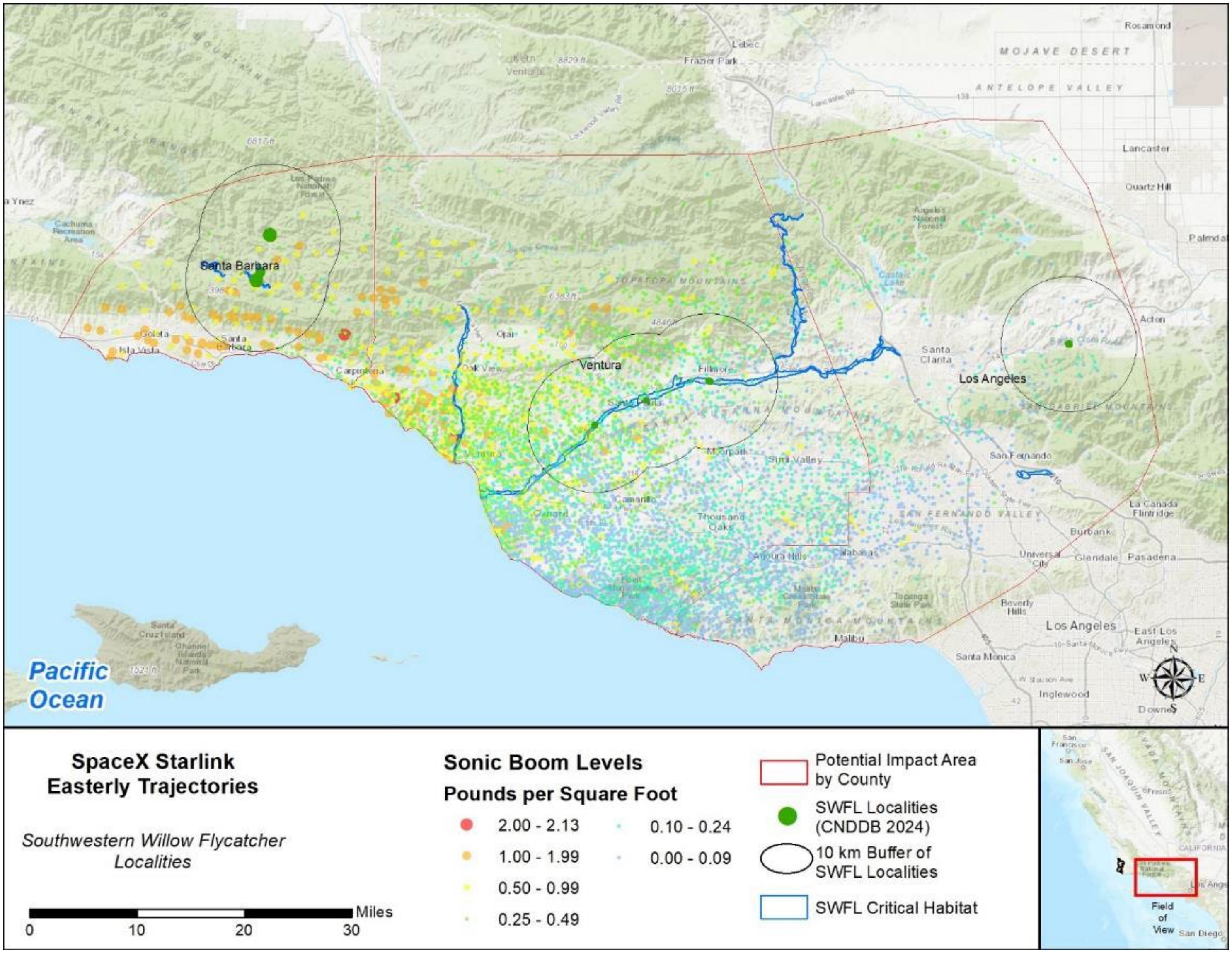

Figure 4.9-3. SWFL localities, critical habitat, and potential sonic boom impact areas in eastern Santa Barbara, Ventura, and Los Angeles Counties.

4.10 Least Bell's Vireo (Federally Listed Endangered Species)

4.10.1 Status

The USFWS listed the LBVI as federally endangered in May 1986 (51 FR 16474-16482). A draft recovery plan was published in 1998 (USFWS 1998).

4.10.2 Life History

The LBVI is a small bird that is approximately 4.5 to 5 inches in length. This species has short, rounded wings, a short straight bill, and a faint white eye ring. Feathers are mostly gray above and pale below. LBVI forage in bushes and shrubs, preying on spiders and insects (USFWS 1998). LBVI overwinter in southern Baja California, Mexico (Kus 2002) and migrate north to nest from mid-March to April (USFWS 1998). Breeding habitat is in coastal California is primarily willow-riparian woodlands (USFWS 1998).

4.10.3 Occurrence within the Action Area

Currently, most LBVI occur in eight counties south of Santa Barbara, with approximately half of all birds occurring on drainages within Marine Corps Base Camp Pendleton in San Diego County. LBVI, however, occurs as far north as Gilroy (Santa Clara County), and nesting birds have been documented at the Santa Clara River (Ventura County) and the Mojave River (San Bernardino County) as well. LBVI generally winter in southern Baja California, Mexico (Kus 2002).

Potential habitat for LBVI exists on VSFB and off-base in Santa Barbara County. There are no breeding records for LBVI on VSFB, and, until 2023, there were only two documented records of occurrence, both of which are east of the 13th Street Bridge and Santa Ynez River crossing approximately 7.6 mi northeast of SLC-6 (Figure 4.10-1 and Figure 4.10-2). Both of these records are more than 20 years old (Holmgren and Collins 1999). LBVI was not detected in riparian point count surveys conducted on VSFB in 1998, annually from 2000 to 2005, 2008, and 2010 (Seavy et al. 2012). However, in 2023, one lone male was detected in June at the Santa Ynez River near 13th Street Bridge (VSFB, unpublished data). The individual was not detected on follow-up surveys and presumed to be a transient unpaired male.

In the off-Base project area, LBVI has been recorded at the Santa Ynez River adjacent to Buellton, approximately 24.5 mi east of SLC-6. In 2016, one territorial male was detected. This male was, however, presumed to be unpaired based on behavior (CNDDB 2023; Figure 4.10-3). A single male was again detected at this location in 2020, a transient male in 2021, and a territorial male in 2022 (Griffith Wildlife Biology 2022). The territorial male was not detected during multiple subsequent surveys conducted later in 2022 (Griffith Wildlife Biology 2022). At the Santa Maria River/Sisquoc River four paired males were detected in 2022, at locations approximately 28.0 to 30.1 mi northeast of SLC-6. Three of these pairs successfully raised young (Griffith Wildlife Biology 2022). In the region potentially impacted by sonic booms during missions with easterly trajectories, LBVI occur across eastern Santa Barbara, Ventura, and western Los Angeles Counties (Figure 4.10-3; CDFW 2024).

4.10.4 Critical Habitat

The USFWS designated Critical Habitat for this species in February 1994 (59 FR 4845-4867). In the region potentially impacted by sonic booms during missions with easterly trajectories, Critical Habitat has been designated in the upper Santa Ynez River in eastern Santa Barbara County and the Santa Clara River drainage in Ventura and Los Angeles Counties (Figure 4.10-3). The essential physical and biological features identified in the designation that support feeding, nesting, roosting, and sheltering are described as: “riparian woodland vegetation that generally contains both canopy and shrub layers, and includes some associated upload habitats.”

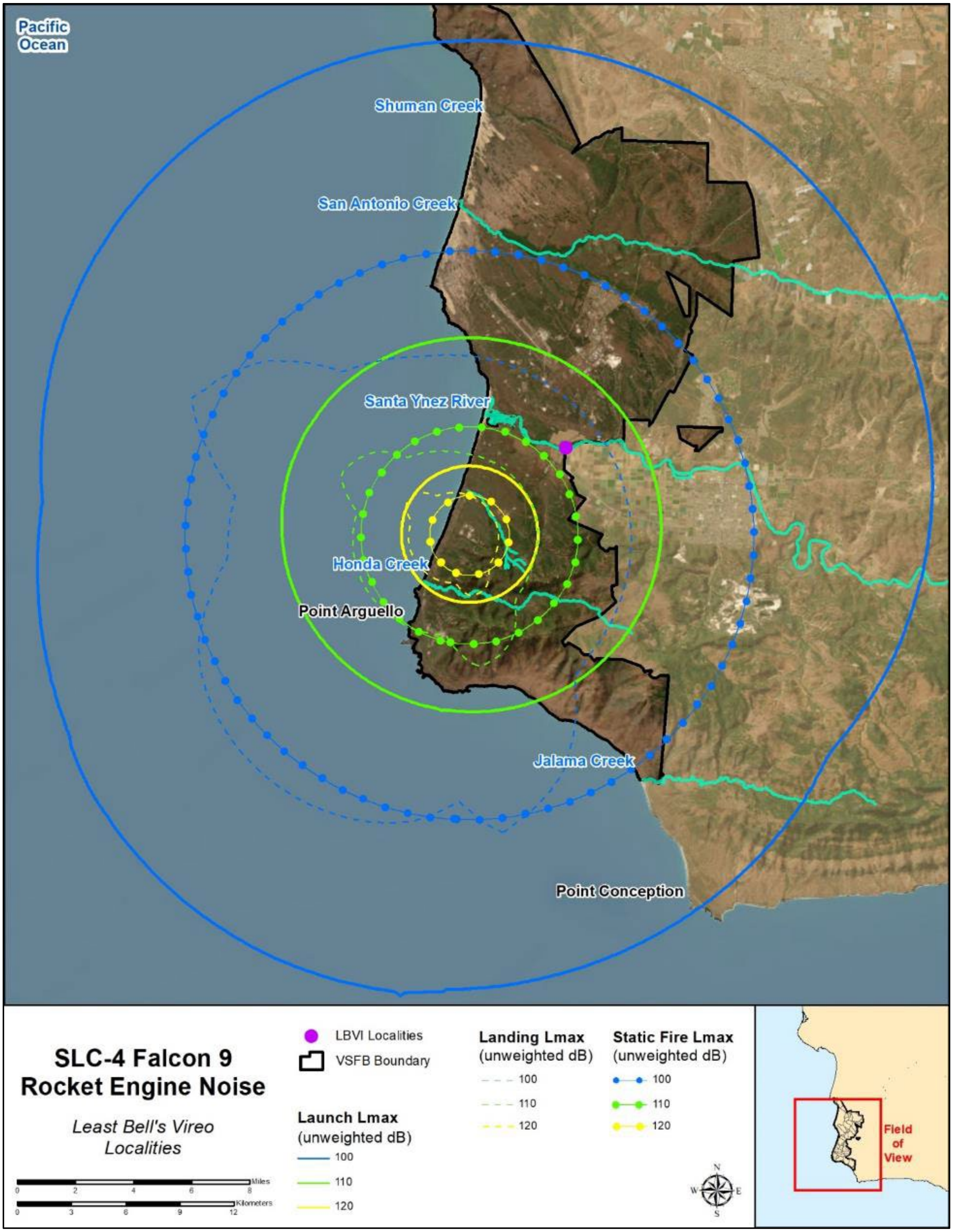

Figure 4.10-1. Least Bell's vireo localities and Falcon 9 SLC-4 static fire, launch, and landing rocket engine noise.

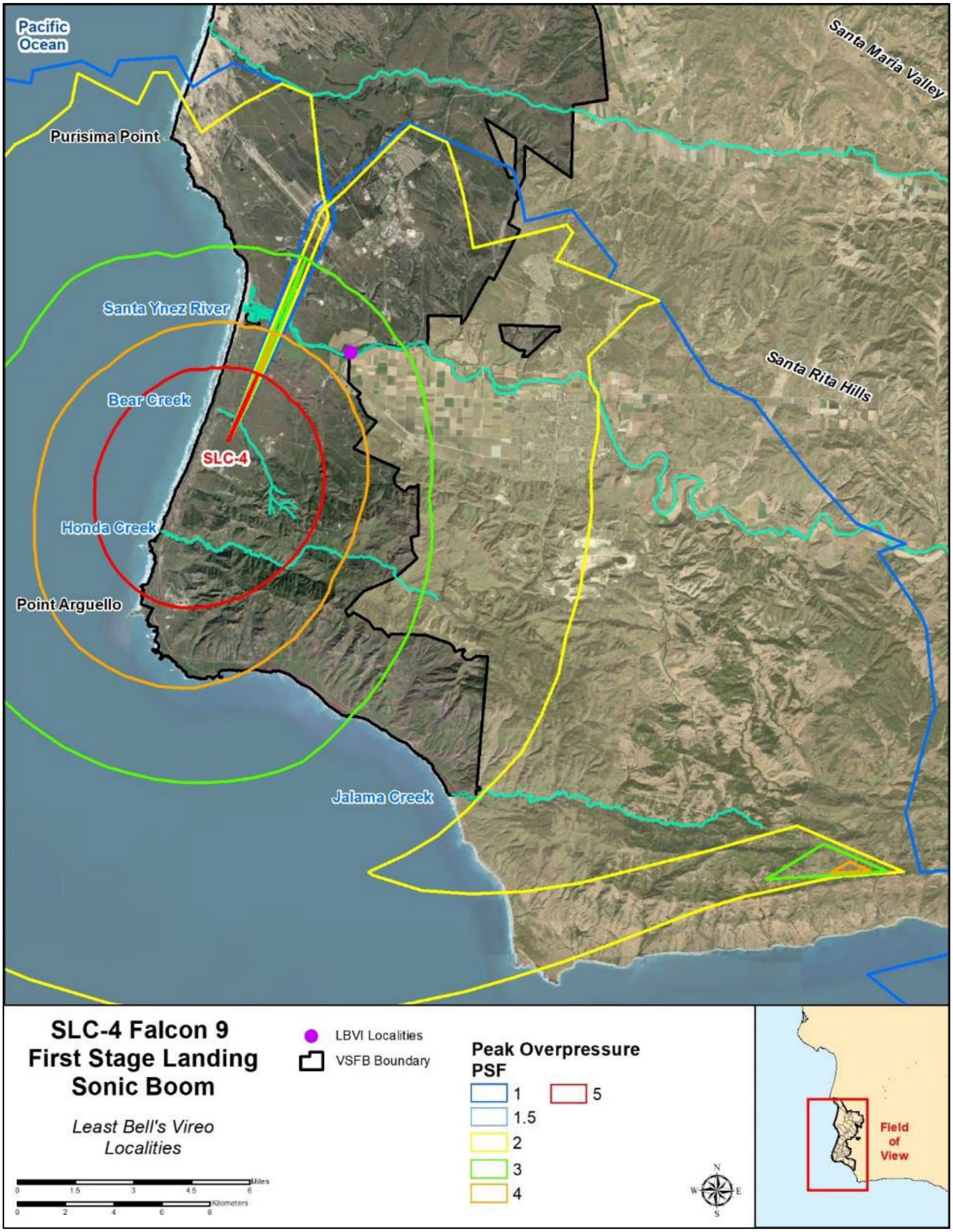

Figure 4.10-2. Least Bell's vireo localities and sample SLC-4 landing sonic boom impact areas..

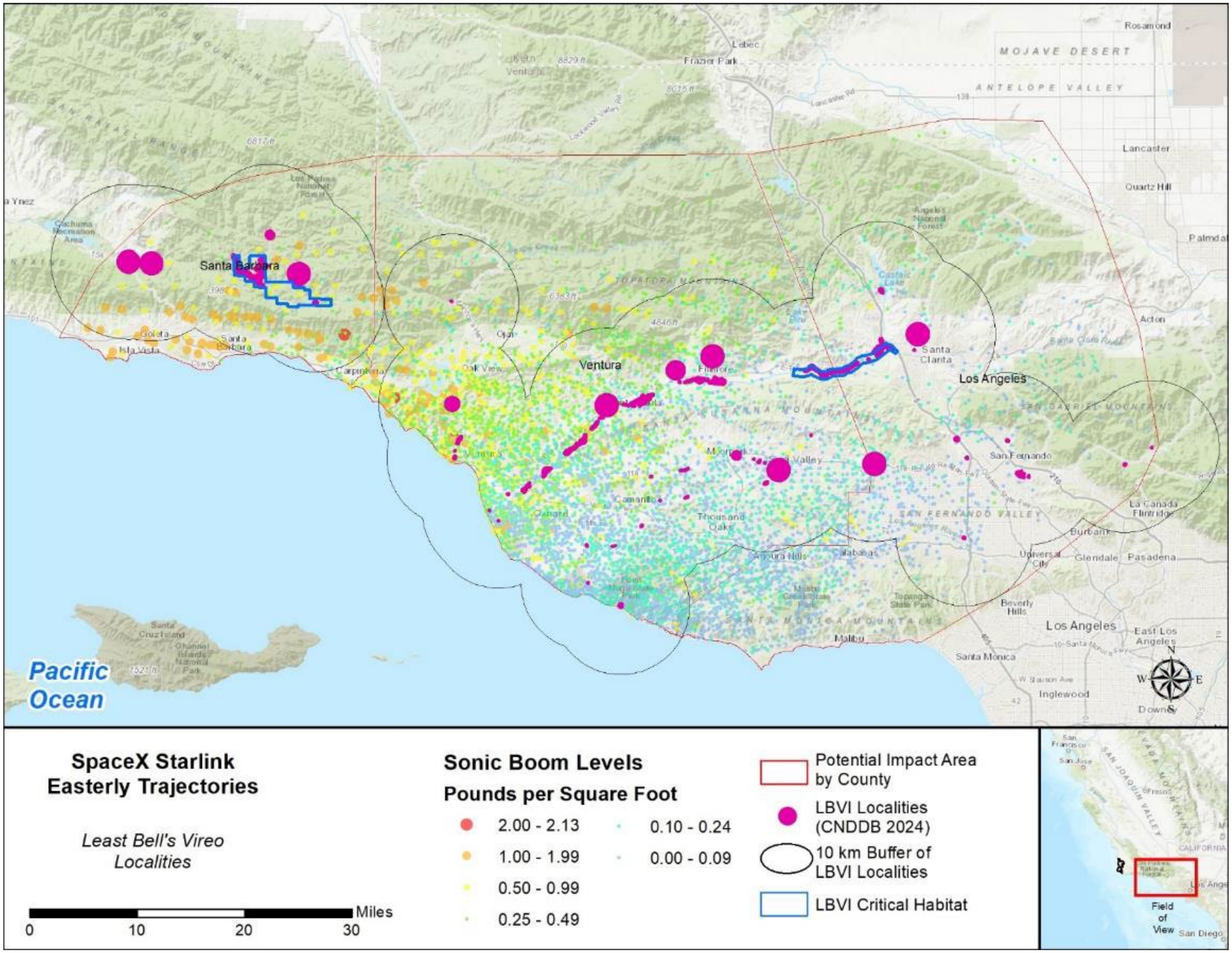

Figure 4.10-3. LBVI localities, critical habitat, and potential sonic boom impact areas in eastern Santa Barbara, Ventura, and Los Angeles Counties.

4.11 Western Snowy Plover (Federally Listed Threatened Species)

4.11.1 Status

The USFWS listed the Pacific coast population of the SNPL as federally threatened in March of 1993 (58 FR 12864–12874) and published a recovery plan for the Pacific coast population in 2007 (USFWS 2007).

4.11.2 Life History

The SNPL is a small shorebird with a pale tan back, white underparts, and dark patches on the sides of the neck reaching around to the top of the chest. The Pacific coast population of snowy plovers is limited to individuals that nest adjacent to tidal waters. The population's range extends from Southern Washington to Baja California, Mexico.

4.11.3 Occurrence within the Action Area

VSFB provides important breeding and wintering habitat for SNPL, which includes all sandy beaches and adjacent coastal dunes from the rocky headlands at the north end of Minuteman Beach to the pocket beaches and dune areas adjacent to Purisima Point on north VSFB (approximately 7.7 mi). Also included are all sandy beaches and adjacent coastal dunes from the rocky headlands at the north end of Wall Beach south to the rock cliffs at the south end of Surf Beach on South VSFB (approximately 4.8 mi).

VSFB has consistently supported one of the largest populations of breeding SNPL along the west coast of the United States (Robinette et al. 2016). VSFB has performed annual monitoring of SNPL since 1993 (Robinette et al. 2021). In 2014, VSFB supported an estimated 11 percent of California's breeding population (USFWS 2014c). The breeding population of SNPL on VSFB has been highly variable but relatively stable since 2007, with 235 adults and 472 nests initiated in 2021 (Robinette et al. 2021). The nearest SNPL nesting area to SLC-4 and SLC-6 is on South Surf Beach, approximately 0.7 mi northwest of SLC-4 and 4.1 mi northwest of SLC-6 (Figure 4.11-1 and Figure 4.11-2).

The SNPL is considered a permanent resident of Santa Rosa Island. On San Miguel Island, a high count of 61 SNPL was documented during the 2016–2017 winter window survey; however, counts at San Miguel Island typically document very few to no individuals (USFWS 2017c).

In the region potentially impacted by sonic booms during missions with easterly trajectories, SNPL occur at various open sandy beaches along the coastline (Figure 4.11-4; CDFW 2024).

4.11.4 Critical Habitat

The USFWS designated Critical Habitat for the SNPL in 1999 and revised this designation on 29 September 2005 (70 FR 56969–57119) and on 19 June 2012 (77 FR 36727). VSFB was exempted from Critical Habitat designation under section 4(a)(3) of the ESA. The nearest Critical Habitat is approximately 8 mi south of VSFB on Santa Rosa Island (Figure 4.11-3). In the region potentially impacted by sonic booms during missions with easterly trajectories, Critical Habitat has been designated at various sandy beaches along the coast of eastern Santa Barbara, Ventura, and Los Angeles Counties (Figure 4.11-4).

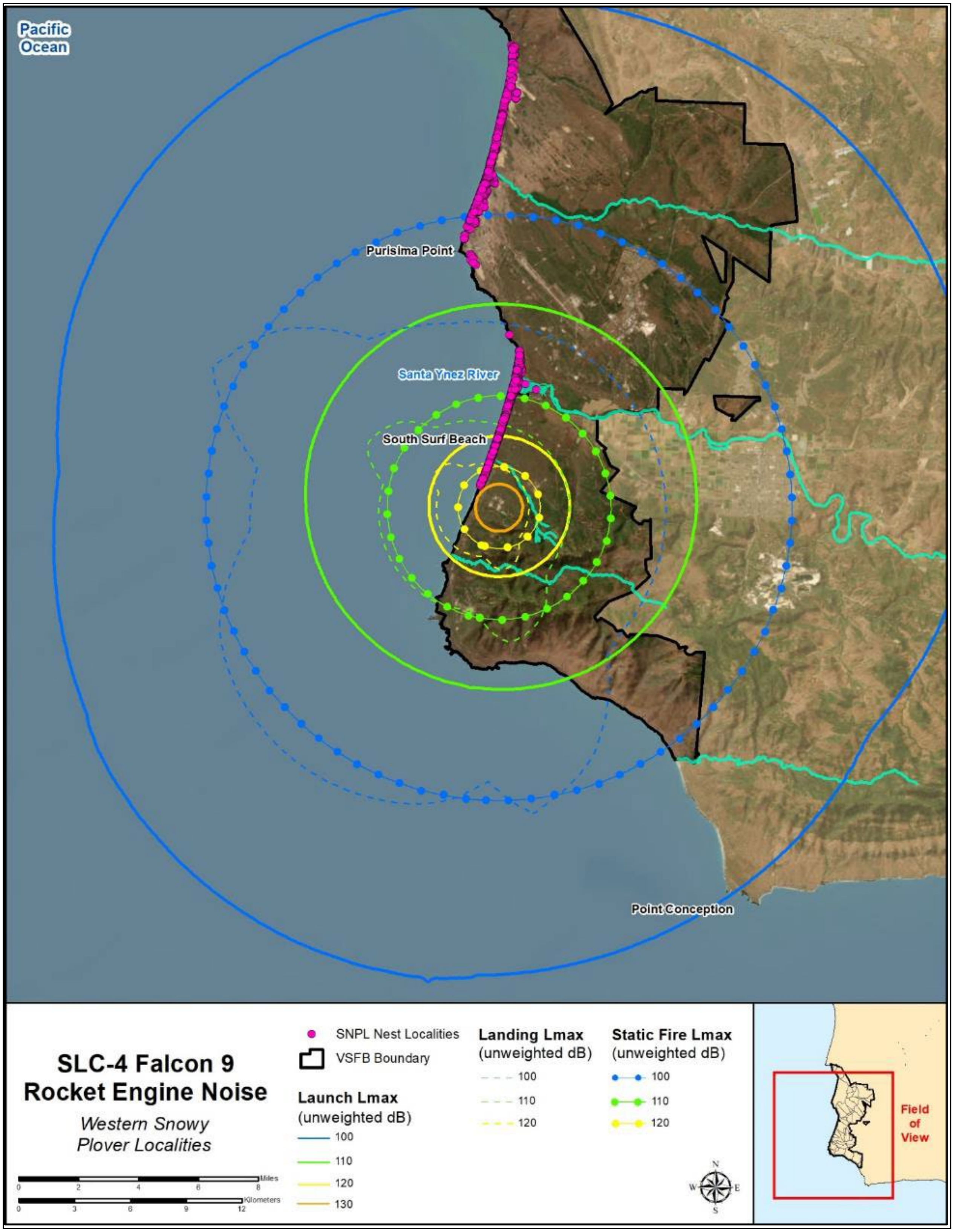

Figure 4.11-1. Western snowy plover nesting localities and Falcon 9 SLC-4 static fire, launch, and landing rocket engine noise.

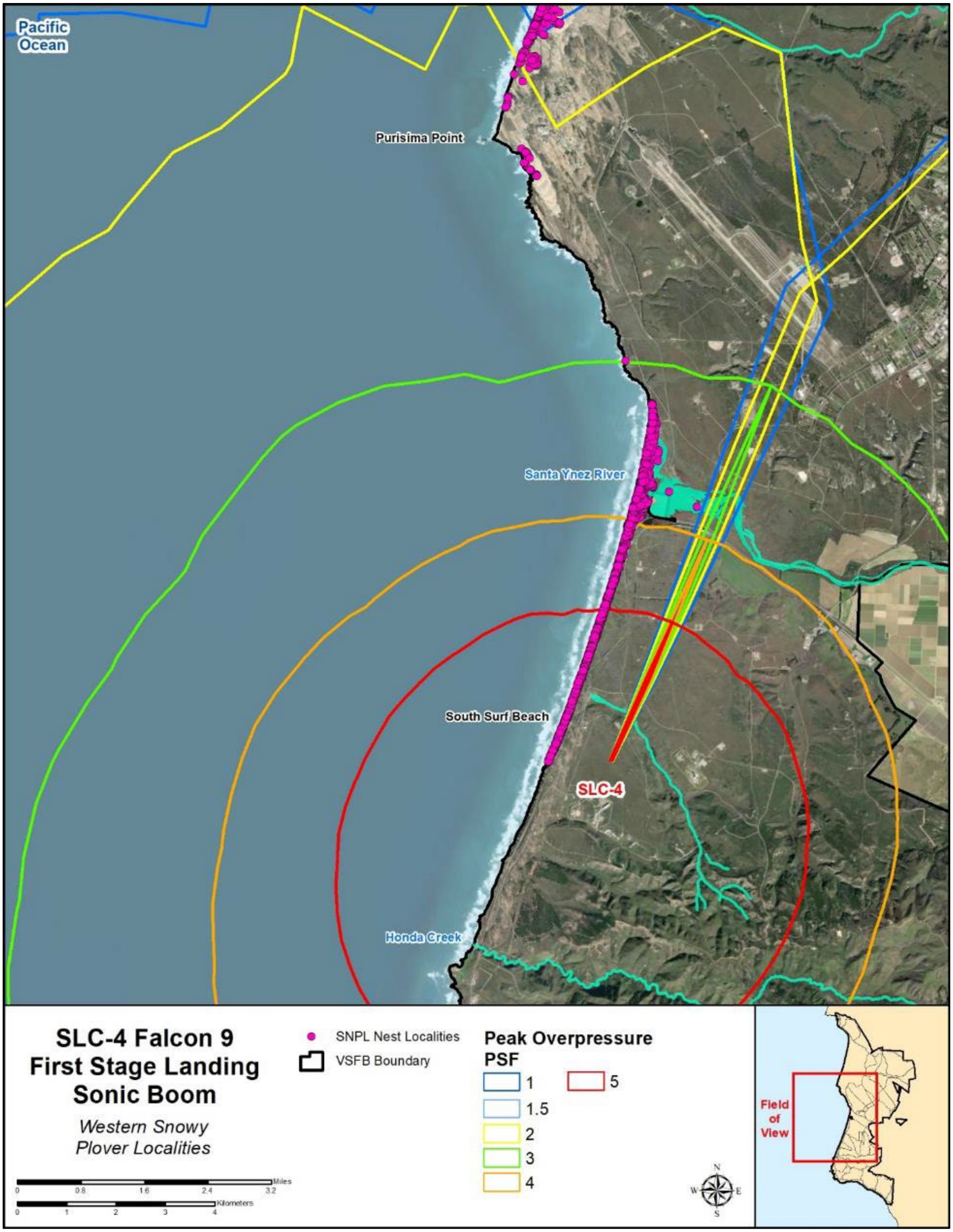

Figure 4.11-2. Western snowy plover nesting records and SLC-4 landing sonic boom impact areas.

Figure 4.11-3. Critical Habitat for the western snowy plover and sample SLC-4 Falcon 9 launch sonic boom model results.

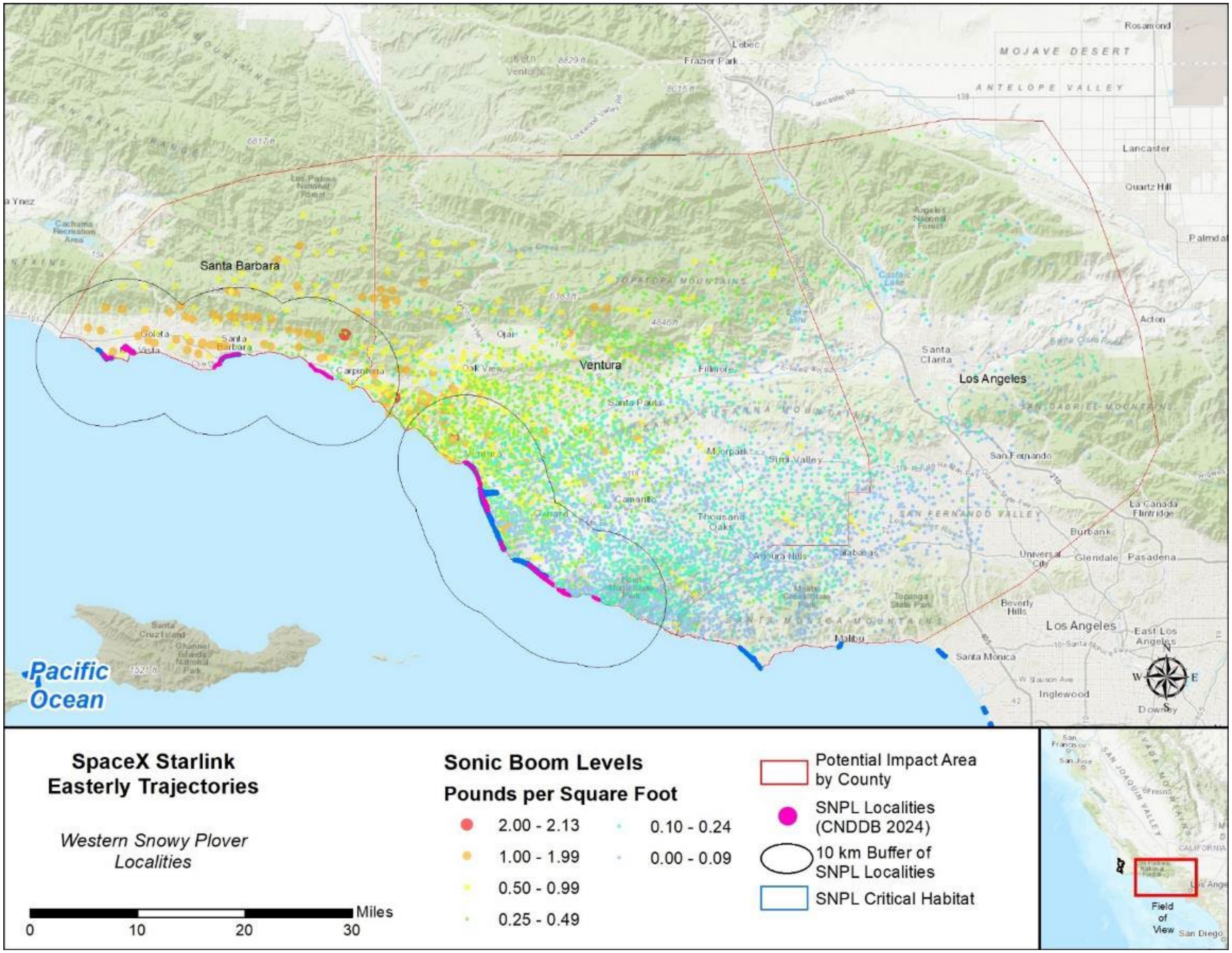

Figure 4.11-4. SNPL localities, critical habitat, and potential sonic boom impact areas in eastern Santa Barbara, Ventura, and Los Angeles Counties.

4.12 California Least Tern (Federally Listed Endangered Species)

4.12.1 Status

The USFWS listed the LETE as federally endangered on 13 October 1970 (35 FR 16047–16048) and published a recovery plan for the species in 1985 (USFWS 1985b).

4.12.2 Life History

The LETE is the smallest of the North American terns and is found along the Pacific Coast of California, from San Francisco southward to Baja California. It has a distinctive black cap with stripes running across the eyes to the beak. The upperparts are gray and the underparts are white. The California populations are localized and increasingly fragmented due to coastal development resulting in habitat loss. LETE are migratory and winter along the Pacific coast of Southern Mexico and the Gulf of California. They usually arrive at breeding grounds by the last week of April and return to wintering grounds in August. This species nests in colonies on relatively open beaches kept free of vegetation by natural scouring from tidal or wind action.

4.12.3 Occurrence in the Action Area

Historically, LETE nested in colonies in several locations along the coastal strand of the north VSFB coastline. Since 1998, except for two nests established south of San Antonio Creek in 2002, LETE have nested only at the primary colony site, in relatively undisturbed blufftop open dune habitat at Purisima Point. The population of LETE at VSFB represents a small percentage of the known breeding colonies. Robinette et al. (2016) estimated that VSFB supports a breeding population of 25 pairs of LETE.

Although this population is small, VSFB is one of only three breeding colonies that nest between Monterey and Point Conception; therefore, the Purisima Point breeding colony is considered important. This colony is approximately 8 mi north of SLC-4 (Figure 4.12-1). Adult LETE forage in the Santa Ynez River lagoon and estuary, approximately 3.7 mi north of SLC-4. After young LETE have fledged in late summer, they will disperse to this location to forage in the lagoon and roost on adjacent sandbars before migrating south for the winter (Robinette & Howar 2010).

In the region potentially impacted by sonic booms during missions with easterly trajectories, LETE breeding records occur at several open sandy beaches in eastern Santa Barbara and Ventura Counties (Figure 4.12-3; CDFW 2024).

4.12.4 Critical Habitat

The USFWS has not designated Critical Habitat for the LETE.

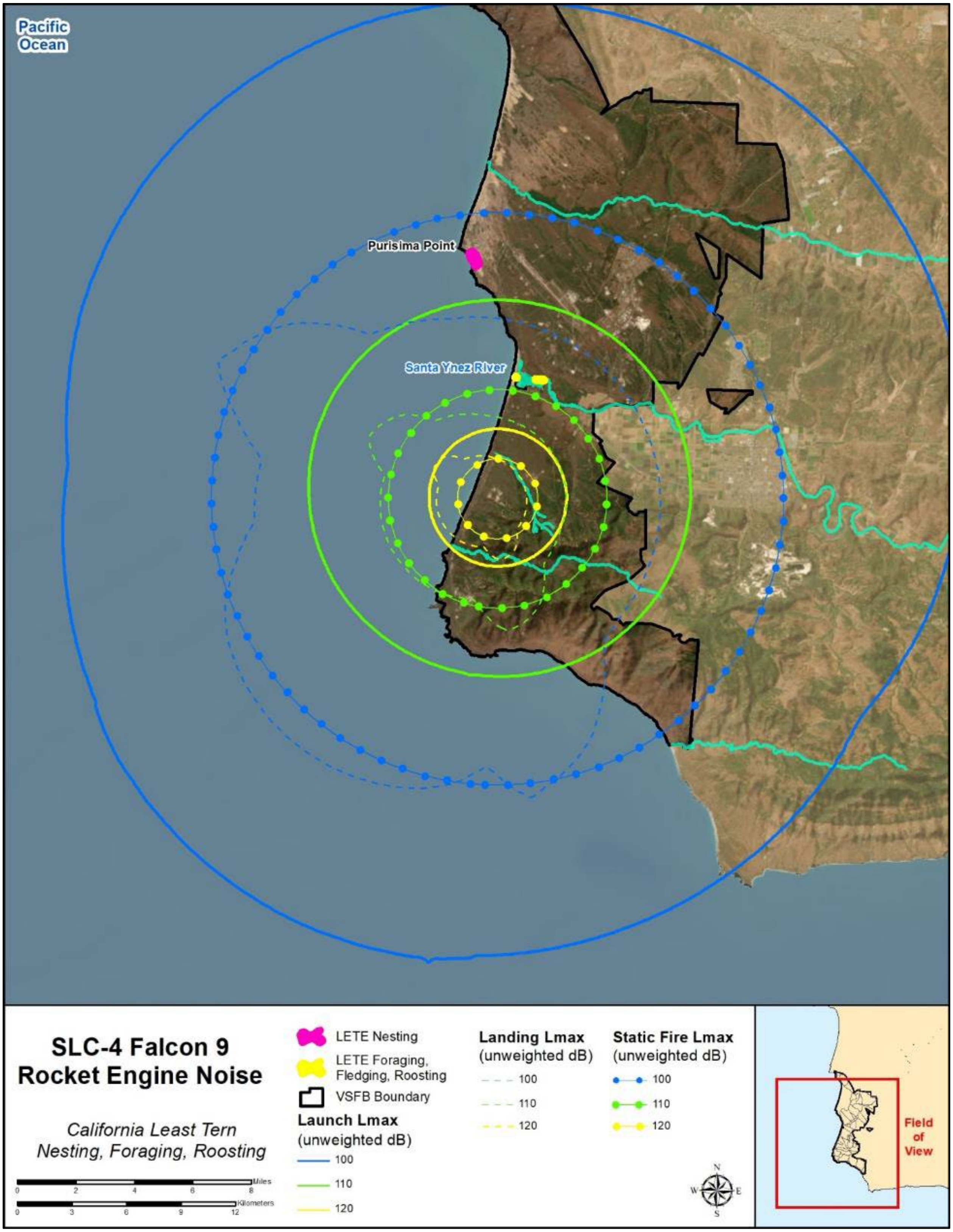

Figure 4.12-1. California least tern foraging, roosting, and nesting areas and Falcon 9 SLC-4 static fire, launch, and landing rocket engine noise.

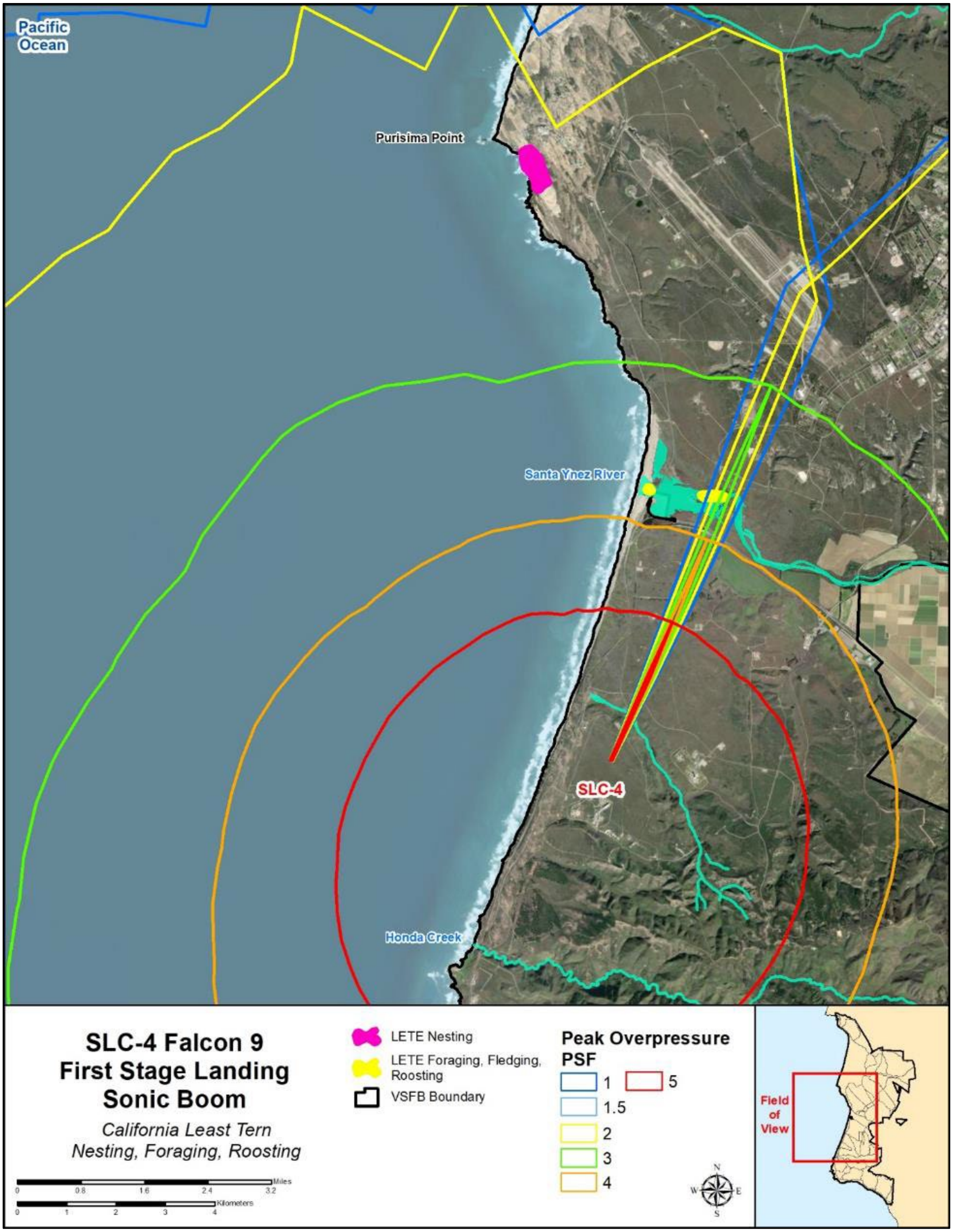

Figure 4.12-2. California least tern foraging, roosting, and sample SLC-4 landing sonic boom impact areas..

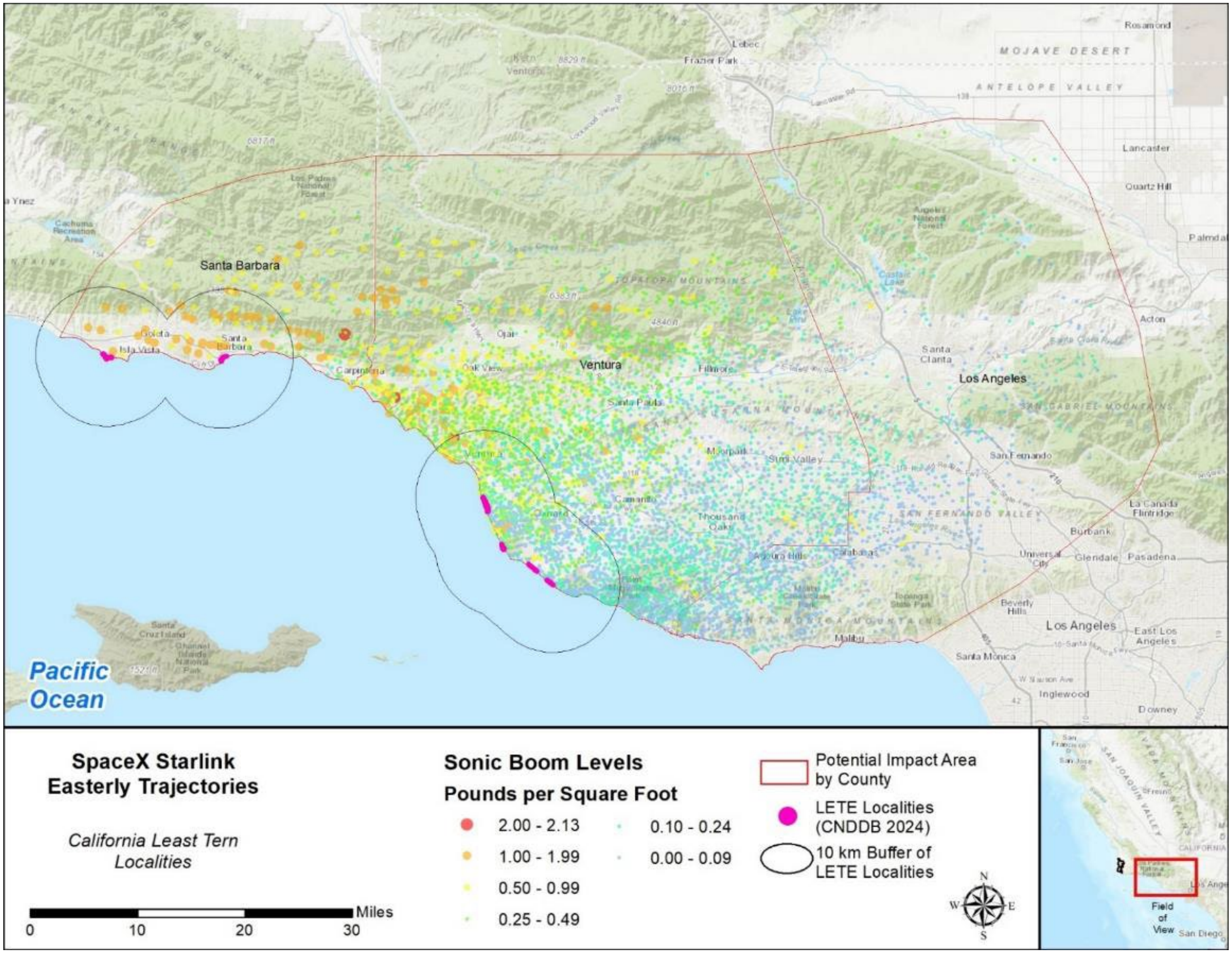

Figure 4.12-3. LETE localities and potential sonic boom impact areas in eastern Santa Barbara, Ventura, and Los Angeles Counties.

4.13 California Condor (Federally Listed Endangered Species)

4.13.1 Status

The USFWS listed the California condor as endangered on 11 March 1967 (32 FR 4001) and completed a Recovery Plan for the species on 25 April 1996 (USFWS 1996). In 1982, there were only 23 California condors in existence. To prevent the condor from going extinct, all remaining condors were placed into a captive breeding program in 1987. The USFWS and its partners began releasing condors back into the wild in 1992. The nearest release site to the Action Area is Bitter Creek National Wildlife Refuge (USFWS 2017b). Other release sites include the Ventana Wilderness and Pinnacles National Park.

4.13.2 Life History

Condors nest in rock formations (e.g., ledges and crevices) and less frequently in giant sequoia trees (*Sequoiadendron giganteum*). They normally lay a single egg between late January and early April. Both parents incubate the egg and share responsibilities for feeding the nestling after hatching. Condors require large remote areas and can range up to 150 mi a day in search of food. Chicks usually take their first flight around 6 to 7 months from hatching. The cause of the California condor's decline is inconclusive, but experts believe that lead poisoning and hunting greatly contributed to their decline (USFWS 1996).

4.13.3 Occurrence within the Action Area

The California condor's current range does not include VSFB. However, in March 2017, the DAF learned that telemetry data from USFWS showed there was a California condor ranging within VSFB. This condor was SB 760 (“VooDoo”), an immature, non-reproductive female (USFWS, personal communication, 27 March 2017). SB 760 hatched in captivity on 22 May 2014. She was released at the Ventana Wilderness on 9 November 2016 (Ventana Wildlife Society 2017). SB 760 departed the VSFB area on or about 22 April 2017 and, several months later, SB 760 was found deceased, in northern San Luis Obispo County.

VSFB natural resource managers maintain routine communications with the USFWS and Ventana Wildlife Society for SpaceX launch monitoring requirements and condors have not been present since this event. However, given the wide-ranging nature of this species, individuals may occur on Base in the future.

In the region potentially impacted by sonic booms during missions with easterly trajectories, California condors occur year-round in the Sisquoc, Matilija, Sespe, and Piru areas (Figure 4.13-1; CDFW 2024).

4.13.4 Critical Habitat

The USFWS designated Critical Habitat for the California condor in 1976 and revised it in 1977 (42 FR 47840). The potential sonic boom footprint from missions with easterly trajectories overlaps the Sisquoc-San Rafael, Matilija, and Sespe-Piru Critical Habitat units (Figure 4.13-1). The designation did not include a description of Critical Habitat Physical and Biological Features.

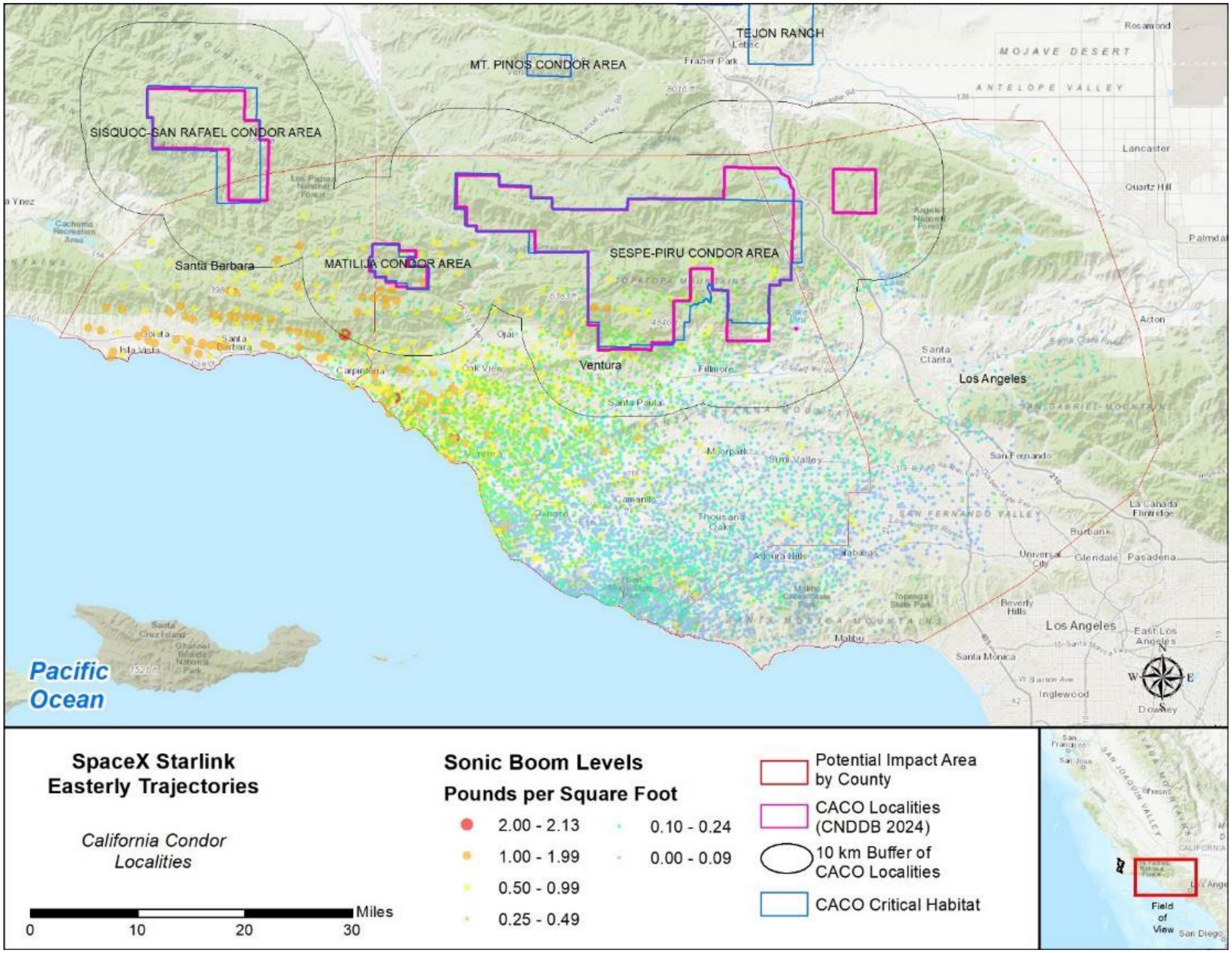

Figure 4.13-1. California condor localities, critical habitat, and potential sonic boom impact areas in eastern Santa Barbara, Ventura, and Los Angeles Counties (note: CACO = California condor).

4.14 Coastal California Gnatcatcher (Federally Listed Threatened Species)

4.14.1 Status

The USFWS listed the CAGN as federally threatened on 30 March 1993 (58 FR 16742-16757). The USFWS has not published a Recovery Plan for this species.

4.14.2 Life History

The CAGN is a small, nonmigratory bird that nests from late February through July in coastal sage scrub habitat from coastal Baja California, Mexico, north to Ventura County in California. CAGN prey on insects and spiders. Because they are found exclusively in coastal sage scrub, this species has been heavily impacted by coastal development in California.

4.14.3 Occurrence within the Action Area

In the region potentially impacted by sonic booms during missions with easterly trajectories, CAGN occur across southern Ventura and western Los Angeles Counties (Figure 4.14-1; CDFW 2024).

4.14.4 Critical Habitat

The USFWS issued a revised designation of Critical Habitat for the CAGN in 2007 (72 FR 72010-72213). The potential sonic boom footprint from missions with easterly trajectories overlaps Unit 13 in western Los Angeles and Ventura Counties (Figure 4.14-1). The PCEs for CAGN are:

> (i) Dynamic and successional sage scrub habitats: Venturan coastal sage scrub, Diegan coastal sage scrub, Riversidean sage scrub, maritime succulent scrub, Riversidean alluvial fan scrub, southern coastal bluff scrub, and coastal sage-chaparral scrub in Ventura, Los Angeles, Orange, Riverside, San Bernardino, and San Diego Counties that provide space for individual and population growth, normal behavior, breeding, reproduction, nesting, dispersal and foraging; and
>
> (ii) Non-sage scrub habitats such as chaparral, grassland, riparian areas, in proximity to sage scrub habitats as described above that provide space for dispersal, foraging, and nesting.

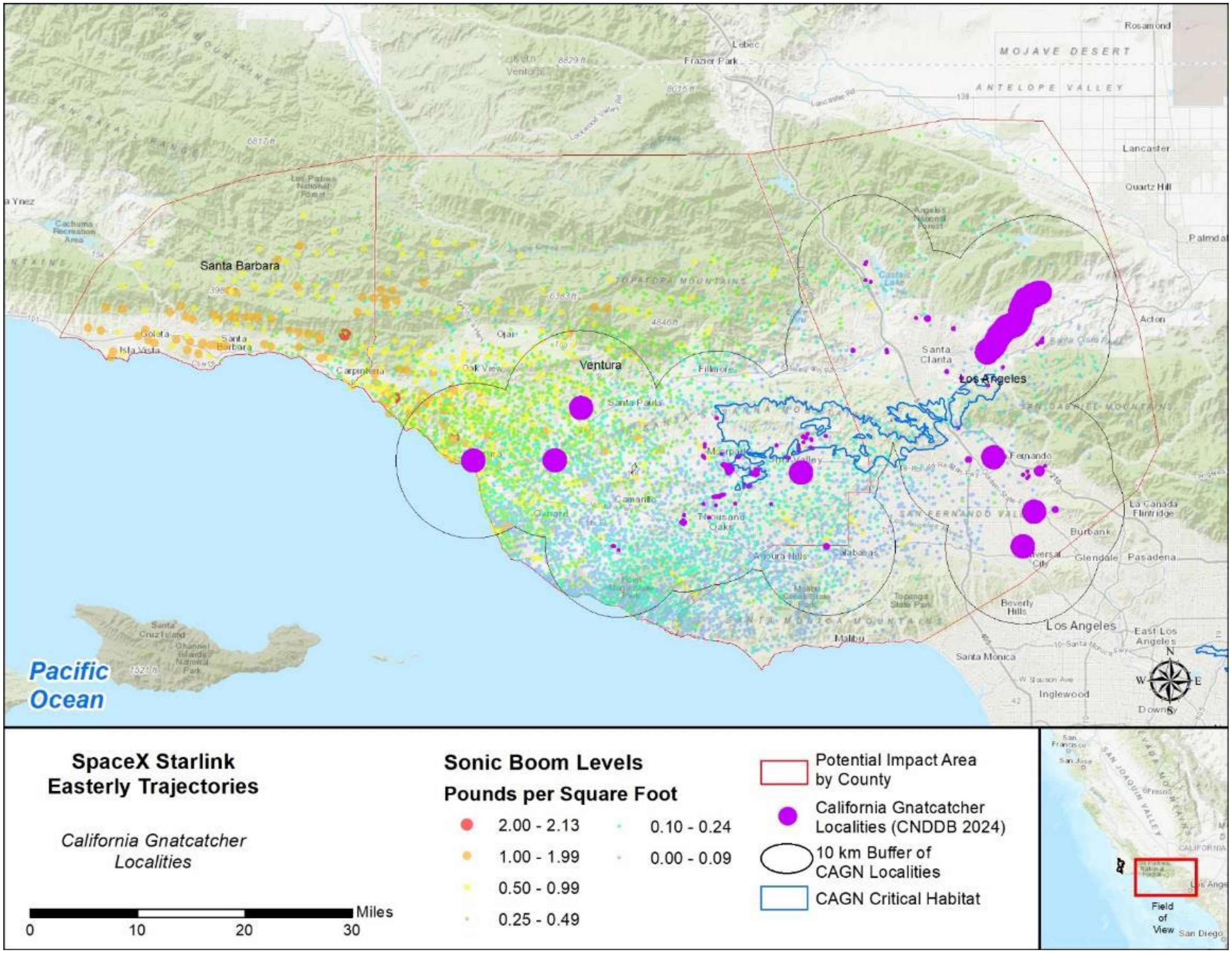

Figure 4.14-1. CAGN localities, critical habitat, and potential sonic boom impact areas in eastern Santa Barbara, Ventura, and Los Angeles Counties.

4.15 Light-footed Ridgeway's Rail (Federally Listed Endangered Species)

4.15.1 Status

The USFWS listed the RIRA as federally threatened on 13 October 1970 (35 FR 16047-16048). The USFWS published a Recovery Plan that included this species in 2014 (79 FR 10830-10831).

4.15.2 Life History

RIRA can be found in southern California coastal salt marshes. This species nests in cordgrass and construct their nests of dried cordgrass, which is intertwined at its edges with upright stems of living cordgrass so that it floats up and down on the tides, held in place by the living stems. The geographic range of the species is from their over-wintering habitat in Central America to Baja California and Southern California. RIRA depends entirely on salt marsh habitat for feeding, resting, and nesting. RIRA are generalists, foraging for invertebrates while utilizing the cover of tidal marsh vegetation.

4.15.3 Occurrence within the Action Area

In the region potentially impacted by sonic booms during missions with easterly trajectories, RIRA occurs at the Carpinteria Salt Marsh and the marshes at Naval Base Ventura County Point Mugu (Figure 4.15-1; CDFW 2024).

4.15.4 Critical Habitat

The USFWS has not designated Critical Habitat for this species.

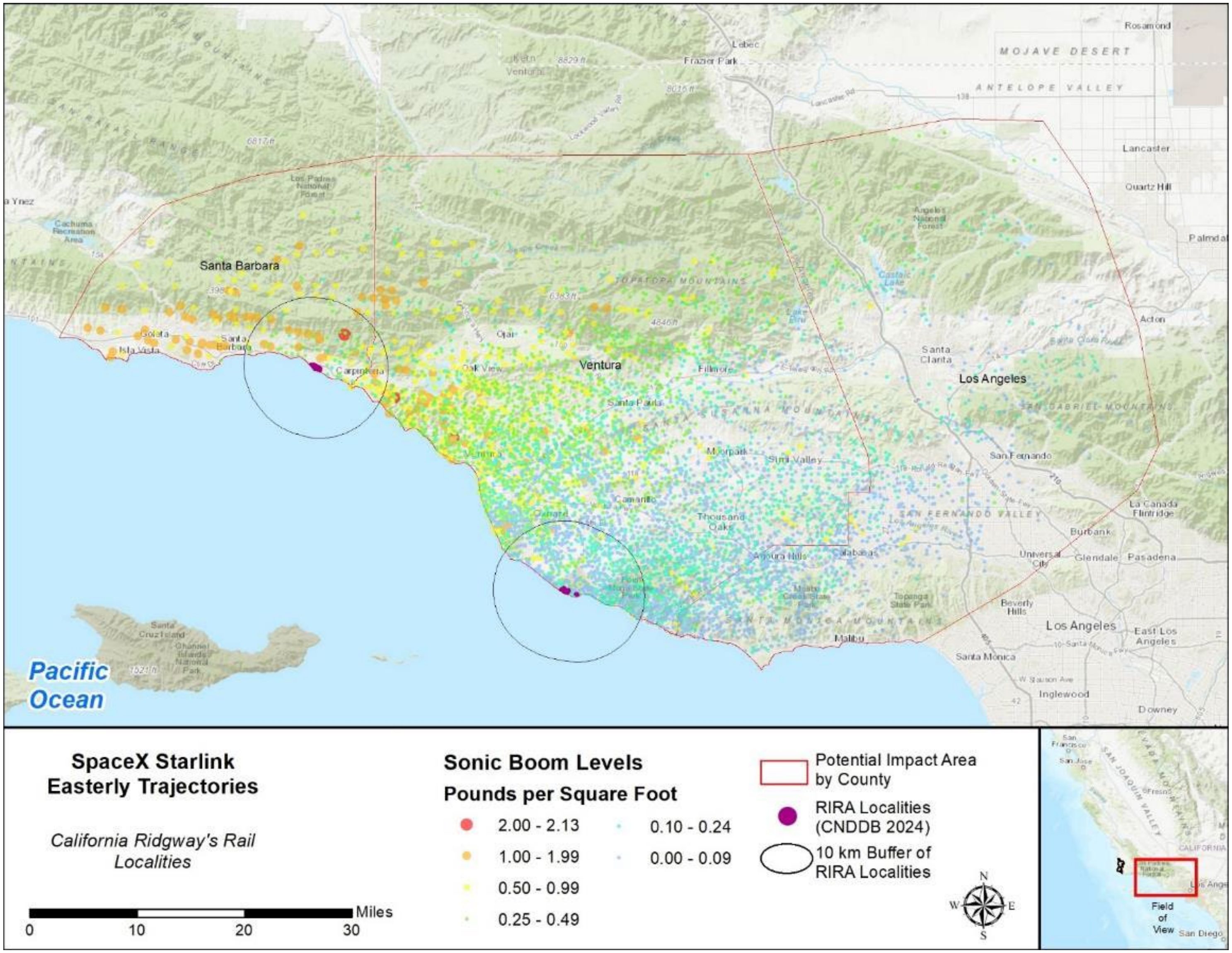

Figure 4.15-1. RIRA localities and potential sonic boom impact areas in eastern Santa Barbara, Ventura, and Los Angeles Counties.

4.16 Southern Sea Otter (Federally Listed Threatened Species)

4.16.1 Status

The USFWS listed the southern sea otter as federally threatened on 14 January 1977 (42 FR 2965) and published a Recovery Plan in 2003 (USFWS 2003). The USWFS completed a 5-year review of the species in 2015 (USFWS 2015b).

4.16.2 Life History

The southern sea otter is the smallest species of marine mammal in North America. It inhabits the nearshore marine environments of California from San Mateo County to Santa Barbara County with a small geographically isolated population around San Nicolas Island. On occasion, southern sea otters have been observed beyond these limits and have been documented as far south as Baja, Mexico (USFWS 2015b).

This species breeds and gives birth year-round and pups are dependent for 120 to 280 days (average 166 days; Riedman & Estes 1990). Sea otters are opportunistic foragers known to eat mostly abalones, sea urchins, crabs, and clams. They play a key ecological role in kelp bed communities by controlling sea urchin grazing.

4.16.3 Occurrence within the Action Area

Southern sea otters occur regularly off the coast of VSFB, with animals typically concentrated in the kelp beds between the Boat House and Jalama Creek on south VSFB (Figure 4.16-1 and Figure 4.16-2). Annual spring surveys performed by United States Geological Survey (USGS) document persistent populations in nearshore waters in this area (USGS Western Ecological Resource Center 2017, 2018, 2020). As many as 55 adult otters have been documented in the Sudden Flats area at one time (SRS Technologies, Inc. 2006a). More recently, a high of 49 adults and 4 pups were observed in March 2023 in the Sudden Flats area during monitoring for a Falcon 9 launch (MSRS, unpubl. data).

Historically, the Purisima Point area has also supported a persistent otter population with as many as 18 adult otters documented in the area at one time (SRS Technologies, Inc. 2002). During the last three annual spring census counts that were performed (2017, 2018, and 2019), however, there is a running average of only one otter within the Purisima Point area (USGS Western Ecological Resource Center 2017, 2018, 2020). Transitory otters also occasionally traverse the coast between Purisima Point and Point Arguello.

4.16.4 Critical Habitat

The USFWS has not designated Critical Habitat for this species.

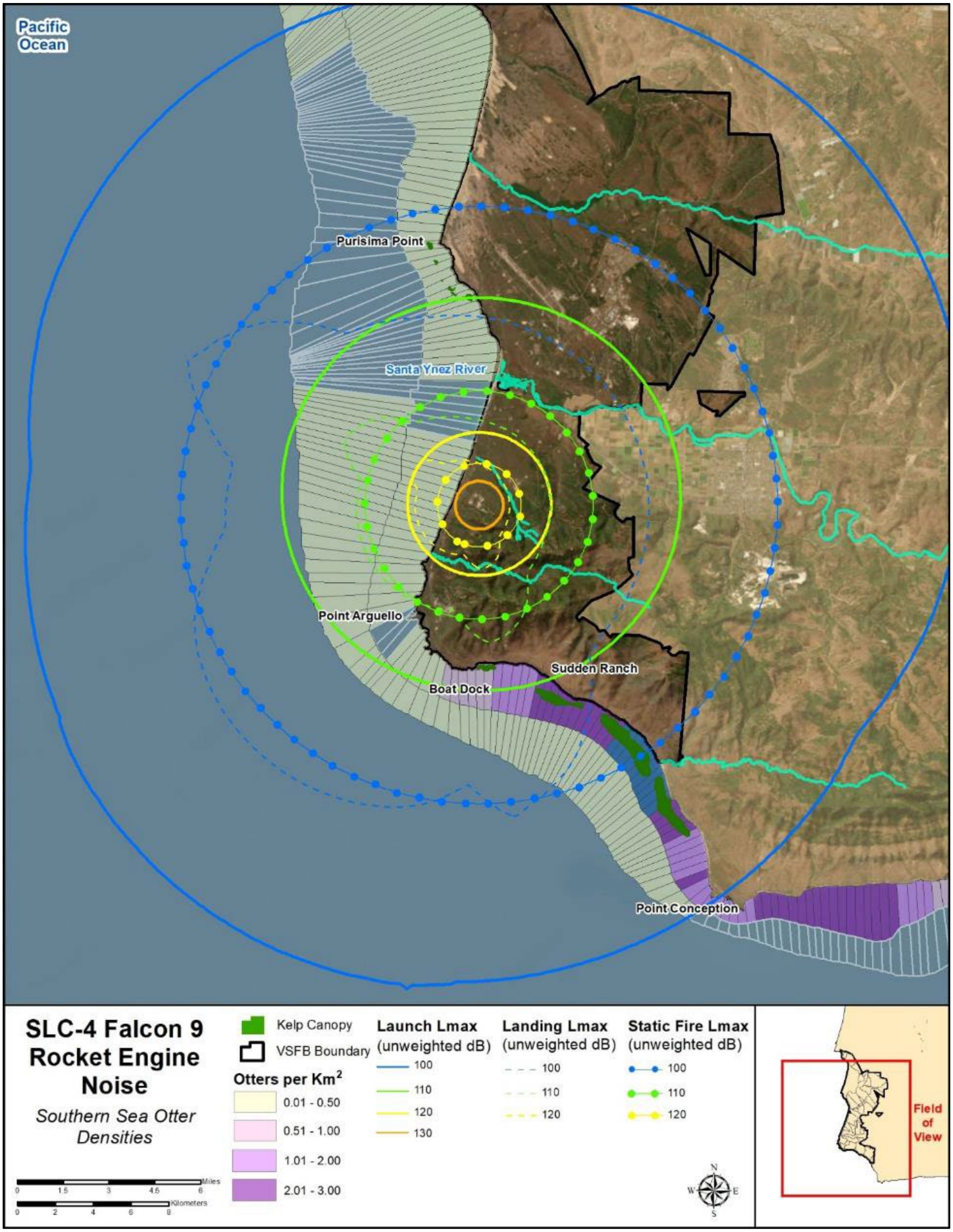

Figure 4.16-1. Southern sea otter densities and areas and Falcon 9 SLC-4 static fire, launch, and landing rocket engine noise (USGS 2020).

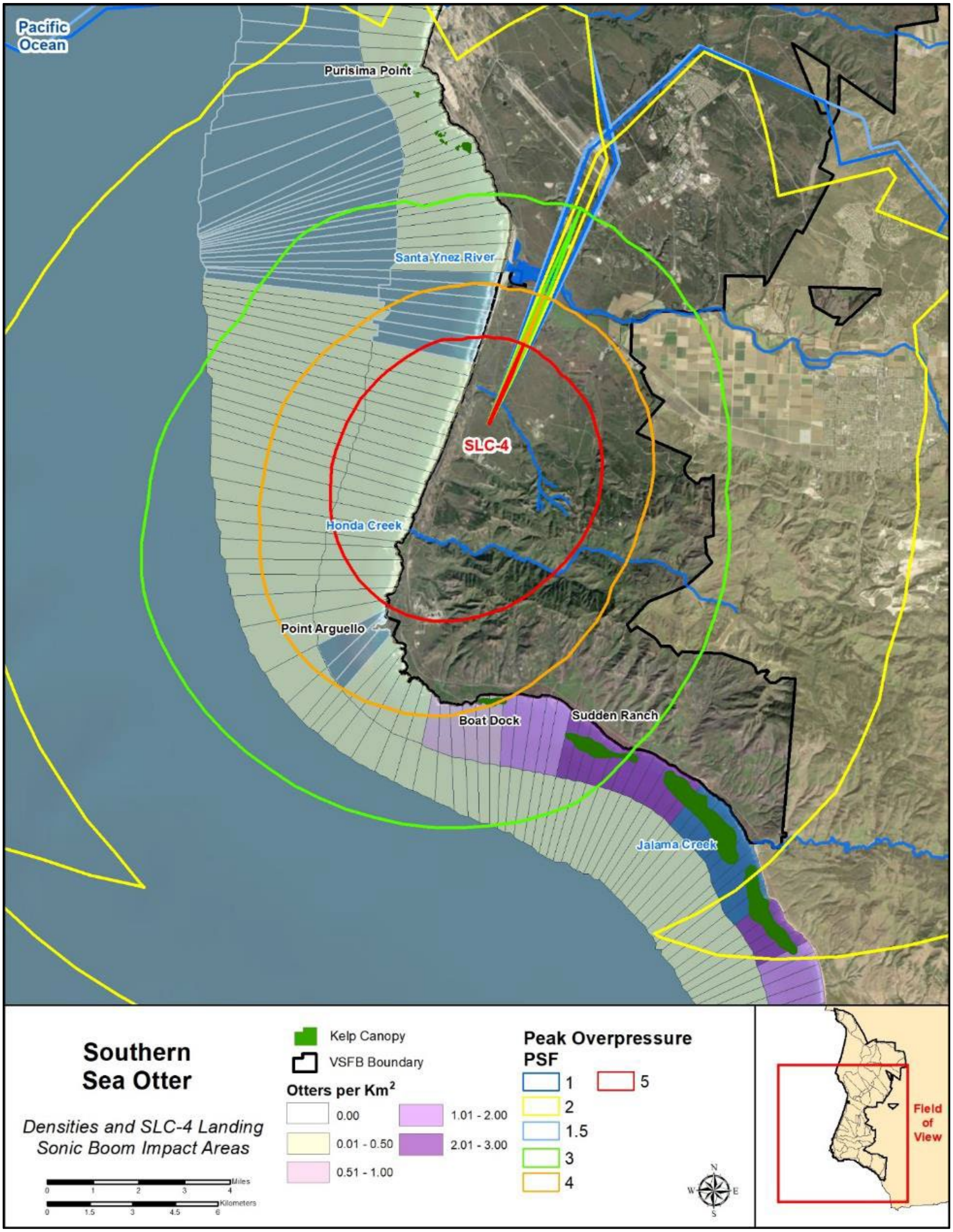

Figure 4.16-2. Southern sea otter densities and sample SLC-4 landing sonic boom impact areas (USGS 2020).

5 Analysis of Effects of the Proposed Action

5.1 Direct and Indirect Effects on Species

Effects of an action include direct and indirect effects. Direct effects are those effects that would be caused by or result from the proposed action and occur contemporaneously with the proposed action (USFWS and National Marine Fisheries Service 1998). USFWS regulations define indirect effects as “those that are caused by the proposed action and are later in time, but still are reasonably certain to occur” (50 C.F.R. section 402.02). The direct impacts potentially resulting from the Proposed Action vary by species, but include loss or degradation of habitat, physical impacts because of water release during launch, noise, vibration, and visual disturbance (including light emissions). Potential indirect impacts could result from water use, which is currently extracted from the San Antonio Creek Basin. Indirect impacts that may affect some species include potential long-term effects of increasing the launch frequency on VSFB over the next five years.

In addition to direct and indirect effects, the DAF analyzed the collective effects of launch-related noise impacts on ESA-listed species on VSFB (Section 5.1.1 to 5.1.16) per prior USFWS requests. For each species, the DAF considered the potential effect of overlapping noise impacts from multiple launch programs.

Determining how much sound energy overlaps the hearing sensitivity of an animal that may be affected by the exposure is critical to evaluating the potential effect the noise will have (Halfwerk et al. 2011; Francis & Barber 2013). Therefore, for most of those species that would potentially be adversely affected by noise impacts because of the Proposed Action, a species-specific frequency-weighting filter, following methods in Southall et al. (2019), was developed. Best available hearing data, from the most closely related taxa for which data were available, was used to estimate audiograms (a graph of audible thresholds for standardized frequencies) in combination with other audiometric data (i.e., equal loudness, equal latency, and temporary threshold shift measurements, and/or vocal range) to derive auditory weighting functions for each species. Weighting functions have been primarily developed and evaluated systematically in humans (A-weighted decibels [dBA]), with very limited efforts to develop them for non-human animals. These functions are like “band-pass” filters—they include a central region corresponding to greatest sensitivity and susceptibility to noise, along with lower- and higher-frequency regions where the relative sensitivity is lower (reflected as negative values on these curves).

Weighting functions provide a means of calculating how a noise exposure would be perceived by a specific species or taxon with similar hearing capabilities and how it may potentially affect the hearing of an animal given the extent to which the frequency spectra match frequency-specific hearing sensitivity. The effect of noise exposure on an animal is determined by first weighting (filtering) the noise exposure using the weighting function—analogous to adding the weighting function amplitude (in dB) to the noise spectral amplitude (in dB) at each frequency. Next, the weighted noise spectrum is integrated across frequency to obtain a species- or taxon-specific weighted noise exposure level, which describes exposure for the entire frequency range with a single metric. The weighting function generally appears as the inverse of the audiogram, with less weighting being applied near the center of the audiogram. For each species where relatively frequent launch-related noise exposure is analyzed below, a discussion of how species-specific weighting functions were developed is presented.

5.1.1 Tidewater Goby

Physical Impacts

No aspects of the Proposed Action would have potential physical impacts on TWG.

Noise Impacts

Noise Impacts in the VSFB Area

During up to 50 launch events per year, engine noise produced during Falcon 9 launches from SLC-4 would reach approximately 123 dB L_{max} at potential TWG habitat in Honda Creek, up to approximately 115 dB L_{max} at TWG habitat in the Santa Ynez River, and up to approximately 105 dB L_{max} at TWG habitat at Jalama Creek (Figure 4.4-1). During up to 12 SLC-4W landing events per year, engine noise would reach approximately 120 dB L_{max} at Honda Creek, approximately 105 dB L_{max} at TWG habitat in the Santa Ynez River, and up to approximately 100 dB L_{max} at TWG habitat at Jalama Creek (Figure 4.4-1). Static fire events at SLC-4 would produce approximately 115 dB L_{max} at Honda Creek, approximately 110 dB L_{max} at TWG habitat in the Santa Ynez River, and up to approximately 100 dB L_{max} at TWG habitat at Jalama Creek (Figure 4.4-1). For first stage landing events at SLC-4, up to 12 sonic booms per year would impact the Santa Ynez River (estimated between 1.5 and 2.0 psf), Honda Creek (estimated between 2.0 and 3.0 psf), and Jalama Creek (estimated at approximately 1.5 psf; Figure 4.4-2). However, these overpressure levels could be higher or lower based on atmospheric conditions at the time of landing.

Exceptionally little sound is transmitted between the air-water interface (Godin 2008). Therefore, in-air sound during launches, landings, and static fire events is not expected to cause more than a temporary behavioral disruption to fish, if present, in Honda Creek, and a similar response to TWG in the Santa Ynez River and Jalama Creek. Since TWG have not been detected during regular survey efforts in Honda Creek dating back to 2008 (MSRS 2009a, 2016, 2018a), they are unlikely to be present during the proposed launch, landing, and static fire activities where the loudest noises would occur; however, TWG could potentially recolonize Honda Creek in the future.

Noise Impacts in Eastern Santa Barbara, Ventura, and Los Angeles Counties

Because there is exceptionally little sound transmitted between the air-water interface (Godin 2008) and the low level of sonic booms impacting Eastern Santa Barbara, Ventura, and Los Angeles Counties, sonic booms caused during missions with easterly trajectories is not expected to have an effect on TWG in these areas.

Water Use

At maximum cadence the annual usage in the flame duct for launches and landings at SLC-4 would be up to 3.98 million gallons (12.2 ac-ft). In addition, a maximum of 1.37 million gallons (4.20 ac-ft) per year would be required to support the personnel and operational activities at SLC-4, a maximum of 1.19 million gallons (3.64 ac-ft) per year to support personnel at Buildings 398 and 520. Therefore, at maximum cadence, the Proposed Action would use up to 6.54 million gallons (20.07 ac-ft) of water per year. Annual VSFB water use from 2019 through 2021 has averaged 910,500,000 gallons (2,794 ac-ft) per year. The current water source for VSFB, including SLC-4, is via an existing connection between State Water and the VSFB water supply system. VSFB primarily relies on State Water; however, during annual maintenance that lasts two to three weeks, VSFB utilizes four water wells in the San Antonio Creek Basin.

TWG in San Antonio Creek would be negatively impacted if the water used for the Proposed Action reduced flow rates, hydration periods, or water levels in San Antonio Creek. Annual VSFB water use over the past three years (2019 through 2021) has averaged 910,500,000 gallons (2,794 ac-ft) per year. SpaceX's proposed use of up to 20.07 ac-ft per year would represent approximately 0.7 percent of the total annual water usage on VSFB. VSFB primarily relies on State Water and even if pumping this entire volume of water from the San Antonio Creek groundwater basin, it would have an indetectable effect of water levels and flow rates in the creek (Cromwell & Faunt 2024). The Proposed Action's water usage would therefore be discountable and not result in any measurable impacts to flow rates, hydration periods, or water levels in San Antonio Creek.

Conclusion

Because of the low likelihood of TWG presence in Honda Creek, the minimal transfer of in-air noise into underwater noise, and the discountable increase in water extraction from the San Antonio Creek Basin, the anticipated level of disturbance from the Proposed Action would be discountable. Therefore, VSFB has determined that the Proposed Action may affect but is not likely to adversely affect the TWG.

5.1.2 Unarmored Threespine Stickleback

Physical Impacts

No aspects of the Proposed Action would have potential physical impacts on UTS.

Noise Impacts

Noise Impacts in the VSFB Area

As discussed in Section 4.1, the UTS was introduced into Honda Creek, south of SLC-5, in 1984 (MSRS 2009a). Extensive surveys conducted in 2008, 2016, and 2017 did not detect any fish in the creek (MSRS 2009a, 2016a, 2018a). Between 2008 and 2022, Honda Creek has gone through multiple cycles of drying and rehydration, which would preclude occupancy by and persistence of fish. Engine noise levels at San Antonio Creek during Falcon 9 launches from SLC-4 would reach approximately 105 dB Lmax during up to 70 launch events per year of Falcon 9 at SLC-4. During up to 12 SLC-4W landing events per year, engine noise would be less than 100 dB Lmax at San Antonio Creek. Static fire events at SLC-4 would produce approximately 100 dB Lmax at San Antonio Creek. For first stage landing events at SLC-4, up to 12 sonic booms per year would impact San Antonio Creek, estimated between 1.5 and 2.0 psf. However, these overpressure levels could be higher or lower based on atmospheric conditions at the time of landing.

Exceptionally little sound is transmitted between the air-water interface (Godin 2008). Therefore, in-air sound during launches, landings, and static fire events is not expected to cause more than a brief behavioral disruption, if any reaction, to UTS.

Noise Impacts in Eastern Santa Barbara, Ventura, and Los Angeles Counties

Because there is exceptionally little sound transmitted between the air-water interface (Godin 2008) and the low level of sonic booms impacting Eastern Santa Barbara, Ventura, and Los Angeles Counties, sonic booms caused during missions with easterly trajectories is not expected to have an effect on TWG in these areas

Water Use

At maximum cadence the annual usage in the flame duct for launches and landings at SLC-4 would be up to 3.98 million gallons (12.2 ac-ft). In addition, a maximum of 1.37 million gallons (4.20 ac-ft) per year would be required to support the personnel and operational activities at SLC-4, a maximum of 1.19 million gallons (3.64 ac-ft) per year to support personnel at Buildings 398 and 520. Therefore, at maximum cadence, the Proposed Action would use up to 6.54 million gallons (20.07 ac-ft) of water per year. Annual VSFB water use from 2019 through 2021 has averaged 910,500,000 gallons (2,794 ac-ft) per year. The current water source for VSFB, including SLC-4, is via an existing connection between State Water and the VSFB water supply system. VSFB primarily relies on State Water; however, during annual maintenance that lasts two to three weeks, VSFB utilizes four water wells in the San Antonio Creek Basin.

UTS in San Antonio Creek would be negatively impacted if the water used for the Proposed Action reduced flow rates, hydration periods, or water levels in San Antonio Creek. Annual VSFB water use over the past three years (2019 through 2021) has averaged 910,500,000 gallons (2,794 ac-ft) per year. SpaceX's proposed use of up to 20.07 ac-ft per year would represent approximately 0.7 percent of the total annual water usage on VSFB. VSFB primarily relies on State Water and even if pumping this entire volume of water from the San Antonio Creek groundwater basin, it would have an indetectable effect of water levels and flow rates in the creek (Cromwell & Faunt 2024). The Proposed Action's water usage would therefore be discountable and not result in any measurable impacts to flow rates, hydration periods, or water levels in San Antonio Creek.

Conclusion

Because of the minimal transfer of in-air noise into underwater noise and that the increase in water extraction from the San Antonio Creek Basin under the Proposed Action would be discountable, VSFB has determined that the Proposed Action may affect but is not likely to adversely affect the UTS.

5.1.3 California Tiger Salamander

Physical Impacts

No aspects of the Proposed Action would have potential physical impacts on CTS.

Noise Impacts

Noise Impacts in the VSFB Area

Engine noise during up to 95 launches of the Falcon 9 from SLC-4 would range from approximately 100 to 105 dB L_{max} at breeding pools in the Santa Rita Hills and Santa Maria Valley (Figure 4.3-1). These noise levels are conservative since the models do not take into account attenuation due to land forms (e.g., mountains, hills, valleys, etc.). Engine noise during landing and static fire events would be less than 100 dB L_{max} at these locations. Sonic booms produced during first stage landing events at SLC-4 are expected to be approximately 1.0 to 1.5 psf at these locations (Figure 4.3-2). However, these overpressure levels could be higher or lower based on atmospheric conditions at the time of landing.

There is very little information regarding the hearing of salamanders. The hearing ability of this group is believed to be rudimentary and likely limited to physical vibrations. Salamanders do not have an inner ear cavity and likely only hear bone-conducted sound. Therefore, it is more likely that urodeles hear sound through substrate, rather than in-air sound (Stebbens 1983). The CTS spends the majority of their life underground, coming out once a year to migrate to and breed in temporary bodies of water. Exceptionally little sound is transmitted between the air-water interface (Godin 2008); thus, in-air sound is not likely to have an effect on submerged CTS. Likewise, exceptionally little sound is transferred underground. There is no known research on salamander's sensitivity to noise underground. However, due to the reflection from the ground, the intensity of the sonic boom would be greatly diminished at ground level (Ventre et al. 2002) and below ground level the overpressures would decrease approximately 30 percent for every centimeter, depending on the type of soil (Oelze et al. 2002). Since CTS are typically in burrows at depths between 0.2 m and 1.36 m underground (Barry and Shaffer 1994), essentially all sound energy would be attenuated before reaching subterranean CTS. Therefore, the sonic boom would not likely affect the CTS when underground.

Emergence from burrows and migration to breeding pools is strongly tied to the onset of significant rainfall (Loredo and Van Vuren 1996; Trenham et al. 2000; Cook et al. 2006; USFWS 2016). Literature searches failed to find any information on noise, either natural or human-caused, causing pre-mature emergence from burrows. It is unlikely that CTS use noise as a cue to emerge for the following reasons: 1: CTS tend to be deeper underground than surface noises would be able to reach (Barry and Shaffer 1994; Ventre et al. 2002); 2: Lightning (and therefore thunder) is rarely associated with winter rainstorms in Santa Barbara County (Meier and Thompson 2009); 3: CTS are not observed moving to breeding ponds until substantial rainfall events that have greater potential to fill pools are underway, suggesting that CTS may be primarily responding to inundation of their burrows with water. Therefore, noise associated with the Proposed Action is unlikely to have any effect on CTS when below ground.

In the unlikely event that a CTS was aboveground and exposed to a 1 to 1.5 psf overpressure or rocket engine noise, the noise could potentially cause a minor temporary behavioral reaction, if any. However, CTS are aboveground very infrequently and for short durations (at most several nights per year during transit between breeding ponds and upland habitat). Therefore, the action is very unlikely to cause disruption of normal behavior.

Noise Impacts in Eastern Santa Barbara, Ventura, and Los Angeles Counties

There are no records of CTS in eastern Santa Barbara, Ventura, and Los Angeles Counties and there would be no noise impacts on this species in this area as a result of the Proposed Action.

Conclusion

Any potential impact on CTS from noise associated with the Proposed Action would be very unlikely to occur given the attenuation of noise due to landforms between SLC-4 and the nearest localities 14 mi to the east, as well as the low likelihood that CTS would be above ground during a launch event. Therefore, the Proposed Action may affect, but is not likely to adversely affect, the CTS.

5.1.4 California Red-Legged Frog

Physical Impacts

Direct impacts on post-metamorphic CRLF within the vegetation management area in Spring Canyon at SLC-4 may include injury or mortality from inadvertent crushing by workers as they walk and operate mechanical equipment while mowing vegetation. The risk of impacts on CRLF during vegetation management would be reduced because USFWS approved or permitted biologists would capture and relocate all individuals detected within the vegetation management area to nearby suitable habitat prior to the onset of vegetation clearing activities. A qualified biologist would be present to monitor vegetation-clearing activities and a USFWS approved or permitted biologist would move any CRLF encountered out of harm's way.

During launch, CRLF may be injured or killed as a result of the release of hot water and vapor into Spring Canyon from the flame bucket. An assessment of Spring Canyon in 2013 (MSRS 2014), in July 2017 (MSRS 2017), and in February 2023 during record rainfall levels (MSRS 2023a) found no suitable aquatic habitat within Spring Canyon within or downstream of the vegetation management area. In addition, since 2017, across 11 survey efforts to perform minimization measures associated with the 2017 BO, no suitable habitat has been found in this area, likely because of the protracted drought conditions in the region. Routinely mowing the vegetation in the area impacted by water and vapor also reduces the suitability and attractiveness of the site for CLRF occupancy. It is therefore unlikely that CRLF occupy this area on a regular basis and no direct impacts during vegetation management activities or water release are anticipated.

Direct impacts on post-metamorphic CRLF, including injury and mortality, may inadvertently occur during removal of vegetation, site grading and contouring, construction, firebreak and fire establishment, and site maintenance from the operation of heavy equipment, machinery, and vehicles at SLC-6. The attractive nuisances (i.e., the flame trench and vault) would be drained prior to demolition and construction activities. CRLF that may disperse through the project area could become entrapped in any holes or trenches left open overnight. However, open holes and trenches would be covered overnight and the risk of impacts on CRLF will be reduced because biologists will monitor construction activities and search for animals trapped in open holes and trenches. Any CRLF detected within the construction area would be captured and relocated to nearby suitable habitat. In addition, when any demolition, contouring, or construction is occurring at SLC-6, the active construction areas would be surrounded by exclusion fence (see Section 2.3.2). A USFWS approved biologist would be present to monitor vegetation-clearing activities and move any CRLF encountered to the nearest suitable habitat out of harm's way. Regardless, post-metamorphic frogs may be injured or killed during construction and vegetation clearing activities. The risk of introducing or spreading chytrid fungus would be reduced by requiring implementation of the DAPTF Fieldwork Code of Practice (USFWS 2002a).

Noise Impacts

Construction noise during day and night hours would potentially disrupt CRLF if present within the area affected by these noise sources. Standard types of construction equipment would be employed that have well known noise profiles. Noise during construction greater than 80 dB is not expected to extend more than 320 ft from the construction site (Table 2-1). There are no current extant CRLF populations or suitable breeding habitat within this distance; Semi-aquatic habitat exists at both the northern and southern drainages and the Industrial Wastewater Treatment Ponds where transitory CRLF could occur (Figure 4.4-3). However, any CRLF transiting through the area would be unlikely to remain at these locations for extended periods of time. In addition, transiting CRLF could be drawn to the vault structure and the flame trench. CRLF would be unlikely to spend extensive time in the flame trench due to the lack of aquatic vegetation and cover. Although CRLF could potentially be trapped in the vault structure, qualified biologists would survey the area while establishing a wildlife exclusion zone and capture and relocate any CRLF found in the vault. The nearest suitable CRLF breeding habitat and extant records are approximately 1.4 mi north at Honda Creek, well outside the typical dispersal distance of CRLF (210 meters). Therefore, construction noise is unlikely to have an effect on any CRLF. In the event that a CRLF is transiting through SLC-6 or upland habitat near the construction areas during construction activities, it could conceivably be exposed to noise levels of 80 dB or above. However, implementation of the avoidance and minimization measures during construction listed in Section 2.3.1 would greatly reduce the likelihood of CRLF being within this area since a wildlife exclusion zone would be established prior to construction which would be surveyed and monitored by a qualified biologist who would capture and relocate any CRLF encountered. Therefore, the likelihood of CRLF being disturbed by construction noise in upland habitat is very low.

During up to 50 events per year, engine noise produced during Falcon 9 launches from SLC-4 would reach approximately 123 dB L_{max} at Honda Creek, up to approximately 115 dB L_{max} at the Santa Ynez River, and up to approximately 105 dB L_{max} at Jalama Creek (Figure 4.4-1). During up to 12 SLC-4W landing events per year, engine noise would reach approximately 120 dB L_{max} at Honda Creek, approximately 105 dB L_{max} at the Santa Ynez River, and up to approximately 100 dB L_{max} at Jalama Creek. Static fire events at SLC-4 would produce approximately 115 dB L_{max} at Honda Creek, approximately 110 dB L_{max} at the Santa Ynez River, and up to approximately 100 dB L_{max} at Jalama Creek. For first stage landing events at SLC-4, up to 12 sonic booms per year would impact the Santa Ynez River (estimated between 1.5 and 2.0 psf), Honda Creek (estimated between 2.0 and 3.0 psf), and Jalama Creek (estimated at approximately 1.5 psf; Figure 4.4-2). However, these overpressure levels could be higher or lower based on atmospheric conditions at the time of landing.

The received maximum noise levels estimates are conservative since the modeling assumes a flat landscape and does not account for features like hills, bluffs, or dense vegetation that would attenuate sound during noise events. Engine noise would reach as high as 150 dB L_{max} with sonic booms up to 8.5 psf in upland CRLF dispersal habitat on SLC-4 (Figure 4.4-2). However, vegetation management within and around SLC-4 and SLC-6 would make CRLF presence above ground in these areas unlikely during typical dry conditions.

There are no studies on the effects of noise on CRLF. Simmons et al. (2014) found that consistent morphological damage of hair cells in the hearing structures of American bullfrogs (*Lithobates catesbeianus*), which are within the same family as the CRLF (Ranidae), were observed with exposure to sound levels greater than 150 dB L_{max} (approximately equivalent to 13 psf). Even after such hearing damage, bullfrogs showed full functional recovery within 3 to 4 days; thus, the hearing damage was temporary (Simmons et al. 2014). CRLF in terrestrial environments may be exposed to engine noise levels of 150 dB L_{max} and sonic booms up to 8.5 psf; therefore, even temporary hearing damage would be unlikely for CRLF that may be present. Additionally, due to vegetation management around the proposed launch vehicle sites, the likelihood of CRLF being present in terrestrial environments exposed to these noise levels would be very low and few individuals would be impacted.

As discussed at the beginning of Section 5.1, determining the amount of sound energy that would be perceived by CRLF is important to analyzing the potential effects that launch noise disturbances would have on this species. There are no CRLF-specific hearing curves (i.e., audiograms) or other data on this species' hearing sensitivity. However, there are published hearing curves for several species in the same family that are similar in size and have similar call frequency spectra. Fay (1988) presents hearing curves for the pool frog (*Pelophylax lessonae*, Family Ranidae), the marsh frog (*P. ridibunda*, Family Ranidae), and the edible frog (*P. esculentus*, Family Ranidae). These data were used to create a mean "Ranidae" hearing curve (Figure 5.1-1), and the mean curve processed following methods established in Southall et al. (2019) to produce a weighting function that would be appropriate for CRLF hearing sensitivity (Figure 5.1-2). Slopes beyond the lower and upper frequency cutoffs surrounding the range of best hearing (in dB/decade) were measured to estimate the amount of weighting to be applied at each frequency (Figure 5.1.2).

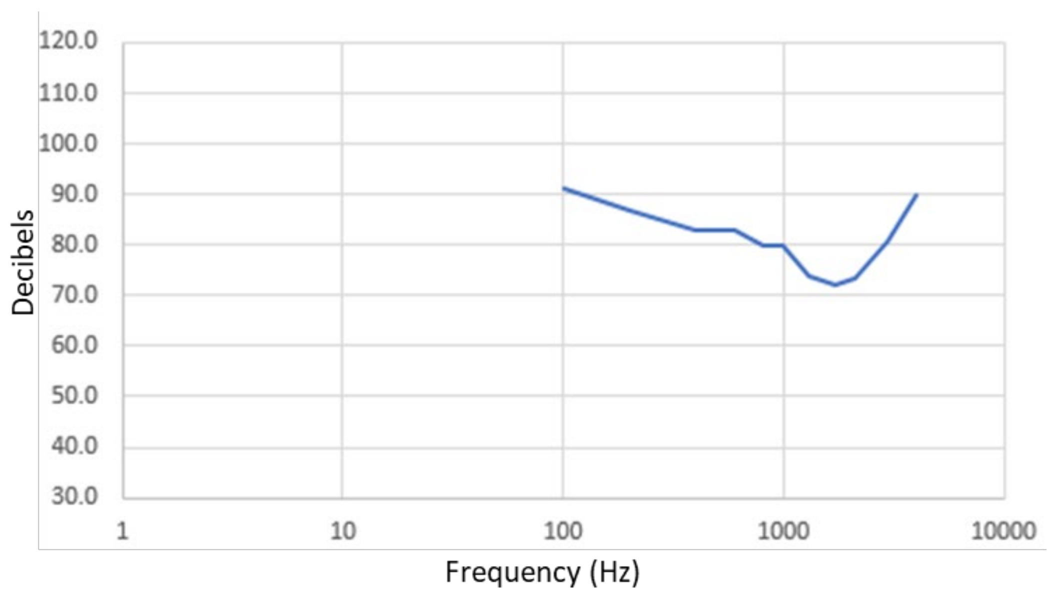

Figure 5.1-1. Mean Ranidae hearing sensitivity curve.

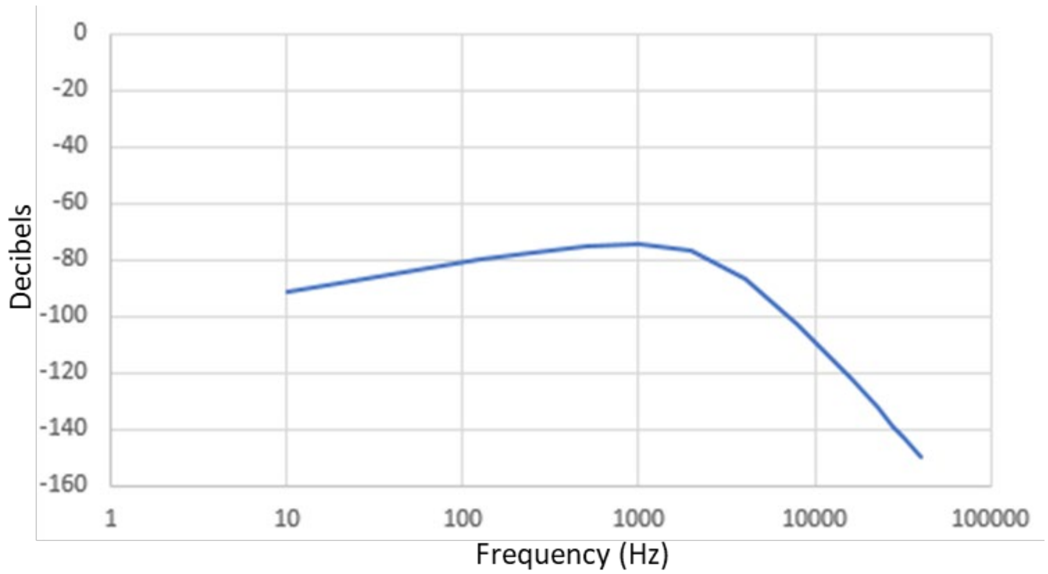

Figure 5.1-2. Ranidae weighting function.

This weighting function was applied to the time waveform recording of a June 2022 launch at VSFB (Falcon 9 SARah-1). The unfiltered time waveform had frequency spectra with an unweighted peak level of approximately 110 dB Lmax (Figure 5.1-3). After applying the Ranidae weighting function, the peak level is approximately 22 dB Lmax (Figure 5.1-3). In humans, 20 dBA is equivalent to whispering. Given the high falloff rates outside the range of best hearing, as well as a much higher hearing threshold, the perceived rocket engine noise in CRLF is very likely to be negligible.

It is assumed that the sonic boom would likely trigger a startle response in CRLF, causing them to flee to water or attempt to hide in place. This would result in a temporary disruption of behaviors including foraging, calling, and mating. However, there are no data on what level of sonic boom would cause this reaction.

Bioacoustic monitoring was performed during the CRLF breeding season during the NROL-87 mission on 2 February 2022 and the SWOT mission on 16 December 2022. MSRS performed bioacoustic monitoring during NROL-87 at two locations within the predicted boom impact area (MSRS 2022e), following the monitoring requirements of the 2017 BO (USFWS 2017a). Though the landing occurred during daylight hours, CRLF were detected calling at both monitoring locations, a drainage near the VSFB Recreation Center and lower Honda Creek. The sonic boom did not cause a measurable reduction in CRLF calling frequency at either of the two locations where the received overpressures were between 1 (VSFB Recreation Center, 6.8 mi northeast of SLC-4) and 2.4 psf (lower Honda Creek, 2.1 mi southwest of SLC-4). At both sites, CRLF calls were detected within 20 to 30 minutes after the sonic boom was received and the average number of calls per hour during the two nights following the sonic boom were greater than the night prior to the boom, suggesting that the noise disturbance did not prompt reduced calling behavior (MSRS 2022e). At the Recreation Center Drainage, three CRLF calls were detected during the hour prior to the sonic boom (1100–1200), and three were detected during the hour period when the sonic boom occurred (1200–1300). One of the three calls detected during the period when the boom was received was 30 minutes prior to the boom with the other two calls 23 and 24 minutes after the boom. At lower Honda Creek, no CRLF calls were detected during the hour period prior to the sonic boom (1100–1200), and four calls were detected during the hour when the boom occurred (1200–1300). Of the four calls that occurred during the hour period when the boom occurred, all four were detected after the boom, at 32, 37, 47, and 48 minutes post boom (MSRS 2022e).

During the SWOT mission in December 2022, no CRLF were detected calling at Honda Creek in the days prior to or during the launch. CRLF were calling at a Recreation Center Drainage approximately 6.8 mi northeast of SLC-4 and were monitored for the launch. There was no evidence that the noise from the launch or sonic boom negatively affected breeding behavior based on calls per hour. CRLF calling rates increased during the 5-hour period after the sonic boom; however, the increase did not appear to be in response to the sonic boom. During the hour immediately prior and following the sonic boom, CRLF calls were not detected prior and only one call was detected after. Call rate then steadily increased for the next several hours, peaking at or near sunrise (MSRS 2023b). Based on the prior CRLF monitoring, the increase in calling for this specific mission appears to preliminary be coincidental.

Figure 5.1-3. Launch peak noise level comparison of unweighted (green) versus Ranidae-weighted (brown) decibels (note: time waveform recording from the June 2022 Falcon 9 SARah-1 launch).

Lewis and Narins (1985) determined that white-lipped frogs (*Leptodactylus albilabris*) can detect seismic signals and use them in communication. This species is not closely related to CRLF; however, it may be reasonable to assume that the strongest reaction to engine noise and sonic booms may be the result of minor physical vibrations of water or the ground caused by the low frequency portion of the sound energy in combination with visual disturbance, rather than the noises themselves. In CRLF, this could translate to a startle response to noise, minor vibrations, and visual disturbance during launch, landing, and static fire, causing them to flee to water or attempt to hide in place. Because landing engine noise occurs approximately 5 to 7 minutes after launch noise and is typically slightly (seconds) before the sonic boom is received, individuals that flee into water because of launch disturbance would have a reduced likelihood of being exposed to the landing engine noise and sonic boom due to the attenuation of sound in water (Godin 2008). It is likely that any reaction would be dependent on the sensitivity of the individual, the behavior in which it is engaged when it experiences the noise, and past exposure to similar noise. Regardless, the reaction is expected to be the same—the frog's behavior would likely be disrupted, and it may flee to cover in a similar reaction to that of a frog reacting to a predator. As a result, there could be a temporary disruption of CRLF behaviors including foraging, calling, and mating (during the breeding season). However, frogs tend to return to normal behavior quickly after being disturbed.

Rodrıguez-Prieto and Fernandez-Juricic (2005) examined the responses in the Iberian frog (*Rana iberica*) to repeated human disturbance and found that the resumption of normal behavior after three repeated human approaches occurred after less than four minutes. Sun and Narins (2005) examined the effects of airplane and motorcycle noise on anuran calling in a mixed-species assemblage, including the sapgreen stream frog (*Rana nigrovittata*). Sun and Narins found that frogs reduced calling rate during the stimulus but increased calling rate immediately after cessation of the stimuli, likely in response to the subsequent lull in ambient sound levels. Similarly, Kruger and Du Preez (2016) found that male Pickersgill's reed frog (*Hyperolius pickersgilli*) exposed to routine airplane overflights increased call rates immediately after the noise but resumed their normal call-rest patterns within a few minutes of absence of plane noise. USFWS permitted biologists working on VSFB and elsewhere in CRLF occupied habitat have also routinely observed a similar response in this species after disrupting individuals while conducting frog surveys (A. Abela, M. Ball, and J. LaBonte, pers. obs.). CRLF would, therefore, be expected to resume normal activities quickly once the disturbance from the noise event has ended and any behavioral response to individual noise events would be short term.

Whether a result of minor physical vibrations caused by noise or overlap of some noise stimuli with various species hearing sensitivity range, there is a growing body of literature on the effects of anthropogenic noise disturbance on anurans. These studies have typically examined the impact of sustained vehicle noise associated with roads near breeding ponds and have generally shown negative effects on individual frog behavior and physiology which potentially have consequences for populations (see examples in Parris et al. 2009 and Tennessen et al. 2014). For instance, a variety of anurans have been shown to alter call signal structure in response to chronic exposure to traffic noise (Bee & Swanson 2007; Lengagne 2008; Cunnington & Fahrig 2010; Kaiser et al. 2011; Hanna et al. 2014) and airplane noise (Sun & Narins 2005, Kruger & Du Preez 2016). Researchers studying chronic exposure to sustained anthropogenic noise in anurans have also found higher levels of stress hormones, lowered immunity, and impacts to reproductive physiology and behavior, all of which may have negative consequences for populations. Tennessen et al. (2014) showed that prolonged exposure to traffic noise increased corticosterone and impaired mate attraction in wood frogs (*Lithobates sylvaticus*). Tennesen et al. (2014) also showed that populations of wood frogs in high traffic noise locations have undergone evolutionary adaptation to avoid physiological costs of the noise to fitness, suggesting that at least some species may be able to adapt to sustained noise. In an experiment where European tree frogs (*Hyla arborea*) were exposed to four hours of continuous recorded traffic noise nightly, Troïanowski et al. (2017) found increased stress hormone level that induced an immunosuppressive effect in the subjects. Similarly, White's treefrogs (*Litoria caerulea*) exposed to continuous, sustained noise (one week of recorded traffic noise) had higher levels of corticosterone and decreased sperm count and sperm viability (Kaiser et al. 2015). In chronic high-noise habitats adjacent to a busy highway (average 30,000 vehicles per day), the time and distance over which male Pacific chorus frogs (*Pseudacris regilla*) calls could be perceived for was significantly reduced, potentially having implications for the reproductive success of this species (Nelson et al. 2017). Japanese tree frogs (*Dryophytes japonicus*) exposed to persistent, low frequency noise caused by wind turbines had faster call rates, increased salivary concentrations of corticosterone, and lower innate immunity (Park & Do 2022). Eastern sedge frogs (*Litoria fallax*) tended to choose less attractive male calls significantly more often when experimentally exposed to background traffic noise, potentially having evolutionary and population level implications over the long term (Schou et al. 2021).

None of the preceding studies are directly comparable to the noise impacts of the Proposed Action, which is likely to be minimally perceptible in the hearing range of CRLF but presumed to cause vibrations that would be sensed, non-sustained, and infrequent compared to the available literature, which examines sustained traffic noise and multiple daily airplane flights. Additionally, there are no thresholds in the literature that quantify what level of noise or frequency of disturbance would elicit stress hormone responses, impacts to breeding and reproduction, or negative population level effects. While these studies show effects on behavior and physiology that could have impacts on fitness and populations, none of them present direct evidence of population impacts so the long-term effects of chronic exposure to anthropogenic noise on populations is unknown for these species. In addition, early evidence suggests that CRLF populations in Honda Creek and Bear Creek have not declined despite the increased Falcon 9 launch cadence in 2024. A night survey of the Bear Creek Lagoon in late February 2024 documented 12 adult and 11 juvenile CRLF, the most ever recorded at this location. In April 2024, 8 adult and 7 juvenile CRLF were documented during a night survey on the lower Honda Creek stretch, exceeding the average number of adults (7.2) observed on this same stretch over the past 11 years.

The DAF will continue to implement a monitoring program (see Section 2.3.2) to track CRLF habitat occupancy, breeding behaviors, and tadpole densities in Lower Honda Creek (the area to receive the highest noise levels) as the frequency of launch and static fire under the Proposed Action. As full tempo under the Proposed Action is reached, the DAF will be able to assess incremental changes in the acoustic environment at Lower Honda Creek through the use of passive bioacoustic recorders and analyze these data to assess any associated impacts on the

CRLF population. If CRLF occupancy, calling frequency, or tadpole densities decline from baseline by 15 percent or more, the 15 percent decline from baseline is maintained for two consecutive years, and the decline is not attributable to other non-launch-related factors, VSFB would mitigate for these impacts by creating new CRLF breeding habitat at the San Antonio Creek Oxbow Restoration Area, an established wetland mitigation site on VSFB. Historically occupied by riparian vegetation, restoration efforts would focus on enhancing this abandoned tract of agricultural land to improve San Antonio Creek and provide breeding habitat for CRLF, thus offsetting population level impacts at Jalama Creek, Honda Creek, Bear Creek, and the Santa Ynez River within an area that is not impacted by launch noise.

Noise Impacts in Eastern Santa Barbara, Ventura, and Los Angeles Counties

Approximately 80% of missions with easterly trajectories are predicted to impact at least one CRLF population in eastern Santa Barbara, Ventura, and Los Angeles Counties. To estimate the potential levels of these sonic booms, a frequency distribution of potential sonic boom levels was constructed by overlaying a 10-km buffer of CRLF localities onto the PCBoom model output described in Section 2.2.4 and as depicted in Figure 4.4-10. As shown in Figure 5.1-4, of the sonic booms predicted to impact within 10 km of a CRLF locality, 93% of the boom levels were predicted to be less than 1.0 psf, and 99.9% were predicted to be less than 2.0 psf. Given that sonic booms greater than 1.0 psf would impact CRLF populations in these areas infrequently and the lack of any coupled visual stimuli, sonic booms created during missions with easterly trajectories are not expected to have an adverse effect on CRLF.

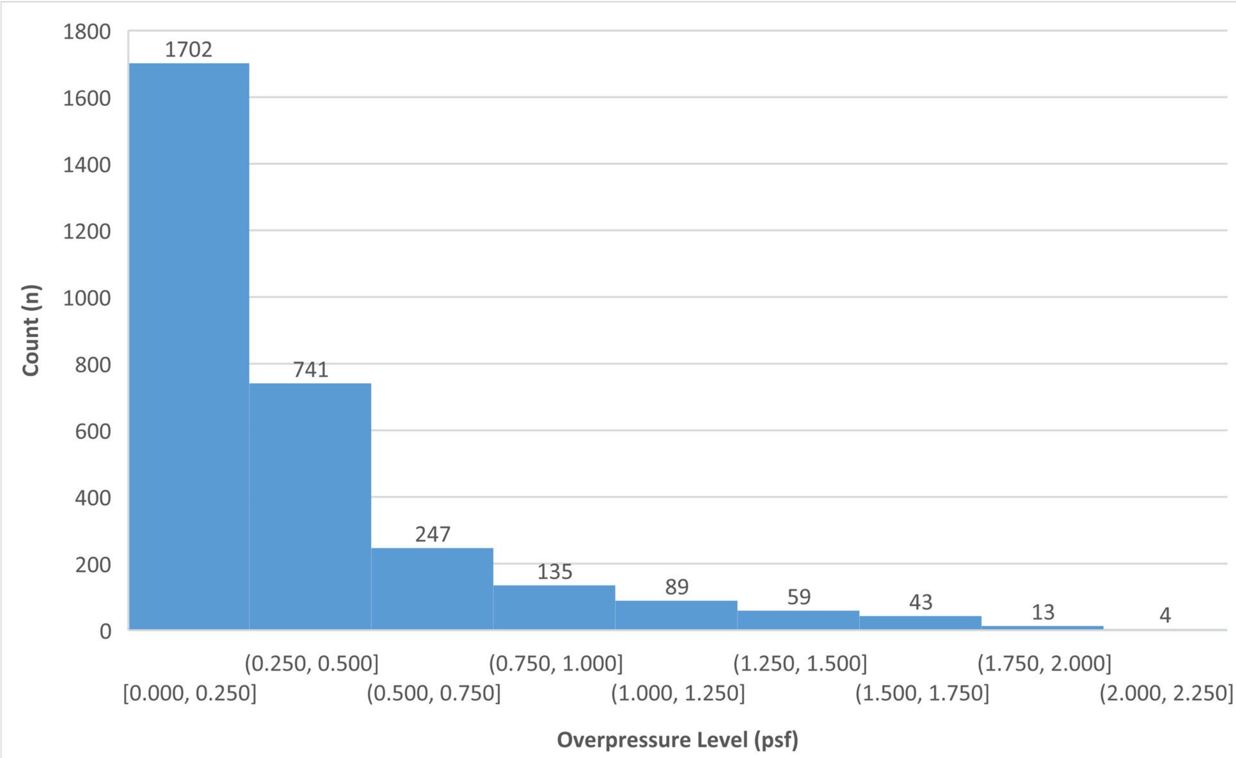

Figure 5.1-4. Distribution of PCBoom sonic boom modeling results within 10 km of CRLF localities shown in Figure 4.4-6.

Water Use

At maximum cadence the annual usage in the flame duct for launches and landings at SLC-4 would be up to 3.98 million gallons (12.2 ac-ft). In addition, a maximum of 1.37 million gallons (4.20 ac-ft) per year would be required to support the personnel and operational activities at SLC-4, a maximum of 1.19 million gallons (3.64 ac-ft) per year to support personnel at Buildings 398 and 520. Therefore, at maximum cadence, the Proposed Action would use up to 6.54 million gallons (20.07 ac-ft) of water per year. Annual VSFB water use from 2019 through 2021 has averaged 910,500,000 gallons (2,794 ac-ft) per year. The current water source for VSFB, including SLC-4, is via an existing connection between State Water and the VSFB water supply system. VSFB primarily relies on State Water; however, during annual maintenance that lasts two to three weeks, VSFB utilizes four water wells in the San Antonio Creek Basin.

CRLF in San Antonio Creek would be negatively impacted if the water used for the Proposed Action reduced flow rates, hydration periods, or water levels in San Antonio Creek. Annual VSFB water use over the past three years (2019 through 2021) has averaged 910,500,000 gallons (2,794 ac-ft) per year. SpaceX's proposed use of up to 20.07 ac-ft per year would represent approximately 0.7 percent of the total annual water usage on VSFB. VSFB primarily relies on State Water and even if pumping this entire volume of water from the San Antonio Creek groundwater basin, it would have an indetectable effect of water levels and flow rates in the creek (Cromwell & Faunt 2024). The Proposed Action's water usage would therefore be discountable and not result in any measurable impacts to flow rates, hydration periods, or water levels in San Antonio Creek.

Conclusion

VSFB has determined that potential physical impacts because of water release and vegetation clearing in Spring Canyon, rocket engine noise, and sonic booms resulting from the Proposed Action may affect, and is likely to adversely affect, the CRLF on VSFB. Launch noise and sonic booms may induce behavioral responses in CRLF on VSFB ranging from momentary startling or freezing by individual frogs to population-level emigration away from impacted areas. To comply with the DAF's sections 7(a)(1) and 7(a)(2) obligations under the ESA, as well as the prospective USFWS Mitigation Policy, post-project restoration activities will be implemented. Restoration activities will align with the objectives of the CRLF Conservation Strategy (USFWS, in prep.) with the goal of achieving no net loss to the species.

5.1.5 Arroyo Toad

Physical Impacts

No aspects of the Proposed Action would have potential physical impacts on ARTO.

Noise Impacts

Noise Impacts in the VSFB Area

There would be no noise impacts to ARTO in the VSFB area.

Noise Impacts in Eastern Santa Barbara, Ventura, and Los Angeles Counties

Approximately 69% of missions with easterly trajectories are predicted to impact an ARTO population in eastern Santa Barbara, Ventura, and Los Angeles Counties. To estimate the potential levels of these sonic booms, a frequency distribution of potential sonic boom levels was constructed by overlaying a 10-km buffer of ARTO localities onto the PCBoom model output described in Section 2.2.4 and as depicted in Figure 4.5-1. Of the sonic booms predicted to impact within 10 km of an ARTO locality, 98% of the boom levels were predicted to be less than 1.0 psf, and 99.9% were predicted to be less than 2.0 psf (Figure 5.1-5). Given that sonic booms greater than 1.0 psf would be very unlikely to impact ARTO populations and the lack of any coupled visual stimuli, sonic booms created during missions with easterly trajectories are discountable thus not expected to have an adverse effect on ARTO.

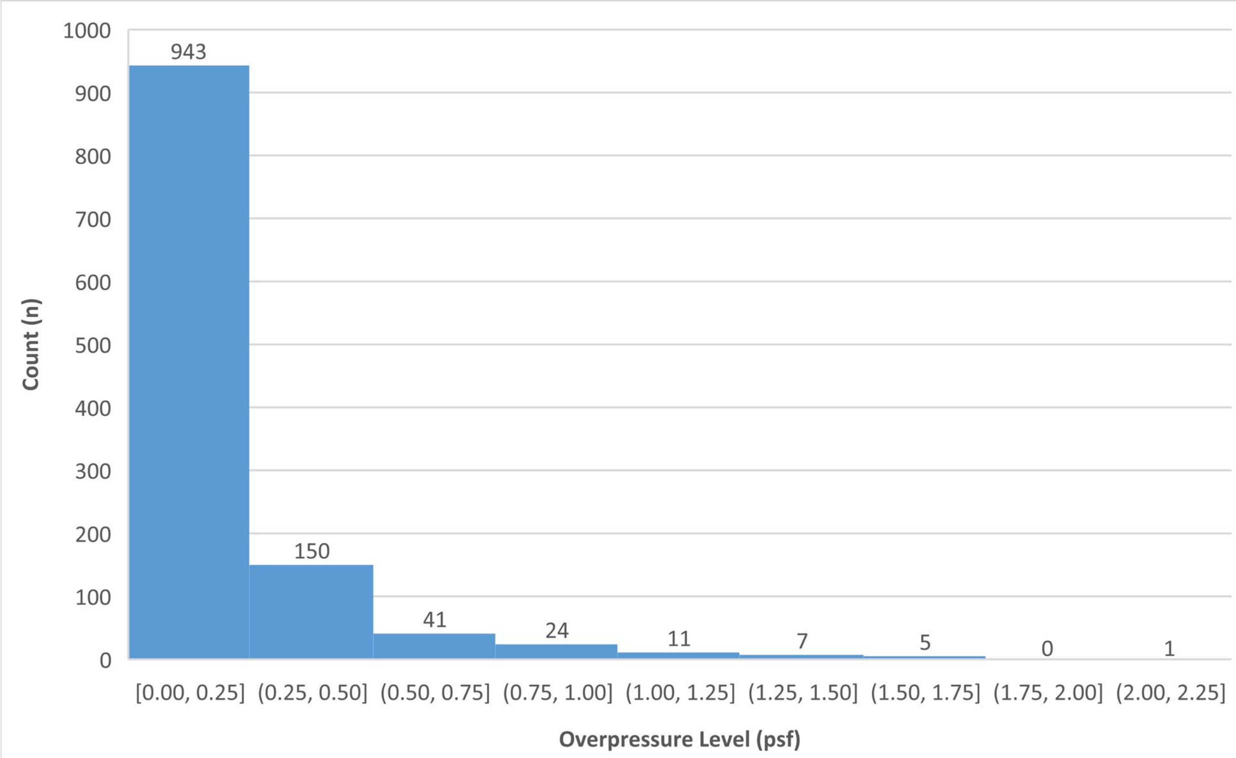

Figure 5.1-5. Distribution of PCBoom sonic boom modeling results within 10 km of ARTO localities shown in Figure 4.5-1.

Conclusion

Given that sonic booms greater than 1.0 psf would be very unlikely to impact ARTO populations and the lack of any coupled visual stimuli, VSFB has determined that the Proposed Action may affect, but is not likely to adversely affect, ARTO.

5.1.6 Western Spadefoot

Physical Impacts

No aspects of the Proposed Action would have potential physical impacts on western spadefoot.

Noise Impacts

Noise Impacts in the VSFB Area

Engine noise during up to 50 launches per year of the Falcon 9 from SLC-4 would range from approximately 100 to 110 dB L_{max} at breeding pools where western spadefoot are still known to occur on VSFB (Figure 4.6-1). At pools where the species has potentially been extirpated noise levels during Falcon 9 launch from SLC-4 may reach 115 dB L_{max}. During up to 12 Falcon 9 first stage landings per year at SLC-4, engine noise levels would be less than 100 dB L_{max} at extant pools and 100 to 105 dB L_{max} at pools where spadefoots are potentially extirpated. Static fire events at SLC-4 would produce noise levels of approximately 100 to 103 dB L_{max} at extant pools and 115 to 118 dB L_{max} at potentially extirpated pools. During up to 12 first stage landings at SLC-4, sonic boom levels would range from 1 to 2 psf at extant and potentially extirpated pools (Figure

4.6-2). However, these overpressure levels could be higher or lower based on atmospheric conditions at the time of landing.

All spadefoot species aestivate in underground burrows and emerge to breed when rainfall fills seasonal pools. Although no studies or data were found in the literature examining the potential for noise to trigger emergence in the western spadefoot, several authors have asserted that noise, potentially thunder or the sound of rainfall striking the surface of the ground, is used Couch's spadefoot (*Scaphiopus couchii*) as a cue to emerge from burrows to breed (Dimmit and Ruibal 1980; Brattstrom and Bondello 1983). Couch's spadefoot is a species native to the arid deserts of the southwestern U.S. that breeds in pools filled by monsoonal thunderstorms in the summer. Dimmit and Ruibal (1980) showed that Couch's spadefoots emerged when stimulated by an electric motor producing noise at approximately 100 Hz (decibels unreported) when the motor was placed on its side on the soil surface near an aestivating spadefoot in an enclosure. This response would be potentially deleterious in the desert environment that Couch's spadefoot occupy, since emergence during hot/dry conditions could cause dehydration and depletion of fat stores. However, the authors also noted that Capranica and Moffat (1975) determined that Couch's spadefoot has a poor auditory sensitivity in low frequencies, with a lower limit of 100 Hz and peaking in sensitivity within low frequencies at 480 Hz. Dimmitt and Ruibal (1980) postulated that the spadefoot's emergence was triggered not by the noise, but by a tactile, auditory stimulus from vibrations in the soil caused by the motor's direct placement on the surface. In other words, vibrations from the motor placed on the soil surface were absorbed by the spadefoot's body rather eardrum, which caused the stimulation and emergence rather than the sound energy itself. As discussed earlier, due to the reflection of sound energy from the ground, the intensity of the any noise, whether sonic boom or engine noise, would be greatly diminished at ground level (Ventre et al. 2002) and below ground level noise would decrease approximately 30 percent for every centimeter, depending on the type of soil (Oelze et al. 2002). Western spadefoots have been unearthed in the natural settings at depths from 33 to 74 centimeters and typically burrow up to 0.9 m deep (Stebbins 1972). At these depths, essentially all sound energy would be attenuated before reaching subterranean western spadefoots. Dimmitt and Ruibal (1980) also showed that Couch's spadefoots emerged due to the sound of rainfall; however, spadefoots in these experiments were in "summer" burrows, only 2 to 10 centimeters deep. As stated by the authors, these are secondary emergences after the spadefoots have already emerged, or moved closer to the surface, from deeper burrows in which they overwintered in.

In another experiment, Brattstrom and Bondello (1983) showed that captive Couch's spadefoots subjected to recordings of motorcycle sounds at 95 dBA caused them to emerge from burrows in cages. However, these authors noted that given the shallow terrariums in which the spadefoots were housed and the presence of hard bottoms, the noise from the recording likely traveled through the soil, bounced off the bottom of the terrarium and traveled past the spadefoots a second time; therefore, the noise stimuli may not resemble those encountered in natural settings where attenuation of the sound occurs with increasing soil depth. Again, given that approximately 30 percent of sound energy attenuates for every centimeter of depth (Oelze et al. 2002) and western spadefoots typically burrow up to 0.9 m deep (Stebbins 1972), it is unlikely that the results from this study are relevant to the potential impacts of noise resulting from the Proposed Action on western spadefoots in natural settings.

Spadefoot species found in the deserts of southwestern U.S. have very different ecologies than the western spadefoot. Spadefoot species in deserts aestivate in deep burrows through the winter and emerge to breed in the summer when monsoonal rainfall fills pools. This contrasts with the western spadefoot, which are adapted to the climate of coastal California, which is typically warm and dry in summer and cool and wet in winter. Thunderstorms are uncommon in in coastal California (Meier and Thompson 2009) so it is unlikely that the western spadefoot depends on noise cues for emergence. In addition, western spadefoot have been observed surface active at night year round (iNaturalist 2023; A. Abela, M. Ball, J. LaBonte pers. obs.). Surface activity, outside of the rainy season, has been observed in Santa Barbara County on nights when a heavy marine layer results in moist surface conditions (A. Abela, M. Ball, J. LaBonte pers. obs.). Western spadefoot movement to breeding ponds is likely triggered by inundation, as is the case with CTS, with the two species encountered together making overland movements across Santa Barbara County roads, during periods of suitable nighttime rainfall (A. Abela, M. Ball, J. LaBonte pers. obs.).

Noise is unlikely to cause any effect on spadefoot tadpoles because very little sound is transmitted between the air-water interface (Godin 2008); thus, in-air sound is not likely to have an effect on submerged western spadefoots or their larvae. In the event that a western spadefoot is aboveground and exposed to a sonic boom or rocket engine noise, these noises could potentially cause a minor temporary behavioral reaction. This could translate to a startle response to noise, minor vibrations, and visual disturbance during launch, landing, and static fire, causing them to flee, dig into the soil, or attempt to hide in place. It is likely that any reaction would be dependent on the sensitivity of the individual, the behavior in which it is engaged when it experiences the noise, and past exposure to similar noise. As a result, there could be a temporary disruption of western spadefoot behaviors including foraging, calling, and mating (during the breeding season). However, frogs tend to return to normal behavior quickly after being disturbed.

Noise Impacts in Eastern Santa Barbara, Ventura, and Los Angeles Counties

Approximately 68% of missions with easterly trajectories are predicted to impact a western spadefoot population in eastern Santa Barbara, Ventura, and Los Angeles Counties. To estimate the potential levels of these sonic booms, a frequency distribution of potential sonic boom levels was constructed by overlaying a 10-km buffer of spadefoot localities onto the PCBoom model output described in Section 2.2.4 and as depicted in Figure 4.6-3. Of the sonic booms predicted to impact within 10 km of a spadefoot locality, 99.7% of the boom levels were predicted to be less than 1.0 psf, and 100% were predicted to be less than 1.25 psf (Figure 5.1-6). Given that sonic booms greater than 1.0 psf would be very unlikely to impact western spadefoot populations and the lack of any coupled visual stimuli, sonic booms created during missions with easterly trajectories are discountable thus not expected to have an adverse effect on western spadefoot.

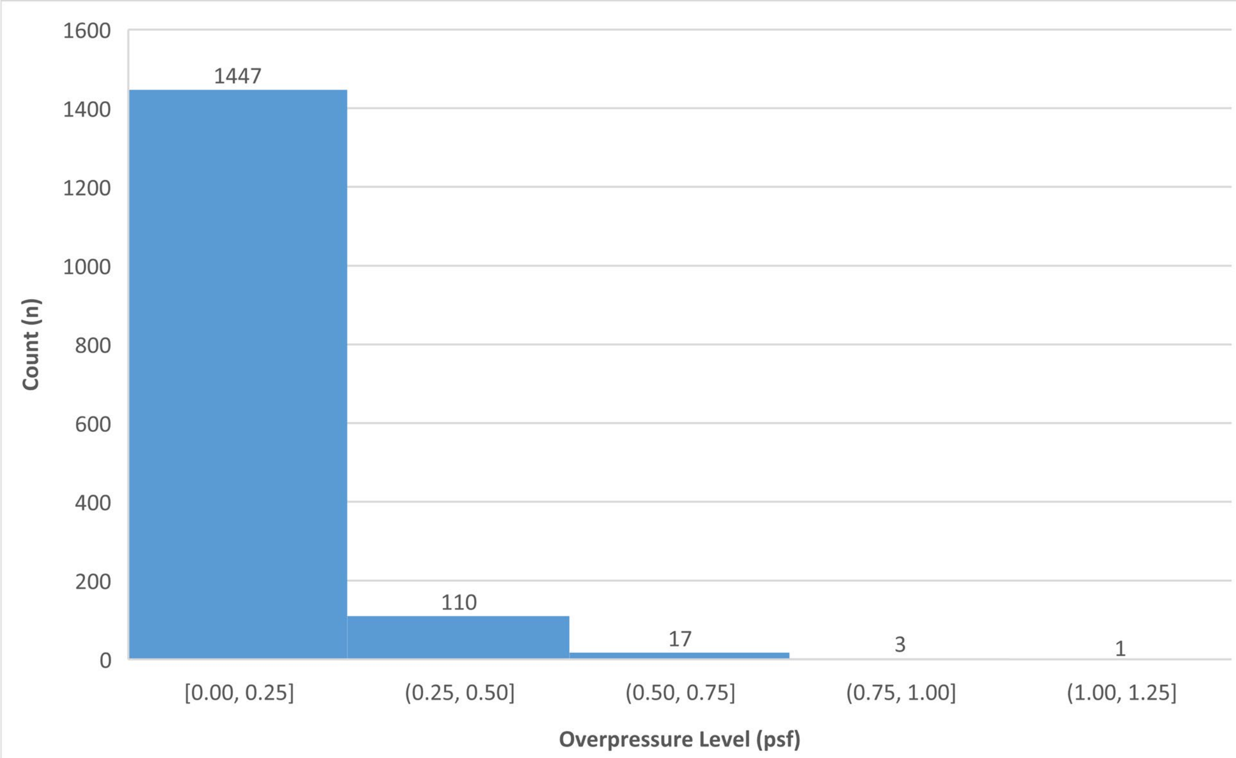

Figure 5.1-6. Distribution of PCBoom sonic boom modeling results within 10 km of western spadefoot localities shown in Figure 4.6-3.

Conclusion

Any potential impact of noise associated with the Proposed Action is expected to be limited to a temporary behavioral response. Additionally, because western spadefoot are typically only surface active during very limited periods of the year, reducing the likelihood that western spadefoot would be above ground during a launch event. Therefore, the Proposed Action may affect, but is not likely to adversely affect, the western spadefoot.

5.1.7 Southwestern Pond Turtle

Physical Impacts

Direct impacts on SWPT within the vegetation management area in Spring Canyon at SLC-4 may include injury or mortality from inadvertent crushing by workers as they walk and operate mechanical equipment while mowing vegetation. The risk of impacts on SWPT during vegetation management would be reduced because USFWS approved or permitted biologists would capture and relocate all individuals detected within the vegetation management area to nearby suitable habitat prior to the onset of vegetation clearing activities. A qualified biologist would be present to monitor vegetation-clearing activities and a USFWS approved or permitted biologist would move any SWPT encountered out of harm's way.

During launch, SWPT may be injured or killed as a result of the release of hot water and vapor into Spring Canyon from the flame bucket. An assessment of Spring Canyon in 2013 (MSRS 2014), in July 2017 (MSRS 2017), and in February 2023 during record rainfall levels (MSRS 2023a) found no suitable CRLF aquatic habitat within Spring Canyon within or downstream of the vegetation management area. SWPT habitat requirements are similar to CRLF requirements and therefore it is unlikely that individuals would be found in Spring Canyon and would use it for anything but transitory habitat. In addition, since 2017, across 11 survey efforts to perform minimization measures associated with the 2017 BO, no suitable habitat has been found in this area, likely because of the protracted drought conditions in the region. Routinely mowing the vegetation in the area impacted by water and vapor also further reduces the suitability and attractiveness of the site for SWPT occupancy. It is therefore unlikely that SWPT occupy this area and no direct impacts during vegetation management activities or water release are anticipated.

Direct impacts on SWPT, including injury and mortality, may inadvertently occur during removal of vegetation, site grading and contouring, construction, firebreak and fire establishment, and site maintenance from the operation of heavy equipment, machinery, and vehicles at SLC-6. SWPT that may disperse through the project area could become entrapped in any holes or trenches left open overnight. However, open holes and trenches would be covered overnight and the risk of impacts on SWPT will be reduced because biologists will monitor construction activities and search for animals trapped in open holes and trenches. Any SWPT detected within the construction area would be captured and relocated to nearby suitable habitat. In addition, when any demolition, contouring, or construction is occurring at SLC-6, the active construction areas would be surrounded by exclusion fence (see Section 2.3.1). A USFWS approved biologist would be present to monitor vegetation-clearing activities and move any SWPT encountered to the nearest suitable habitat out of harm’s way. Regardless, SWPT have the potential to be injured or killed during construction and vegetation clearing activities.

Noise Impacts

Noise Impacts in the VSFB Area

Construction noise during day and night hours would potentially disrupt SWPT if present within the area affected by these noise sources. SpaceX would employ standard types of construction equipment that have well known noise profiles. Noise during construction greater than 80 dB is not expected to extend more than 320 ft from the construction site (Table 2-1). There are no past or current SWPT records or suitable aquatic habitat within this distance. The assessment of the drainages and potential aquatic features in and around SLC-6 in February and March 2024 found no sites that would support SWPT for extended periods (Figure 4.4-3). At most, these sites would provide temporary habitat for transiting SWPT. In addition, the nearest records of SWPT are in Honda Creek, approximately 1.4 mi north of SLC-6, making it unlikely that SWPT would transit through the SLC-6 area. Therefore, construction noise is unlikely to have an effect on any SWPT aquatic habitats. In the unlikely event that a SWPT is transiting through upland habitat near the construction areas during construction activities, it could conceivably be exposed to noise levels of 80 dB or above. However, implementation of the avoidance and minimization measures during construction listed in Section 2.3.1 would greatly reduce the likelihood of SWPT being within this area since a wildlife exclusion zone would be established prior to construction which would be surveyed and monitored by a qualified biologist who would remove any SWPT encountered. Therefore, the likelihood of SWPT being affected by of construction noise in upland habitat is very low

During up to 50 events per year, engine noise produced during Falcon 9 launches from SLC-4 would reach approximately 123 dB L_{max} at Honda Creek, up to approximately 115 dB L_{max} at the Santa Ynez River, and up to approximately 105 dB L_{max} at Jalama Creek (Figure 4.7-1). During up to 12 SLC-4W landing events per year, engine noise would reach approximately 120 dB L_{max} at Honda Creek, approximately 105 dB L_{max} at the Santa Ynez River, and up to approximately 100 dB L_{max} at Jalama Creek. Static fire events at SLC-4 would produce approximately 115 dB L_{max} at Honda Creek, approximately 110 dB L_{max} at the Santa Ynez River, and up to approximately 100 dB L_{max} at Jalama Creek. For first stage landing events at SLC-4, up to 12 sonic booms per year would impact the Santa Ynez River (estimated between 1.5 and 2.0 psf), Honda Creek (estimated between 2.0 and 3.0 psf), and Jalama Creek (estimated at approximately 1.5 psf; Figure 4.7-2). However, these overpressure levels could be higher or lower based on atmospheric conditions at the time of landing.

The received maximum noise levels estimates are conservative since the modeling assumes a flat landscape and does not account for features like hills, bluffs, or dense vegetation that would attenuate sound during noise events. Engine noise would reach as high as 150 dB L_{max} with sonic booms up to 8.5 psf in upland SWPT dispersal habitat adjacent to SLC-4 (Figure 4.7-2). However, vegetation management within and around SLC-4 would make SWPT presence above ground in these areas unlikely during typical dry conditions.

There are no studies on the effects of noise on SWPT that could be located in literature searches. Bury and Germano (2008) claim that western pond turtles, a taxon that was later determined to be two species, including the SWPT, rapidly flee basking sites when disturbed by sound or visual stimuli at over 100 m; however, the authors provided no data to evaluate whether the reaction was in response to noise or visual stimuli. While SWPT are commonly known to be very wary species, turtles are much less sensitive to airborne sound than other tetrapods with tympanic hearing structures (Wever 1978). There are numerous studies of hearing anatomy and hearing sensitivity in red-eared sliders (*Trachemys scripta elegans*), an aquatic turtle similar in size to the SWPT and within the same family (Emydidae). Red-eared sliders have a narrow hearing range between 0.2 and 0.9 kHz, with lowest thresholds of approximately 40 dB L_{max} of 0.6 kHz in females and 45 dB L_{max} of 0.6 kHz in males, below which sound is undetectable (Wang et al. 2019a). The poor sensitivity to airborne sound is a result of the morphology of the inner ear which is adapted for underwater hearing (Christensen-Dalsgaard et al. 2012).

As discussed at the beginning of Section 5.1, determining the amount of sound energy that could potentially be perceived by SWPT is important to analyzing the potential effects that launch noise disturbances would have on this species. There are no SWPT-specific hearing curves (i.e., audiograms) or other data on this species' hearing sensitivity. However, there are published hearing curves for red-eared sliders (Wang et al. 2019a; Wang et al. 2019b), a similar-size species in the same family with similar behavior and ecological requirements. These data were used to create a mean "SWPT" hearing curve (Figure 5.1-7), and the mean curve processed following methods established in Southall et al. (2019) to produce a weighting function that would be appropriate for SWPT hearing sensitivity (Figure 5.1-8). Slopes beyond the lower and upper frequency cutoffs surrounding the range of best hearing (in dB/decade) were measured to estimate the amount of weighting to be applied at each frequency (Figure 5.1-8).

This weighting function was applied to the time waveform recording of a June 2022 launch at VSFB (Falcon 9 SARah-1). The unfiltered time waveform had frequency spectra with an unweighted peak level of approximately 110 dB Lmax (Figure 5.1-9). After applying the SWPT weighting function, the peak level is approximately 53 dB Lmax (Figure 5.1-9). In humans, 50 dBA is equivalent to a quiet conversation, a quiet suburb, a quiet office, or a quiet refrigerator. Given the high falloff rates outside the range of greatest sensitivity hearing the perceived rocket engine noise in SWPT is very likely to be negligible.

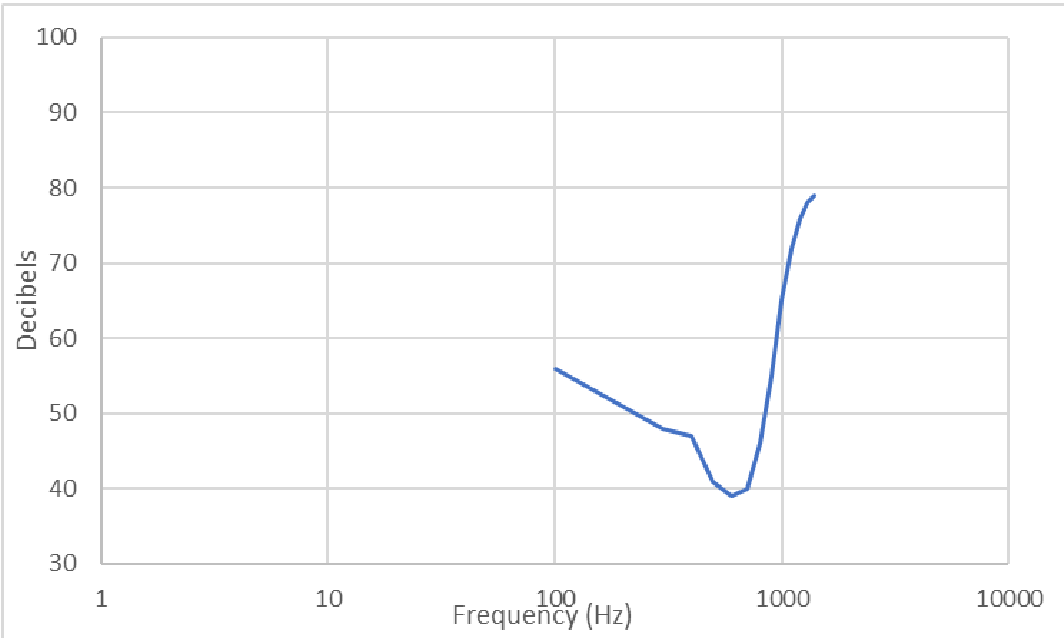

Figure 5.1-7. Mean SWPT hearing sensitivity curve.

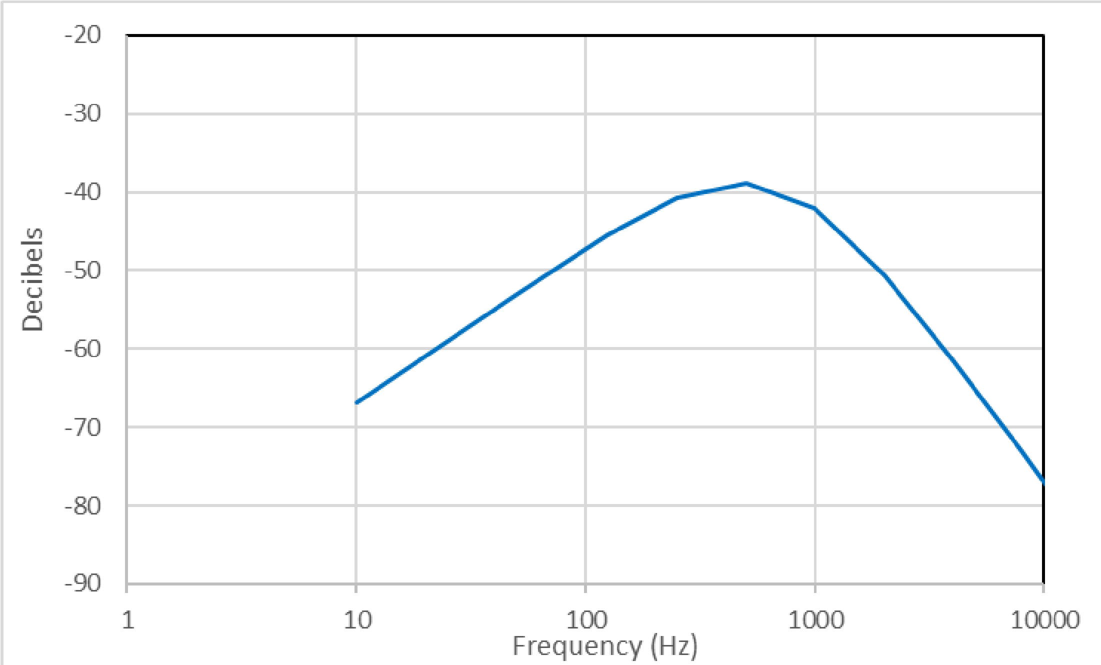

Figure 5.1-8. SWPT weighting function.

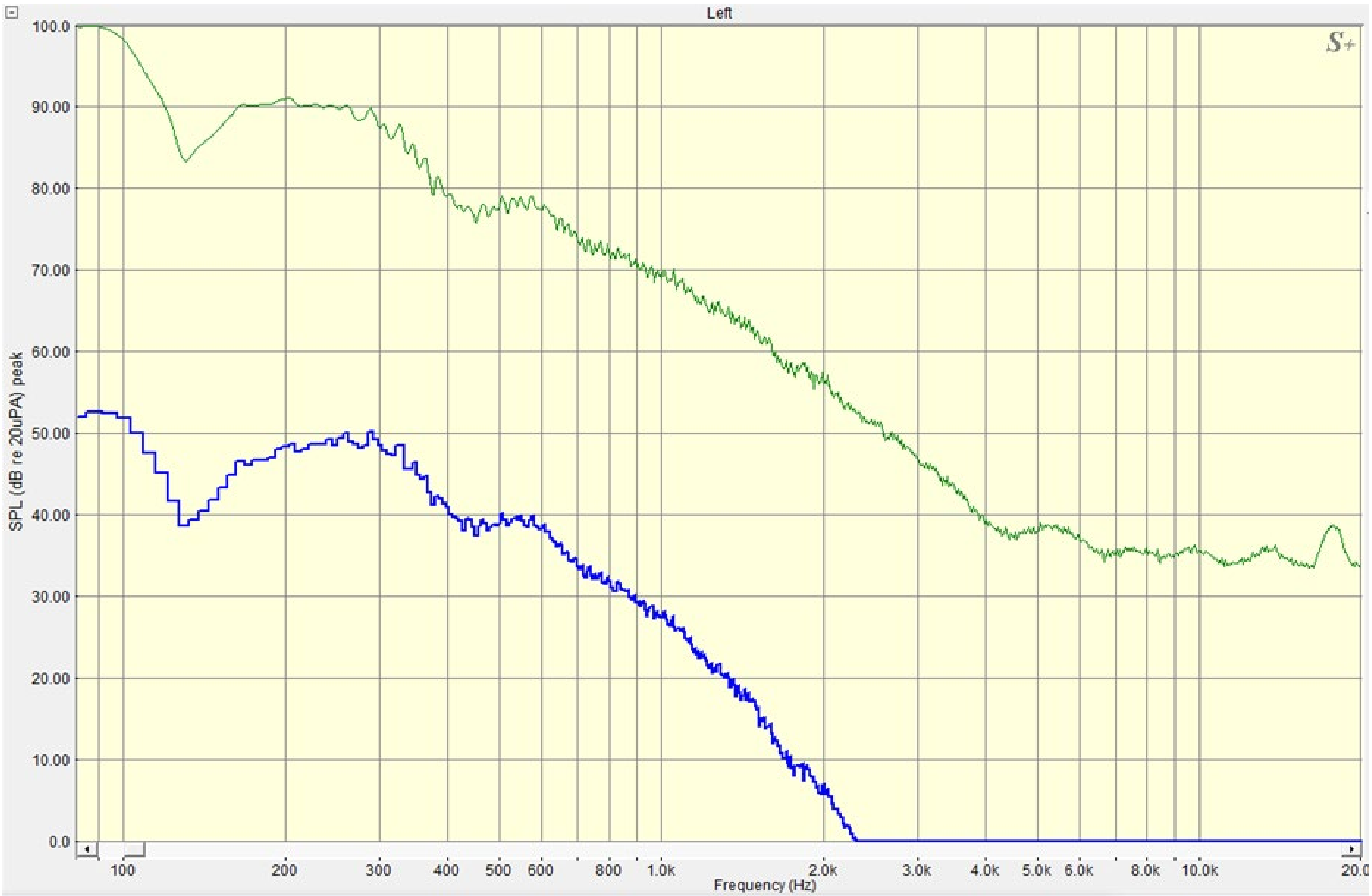

Figure 5.1-9. Launch peak noise level comparison of unweighted (green) versus SWPT-weighted (brown) decibels (note: time waveform recording from the June 2022 Falcon 9 SARah-1 launch).

Although perceived noise during launch and landing activities would be diminished due to SWPT hearing acuity, it is still assumed that SWPT, especially if closer to the launch sites, would respond to launches and landings to some degree, because of the increased loudness and potential vibrations of substrate near the launch facilities and the greater likelihood of experiencing visual disturbance from the flight of the rocket.

If SWPT are startled, they tend to flee basking sites into water where they hide. Because landing engine noise occurs approximately 5 to 7 minutes after launch noise and is typically slightly (seconds) before the sonic boom is received, individuals that flee into water because of launch disturbance would have a reduced likelihood of being exposed to the landing engine noise and sonic boom due to the attenuation of sound in water (Godin 2008). It is likely that any reaction would be dependent on the proximity of the individual to the launch, whether the individual is basking or otherwise above the water surface, and past exposure to similar noise. As a result, the Proposed Action could cause a temporary disruption of SWPT behaviors including foraging and mating (during the breeding season). SWPT are expected to return to normal behavior quickly after being disturbed.

The response to noise disturbances in wildlife depends on how frequent and predictable the noise is, acuteness, overlap with biologically relevant sounds, and overlap with animals hearing sensitivity range (reviewed in Francis & Barber 2013). Chronic (i.e., sustained) noise generally causes acoustic que masking, which can impact a variety of behaviors important to reproduction and fitness (Francis & Barber 2013). Infrequent, acute noise tends to cause startle responses (Francis & Barber 2013). There are no definitive thresholds determining at what frequency startling animals results in chronic physiological responses. Such responses could include chronic levels of stress hormones, changes in habitat use, impacts on reproduction and nest success, as well as the other negative factors discussed above, which are related to fitness, and may result in population level effects, as discussed for other species elsewhere in this document. Only one study on chronic noise impacts to non-marine turtles could be found in literature searches. Delay et al. (2023) found that spotted turtles (*Clemmys guttata*) showed no avoidance of habitats near wind turbines that produce chronic noise, vibrations, and shadow flicker from turbine blades. This single data point should not be used to draw conclusions about SWPT, but does suggest that at least one non-marine turtle species may be less affected by chronic noise than other types of animals.

The DAF will implement a monitoring program (see Section 2.3.3) to track SWPT habitat occupancy in Jalama Creek, Honda Creek, Bear Creek, and Santa Ynez River as the frequency of launch and static fire under the Proposed Action increases. As full tempo under the Proposed Action is reached, the DAF will be able to assess whether changes in the acoustic environment have impacted the SWPT population status. If SWPT population estimates decline by 15 percent or more, the 15 percent decline from baseline is maintained for two consecutive years, and the decline is not attributable to other non-launch-related factors, VSFB would mitigate for these impacts by creating new SWPT habitat at the San Antonio Creek Oxbow Restoration Area, an established wetland mitigation site that is located outside of areas currently impacted by launch noise on VSFB. Historically occupied by riparian vegetation, restoration efforts would focus on enhancing this abandoned tract of agricultural land to improve San Antonio Creek and provide habitat for SWPT, thus offsetting population level impacts at Jalama Creek, Honda Creek, and the Santa Ynez River within an area that is not impacted by launch noise.

Noise Impacts in Eastern Santa Barbara, Ventura, and Los Angeles Counties

Approximately 98% of missions with easterly trajectories are predicted to impact a SWPT population in eastern Santa Barbara, Ventura, and Los Angeles Counties. To estimate the potential levels of these sonic booms, a frequency distribution of potential sonic boom levels was constructed by overlaying a 10-km buffer of SWPT localities onto the PCBoom model output described in Section 2.2.4 and as depicted in Figure 4.7-3. Of the sonic booms predicted to impact within 10 km of a SWPT locality, 97% of the boom levels were predicted to be less than 1.0 psf, and 99.9% were predicted to be less than 2.0 psf (Figure 5.1-10). Given that sonic booms greater than 1.0 psf would be very unlikely to impact SWPT populations and the lack of any coupled visual stimuli, sonic booms created during missions with easterly trajectories are discountable thus not expected to have an adverse effect on SWPT.

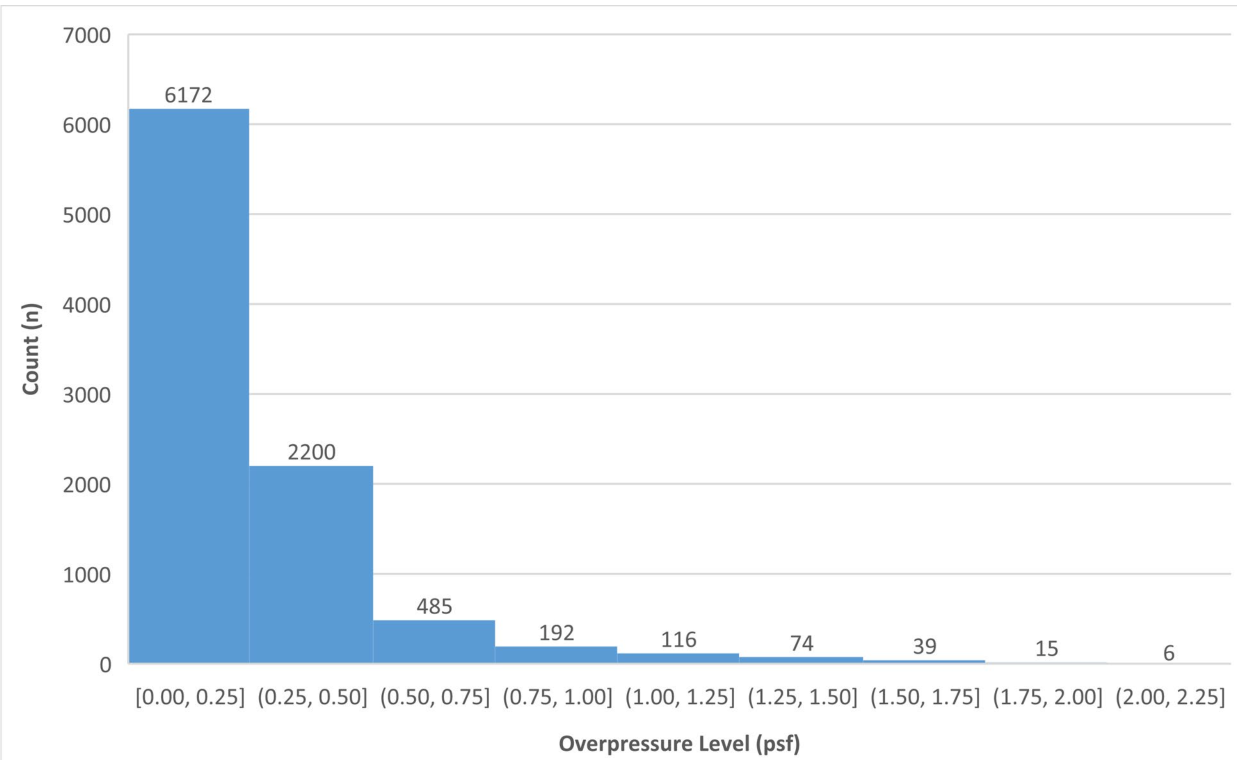

Figure 5.1-10. Distribution of PCBoom sonic boom modeling results within 10 km of SWPT localities shown in Figure 4.7-3.

Water Use

At maximum cadence the annual usage in the flame duct for launches and landings at SLC-4 would be up to 3.98 million gallons (12.2 ac-ft). In addition, a maximum of 1.37 million gallons (4.20 ac-ft) per year would be required to support the personnel and operational activities at SLC-4, a maximum of 1.19 million gallons (3.64 ac-ft) per year to support personnel at Buildings 398 and 520. Therefore, at maximum cadence, the Proposed Action would use up to 6.54 million gallons (20.07 ac-ft) of water per year. Annual VSFB water use from 2019 through 2021 has averaged 910,500,000 gallons (2,794 ac-ft) per year. The current water source for VSFB, including SLC-4, is via an existing connection between State Water and the VSFB water supply system. VSFB primarily relies on State Water; however, during annual maintenance that lasts two to three weeks, VSFB utilizes four water wells in the San Antonio Creek Basin.

SWPT in San Antonio Creek would be negatively impacted if the water used for the Proposed Action reduced flow rates, hydration periods, or water levels in San Antonio Creek. Annual VSFB water use over the past three years (2019 through 2021) has averaged 910,500,000 gallons (2,794 ac-ft) per year. SpaceX's proposed use of up to 20.07 ac-ft per year would represent approximately 0.7 percent of the total annual water usage on VSFB. VSFB primarily relies on State Water and even if pumping this entire volume of water from the San Antonio Creek groundwater basin, it would have an indetectable effect of water levels and flow rates in the creek (Cromwell & Faunt 2024). The Proposed Action's water usage would therefore be discountable and not result in any measurable impacts to flow rates, hydration periods, or water levels in San Antonio Creek.

Conclusion

VSFB has determined that potential physical impacts because of construction activities at SLC-6, rocket engine noise, and sonic booms resulting from the Proposed Action may affect, and are likely to adversely affect, the SWPT on VSFB. Launch noise and sonic booms at VSFB may induce behavioral responses in SWPT ranging from momentary startling or freezing by individual SWPT to population-level emigration away from impacted areas. The DAF will implement post-project restoration activities with the goal of achieving no net loss to the species.

5.1.8 Marbled Murrelet

Physical Impacts

No ground disturbing activities would occur within or near MAMU habitat; therefore, the Proposed Action would have no direct physical impacts on MAMU or MAMU habitat.

Noise and Visual Disturbance

Noise Impacts in the VSFB Area

MAMU do not nest on VSFB so exposure to noise impacts would be limited to foraging adults that have occasionally been observed between the late summer through winter off the coast of south VSFB (eBird 2022). Although unlikely, if MAMU were present immediately off the coast of SLC-4 they would experience engine noise of less than 130 dB L_{max} during Falcon 9 launch at SLC-4, less than 115 dB L_{max} during SLC-4 landings, approximately 125 dB L_{max} during static fire events at SLC-4 (Figure 4.8-1), and sonic booms up to 4 psf during SLC-4 landings (Figure 4.8-2). However, the majority of MAMU are found in a band about 984 to 6,561 ft (300 to 2,000 m) from shore (Strachan et al. 1995) where noise levels would be lower and decrease with distance from SLC-4.

Very little data are available regarding MAMU's response to noise and visual disturbances; however, Bellefleur et al. (2009) examined the response of MAMU to boat traffic. MAMU response was found to depend on the age of the birds, the distance and speed of the boats encountered, and the season. MAMU either showed no reaction, flew, or dove in response. Late in the season (July through August), some MAMU were found to fly completely out of feeding areas when approached by boats traveling in excess of 17.9 mi per hour. The dominant response of MAMU to approach by boats was, however, for birds to dive and resurface a short distance away. MAMU are, therefore, expected to exhibit a startle response that would cause birds to dive and resurface, but they are expected to return to normal behavior soon after each launch or static fire event has been completed.

Noise Impacts in Eastern Santa Barbara, Ventura, and Los Angeles Counties

There are no records of MAMU in eastern Santa Barbara, Ventura, and Los Angeles Counties and there would be no noise impacts on this species in this area as a result of the Proposed Action.

Conclusion

Because MAMU would be unlikely to be present during a launch, landing, or static fire event, and the expected impact would be a temporary behavioral reaction in response to noise, the Proposed Action would have a discountable effect on MAMU. Therefore, VSFB has determined that the Proposed Action may affect, but is not likely to adversely affect, the MAMU.

5.1.9 Southwestern Willow Flycatcher

Physical and Habitat Impacts

No ground disturbing activities or vegetation management activities would occur within SWFL habitat and avoidance and minimization measures discussed in Section 2.3.1 would ensure that there are no SWFL near the construction area. Therefore, these actions would have no effect on SWFL. The potential effects of noise are discussed below.

Noise and Visual Disturbance

Noise Impacts in the VSFB Area

As discussed at the outset of Section 5.1, unweighted noise levels are very conservative when considering the perceived loudness an animal would experience because only a portion of launch sound energy across frequency spectra would overlap with the hearing sensitivity of each species. Although there are no SWFL-specific audiograms or other data on this species' hearing sensitivity available, most bird species greatest sensitivity to sounds is within a relatively narrow frequency from 1 kHz - 4 kHz (Konishi 1970). Most of the sound energy produced by rocket engines is less than 200 Hz. In addition, sound energy in higher frequencies ranges attenuates more quickly while traveling through the atmosphere; therefore, the maximum noise levels within bird's hearing sensitivity range that would reach SWLF sites near Buellton, approximately 22 mi from SLC-4, would have reduced significantly as they travel through the atmosphere. Finally, the predicted noise levels based on modeling are conservative since the models do not take into account attenuation due to land forms (e.g., mountains, hills, valleys, etc.). It is therefore reasonable to conclude that perceived noise levels for SWFL at this location would be substantially less than 105 dB and very little of the sound energy perceivable by SWFL would reach these sites.

Noise Impacts in Eastern Santa Barbara, Ventura, and Los Angeles Counties

Approximately 57% of missions with easterly trajectories are predicted to impact a SWFL population in eastern Santa Barbara, Ventura, and Los Angeles Counties. To estimate the potential levels of these sonic booms, a frequency distribution of potential sonic boom levels was constructed by overlaying a 10-km buffer of SWFL localities onto the PCBoom model output described in Section 2.2.4 and as depicted in Figure 4.9-7. Of the sonic booms predicted to impact within 10 km of a SWFL locality, 81% of the boom levels were predicted to be less than 1.0 psf, and 99.9% were predicted to be less than 2.0 psf (Figure 5.1-11). Given that sonic booms greater than 1.0 psf would be very unlikely to impact SWFL populations and the lack of any coupled visual stimuli, sonic booms created during missions with easterly trajectories are discountable thus not expected to have an adverse effect on SWFL.

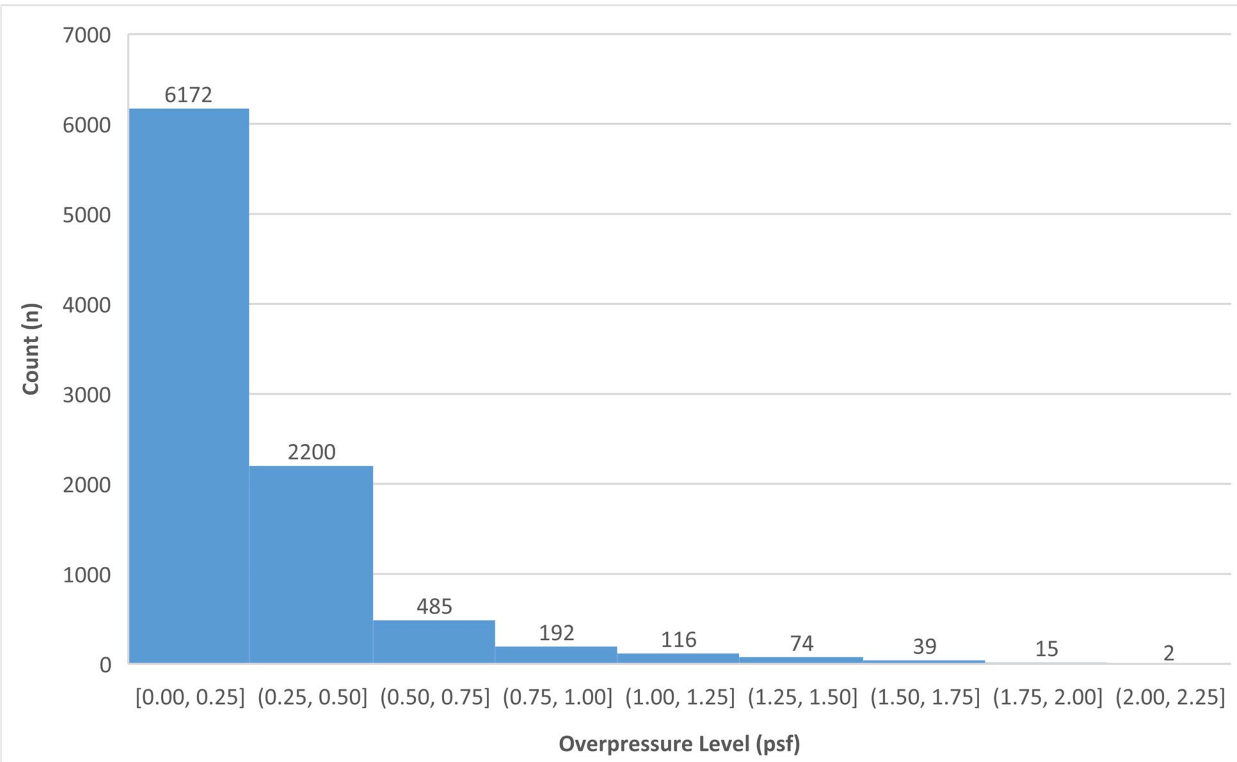

Figure 5.1-11. Distribution of PCBoom sonic boom modeling results within 10 km of SWFL localities shown in Figure 4.9-3.

Conclusion

Given the lack of an extant SWFL breeding population on VSFB, SWFL presence on VSFB is likely limited to migrants. Recent observations of SWFL at the Santa Ynez River in Buellton were limited to one territorial male with suspected, but unconfirmed, pairing. SWFL occurrence and breeding activity within the Action Area during a launch event is, therefore, rare. Additionally, attenuation of noise over SWLF sites would reduce noise levels within the sensitivity range of birds. Finally, sonic booms greater than 1.0 psf at SWFL localities in eastern Santa Barbara, Ventura, and Los Angeles Counties would be very rare. For these reasons, the DAF has determined that the Proposed Action would have a discountable effect and may affect, but is not likely to adversely affect the SWFL.

5.1.10 Least Bell's Vireo

Physical and Habitat Impacts

No ground disturbing activities or vegetation management activities would occur within LBVI habitat and avoidance and minimization measures discussed in Section 2.3.1 would ensure that there are no LBVI near the construction area. Therefore, these actions would have no effect on LBVI. The potential effects of noise are discussed below.

Noise and Visual Disturbance

Noise Impacts in the VSFB Area

As discussed at the outset of Section 5.1, unweighted noise levels are very conservative when considering the perceived loudness an animal would experience because only a portion of launch sound energy across frequency spectra would overlap with the hearing sensitivity of each species. Although there are no LBVI-specific audiograms or other data on this species' hearing sensitivity available, most bird species' greatest sensitivity to sounds is within a relatively frequency from 1 kHz - 4 kHz (Konishi 1970). Most of the sound energy produced by rocket engines is less than 200 Hz. In addition, sound energy in higher frequencies ranges attenuates more quickly while traveling through the atmosphere; therefore, the maximum noise levels within bird's hearing sensitivity range that would reach LBVI sites near Buellton, approximately 22 mi from SLC-4, and Santa Maria, approximately 26 mi from SLC-4, would have reduced significantly as they travel through the atmosphere. Finally, the predicted noise levels based on modeling are conservative since the models do not take into account attenuation due to land forms (e.g., mountains, hills, valleys, etc.). It is therefore reasonable to conclude that perceived noise levels for LBVI at this location would be substantially less those modeled very little of the sound energy perceivable by LBVI would reach these sites.

Noise Impacts in Eastern Santa Barbara, Ventura, and Los Angeles Counties

Approximately 98% of missions with easterly trajectories are predicted to impact a LBVI population in eastern Santa Barbara, Ventura, and Los Angeles Counties. To estimate the potential levels of these sonic booms, a frequency distribution of potential sonic boom levels was constructed by overlaying a 10-km buffer of LBVI localities onto the PCBoom model output described in Section 2.2.4 and as depicted in Figure 4.10-7. Of the sonic booms predicted to impact within 10 km of a LBVI locality, 98% of the boom levels were predicted to be less than 1.0 psf, and 99.9% were predicted to be less than 2.0 psf (Figure 5.1-12). Given that sonic booms greater than 1.0 psf would be very unlikely to impact LBVI populations and the lack of any coupled visual stimuli, sonic booms created during missions with easterly trajectories are discountable thus not expected to have an adverse effect on LBVI.

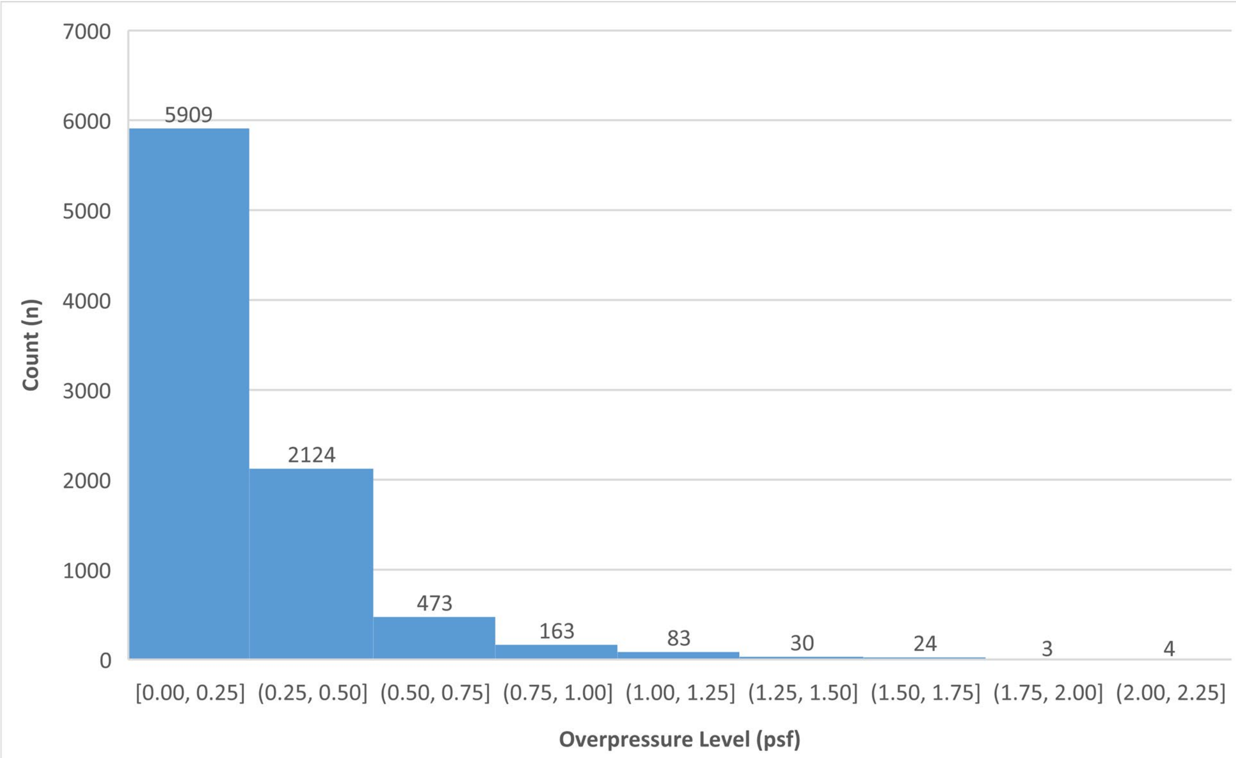

Figure 5.1-12. Distribution of PCBoom sonic boom modeling results within 10 km of LBVI localities shown in Figure 4.10-3.

Conclusion

Given the lack of an extant LBVI breeding population on VSFB, LBVI presence on VSFB is likely limited to migrants. Recent observations of LBVI at the Santa Ynez River in Buellton were limited to one territorial male with suspected, but unconfirmed, pairing. LBVI occurrence and breeding activity within the Action Area during a launch event is, therefore, rare. Additionally, attenuation of noise over the distance to LBVSI sites off-VSFB would reduce noise levels within the sensitivity range of birds. Finally, sonic booms greater than 1.0 psf at LBVI localities in eastern Santa Barbara, Ventura, and Los Angeles Counties would be very rare. For these reasons, the DAF has determined that the Proposed Action would have a discountable effect and may affect, but is not likely to adversely affect the LBVI.

5.1.11 Western Snowy Plover

Physical Impacts

No ground disturbing activities would occur within or near SNPL habitat; therefore, the Proposed Action would have no direct physical impacts on SNPL or SNPL habitat.

Noise and Visual Disturbance

Noise Impacts in the VSFB Area

SNPL on VSFB beaches would be exposed to levels between 100 and 130 dB L_{max} during up to 50 Falcon 9 launches from SLC-4 per year (Figure 4.11-1), between approximately 100 and 110 dB

L_{max} during up to 12 SLC-4W first stage landings, and between 100 and 125 dB L_{max} during static fire events at SLC-4. During first stage landings at SLC-4, sonic booms between 1.5 and 5.0 psf are expected to impact these areas up to 12 times per year (Figure 4.11-2). However, these overpressure levels could be higher or lower based on atmospheric conditions at the time of landing. Launch and landing noise events would last less than one minute and static fire noise would last less than 7 seconds.

As discussed at the outset of Section 5.1, determining the amount of sound energy that overlaps with the hearing sensitivity of SNPL is critical to understanding the potential effects that the noise disturbances would have. With the lack of SNPL-specific audiograms or other data on this species' hearing sensitivity, a weighted noise function for SNPL was deduced based on call frequency. There is a strong correlation between the range of hearing in birds and the frequency spectrum of bird vocalizations (Dooling & Popper 2007). That is, except for some nocturnal predators, birds hear best in the spectral region of their species-specific vocalizations. Typical frequency components of SNPL call and song were identified using field recordings from California. As presented in Figure 5.1-13, the highest energy in a plover call falls between 1.2 and 4 kilohertz (kHz), equating to a best hearing range between 1.2 and 4 kHz. This range was used to review several avian hearing curves (i.e., audiograms) to identify an approximate match for the SNPL that could be used in developing a weighting filter.

The hearing curve of the mallard duck (*Anas platyrhynchos*) was used for analysis. Of the species for which data were available, the mallard possessed the most similar frequency range to the SNPL (Figure 5.1-14). This audiogram was then processed following methods established in Southall et al. (2019), deriving an auditory weighting function serving as a frequency-specific filter to quantify how noise would be perceived by SNPL, and how that would relate to the spectral characteristics of a SNPL's potential susceptibility to noise. Weighting functions are used to de-emphasize noise at frequencies where susceptibility is lower and emphasize noise at frequencies where sensitivity is greater. The high and low frequency cutoffs of the audiogram were noted as were the "fall-offs" outside of the range of best hearing. The slopes of the lower and upper frequency cutoffs were measured (dB/decade) and used to estimate the amount of weighting to be applied at each frequency (Figure 5.1-15).

Finally, this weighting function was applied to the timewave form recording of the June 2022 Falcon 9 SARah-1 launch. The unfiltered time waveform had a frequency spectra with an unweighted peak level of approximately 110 dB Lmax (Figure 5.1-16). Given the high falloff rates outside the range of best hearing, both the low- and high-frequency component of the rocket launch noise were notably reduced. After applying the SNPL weighting function, the peak level was approximately 60 dB Lmax (Figure 5.1-16). In comparison to human hearing sensitivity, 60 dBA is equivalent to the noise level of typical conversation. The very low incidence of behavioral responses to launch noise and lack of evidence of changes in SNPL abundance, nesting behavior, and distribution on VSFB beaches in response to launches, discussed below, is likely because very little of the noise produced by rocket engine noise is perceived by SNPL.

Figure 5.1-13. Western snowy plover call frequency.

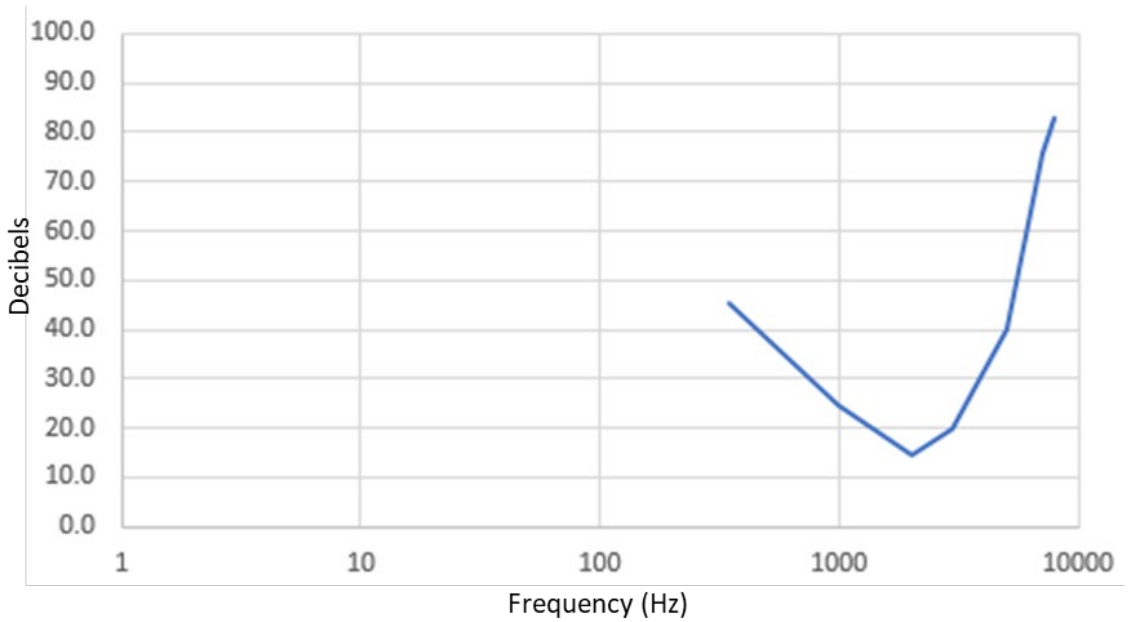

Figure 5.1-14. Mallard duck hearing sensitivity curve.

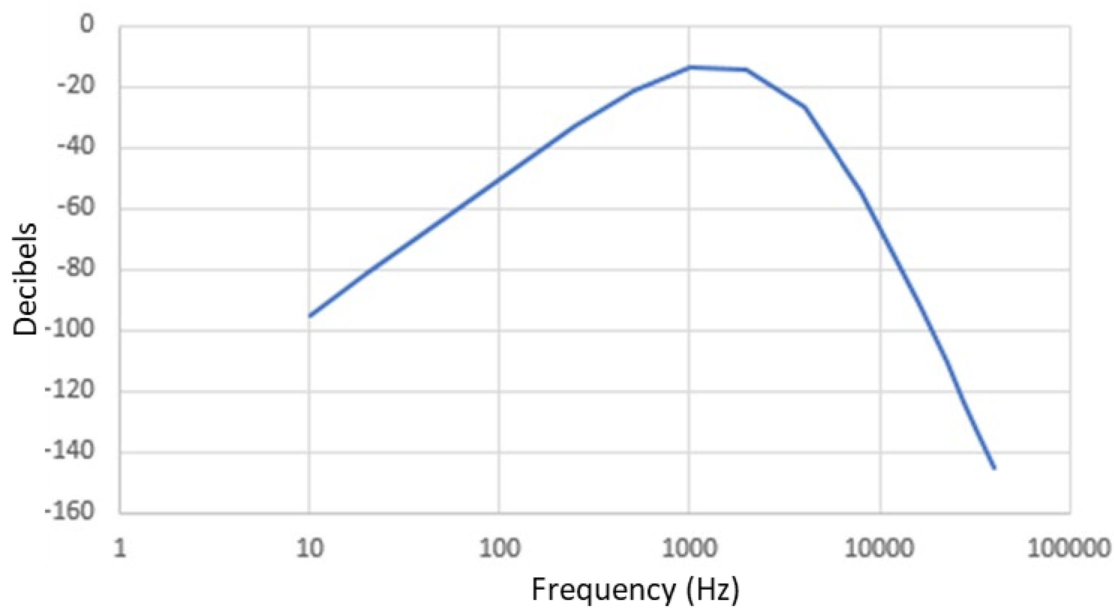

Figure 5.1-15. Mallard duck weighting function.

Figure 5.1-16. Launch peak noise level comparison of unweighted (green) versus SNPL-weighted (orange) decibels (note: time waveform recording from the June 2022 Falcon 9 SARah-1 launch).

The DAF has monitored SNPL during the breeding and non-breeding seasons on VSFB during numerous launches over the past 23 years, including Falcon 9 missions with boostback and landing at SLC-4W. The monitoring has routinely demonstrated that launch noise only has a minor effect on SNPL behavior, and no incidents of injury or mortality to adults, young, or eggs attributable to launch activities have been documented (SRS Technologies, Inc. 2001, 2006a, 2006b, 2006c, 2006f, 2006g, 2006h, 2006i, 2006j, 2006k; MSRS 2007a, 2008a, 2008b, 2008c, 2009c, 2010a, 2010b, 2013; Robinette & Ball 2013; Robinette & Miller 2017a, 2017b; Robinette & Rice 2019; Robinette & Rice 2022a, 2022b; Robinette et al., in prep.).

Incubating SNPLs were captured on video during two Falcon 9 launches with first stage landing in 2022 and twelve Falcon 9 launch events, some with first stage landing, in 2023. The majority of these SNPL's only exhibited alerting behavior involving minor head movements; a smaller proportion showed a startle effect, where the bird was observed to physically jolt, often accompanied by quick head movements; and an even smaller proportion "hunkered down" on the nest (Robinette & Rice 2022a, 2022b; Robinette et al., in prep.). In 2023, these videos showed SNPL that 92% had minor alerting, 11% startled, 7 % hunkered, and 0% flushed off nests during launch noise events (n=26; Robinette et al., in prep.). In response to sonic booms during first stage SLC-4 landings, 100% exhibited minor alerting, 43% startled, 14% hunkered, and 0% flushed off nests during sonic booms (n=7; Robinette et al., in prep.). Overall in 2022 and 2023, there were no significant changes in incubation rates, overall plover abundance, or nest attendance before and after the launches and boost-back events and no observed cases of plovers flushing off of nests in response to rocket noise (Robinette et al., in prep.).

There have, however, been four cases of failed eggs being found within areas that are impacted by launch and landing noise that may have been damaged on or around the date of the launch. During 2019, one SNPL egg that failed to hatch was found with signs of potential damage (a slight crack). This egg was part of a three-egg clutch in which the other two eggs successfully hatched. Based on inspection of the failed egg, the embryo may have stopped developing around the time of monitoring for the 12 June 2019 Falcon 9 Radarsat lauch (Robinette and Rice 2019). Similarly, one failed SNPL egg was found at north Wall Beach in 2022 that had a long crack. The damaged egg had an approximately three-week-old embryo that may have stopped developing around the time of the 18 June 2022 Falcon 9 SARah-1 mission (Robinette & Rice 2022b). During 2023, two failed eggs were found: one a dented egg with an embryo that would have stopped developing around 16 May 2023, near the 20 May 2023 Falcon Iridium mission; and a second undamaged egg that stopped developing around 22 June 2023, the date of the Falcon 9 Starlink G5-7 mission (Robinette et al., in prep.).

In all four cases, there was no evidence of what caused the damage to the eggs or chicks to stop developing. The sonic booms produced during first stage landing are of vastly insufficient levels to break avian eggs (Ting et al. 1997), which found the peak overpressure required for egg failure to be 24,900 psf. However, a possibility is that rocket noise caused incubating SNPLs to flush and in doing so, they inadvertently damaged these eggs. None of the 33 launch noise events monitored in 2023 showed any SNPL flushing off nests, making this explanation unlikely. Although VSFB does not yet have data on how often eggs are damaged under normal (i.e., non-launch) circumstances, it is common that one or more eggs from a successful nest do not hatch (Robinette and Rice 2019; Robinette & Rice 2022b). Overall, all of the monitoring that has been performed has shown there are no changes in bird abundance, nest attendance, or hatching rates, before and after launches.

The scientific literature shows that the effects of frequent noise disturbance on bird species varies greatly. Reviewed in Francis and Barber (2013), response to noise disturbances in wildlife depends on how frequent and predictable the noise is, acuteness, overlap with biologically relevant sounds, and overlap with animals hearing sensitivity range. Chronic (i.e., sustained) noise generally causes acoustic cue masking, which can impact a variety of behaviors important to reproduction and fitness (Francis & Barber 2013). On the opposite side of the spectrum, infrequent, acute noise tends to cause startle responses (Francis & Barber 2013). In birds, sustained, chronic noise, such as that produced by traffic, wind turbines, and gas/oil fields, has been shown to correlate to a variety of negative effects, including changes in levels of stress hormones and stress physiology (Kleist et al. 2018; Zollinger et al 2019), acoustic que masking (Francis et al. 2011a; Francis & Barber 2013), changes in breeding behavior (Goudie & Jones 2004; Swaddle & Page 2007; Alquezar et al. 2020), changes in territorial behavior and aggression (Goudie & Jones 2004; Mockford & Marshall 2009; Wolfenden et al. 2019; Passos et al. 2020), impacts on reproduction and nest success (Halfwerk et al. 2011; Kleist et al. 2018; Zollinger et al. 2019), and declines in bird abundance (Francis et al. 2011b; McClure et al. 2013; Mejia et al. 2019; Rosa & Koper 2022), all of which have implications for survival and fitness (Francis & Barber 2013).

In many species, however, research has shown a lack of effect of chronic noise and evidence of habituation. It should, therefore, not be assumed that chronic noise exposure in birds is necessarily associated with the negative impacts listed above or that closely related species, or even individuals, will respond similarly. Yorzinski and Hermann (2016) found that peafowl (*Pavo cristatus*) exposed to continuous white noise showed no preference for roosting near or away from the noise source. Walthers and Barber (2020) found that traffic noise was not associated with stress indicators in nestling European starlings (*Sturnus vulgaris*). Similarly, stress physiology and immune function in nestling tree swallows (*Tachycineta bicolor*) was not altered when exposed to continuous white noise. Although Meillere et al. (2015) found differences in predator vigilance in house sparrows (*Passer domesticus*) exposed to traffic noise, they found no effect of the chronic exposure on reproductive performance. In response to loud, frequent, but non-sustained aircraft noise, a study of domestic turkeys (*Meleagris gallopavo domesticus*) showed they quickly acclimated to the noise (Bradley et al. 1990). Conomy et al. (1998) found that black duck (*Anas rubripes*) reactions to jet noise declined with exposure, but wood duck (*Aix sponsa*) reactions did not change. Aircraft noise was also shown not to have a significant effect on physiological stress in nestling tree sparrows (*Passer montanus*; Redondo et al. 2021).

The effect of increasing noise disturbances on SNPL is uncertain based on the scientific literature. However, none of the scientific literature studies are directly comparable to the noise impacts of the Proposed Action. Launch engine noise and sonic booms are acute, non-sustained, and unpredictable. It is most similar to aircraft noise disturbance yet would be much less frequent. Beyond the launch monitoring efforts discussed above, there are no relevant studies on the effects of rocket launch on birds.

VSFB would augment the existing SNPL monitoring program on Base, which records habitat use, nesting efforts, nest fates, fledgling survival, and population size through each breeding season, with geospatial analysis of SNPL nesting and the noise environment, as presented in Section 2.3.7. SLMs would be deployed immediately inland of South Surf Beach to characterize the noise environment during the breeding season within Falcon 9's 100 dB L_{max} footprint. Geospatial analysis would be performed annually to assess whether patterns of nesting activity, nest fates, or fledgling success are negatively impacted by noise from the Proposed Action or other launch programs on VSFB. If geospatial analysis shows that a statistically significant decline in breeding effort or nest success over two consecutive years is not attributable to other factors, VSFB would offset this impact by increasing predator removal efforts on Base to include the non-breeding season, particularly focusing on raven removal at and adjacent to VSFB beaches.

On the NCI, impacts on SNPL would be substantially less (Figure 4.11-3). Over the past 29 Falcon 9 launches, only seven have impacted the NCI, and only four have impacted Santa Rosa Island where SNPL is considered a permanent resident. Sonic booms impacting Santa Rosa Island as a result of the Proposed Action during the SNPL breeding season would be infrequent. As established through monitoring on VSFB (discussed above) SNPL would be expected to have a startle reaction to a sonic boom on Santa Rosa Island. However, there would not be any exposure to launch or landing noise or any associated visual stimuli. Since the sonic boom would be disassociated from these other stimuli, SNPL on Santa Rosa Island would likely have less intensity than on VSFB, but would still be expected to have a brief startle reaction. Reactions would likely be short term, infrequent, and be unlikely to cause any long-term consequences for individuals or populations. Because of the infrequent, short-term, and transient nature of the sonic booms and the relatively few numbers of individuals occurring on the NCI, the impacts would be insignificant and discountable to SNPL on the NCI.

Noise Impacts in Eastern Santa Barbara, Ventura, and Los Angeles Counties

An estimated 100% of missions with easterly trajectories are predicted to impact a SNPL population in eastern Santa Barbara, Ventura, and Los Angeles Counties. To estimate the potential levels of these sonic booms, a frequency distribution of potential sonic boom levels was constructed by overlaying a 10-km buffer of SNPL localities onto the PCBoom model output described in Section 2.2.4 and as depicted in Figure 4.11-4. Of the sonic booms predicted to impact within 10 km of a SNPL locality, 96% of the boom levels were predicted to be less than 1.0 psf, and 99.9% were predicted to be less than 2.0 psf (Figure 5.1-17). Given that sonic booms greater than 1.0 psf would be very unlikely to impact SNPL populations and the lack of any coupled visual stimuli, sonic booms created during missions with easterly trajectories are discountable thus not expected to have an adverse effect on SNPL.

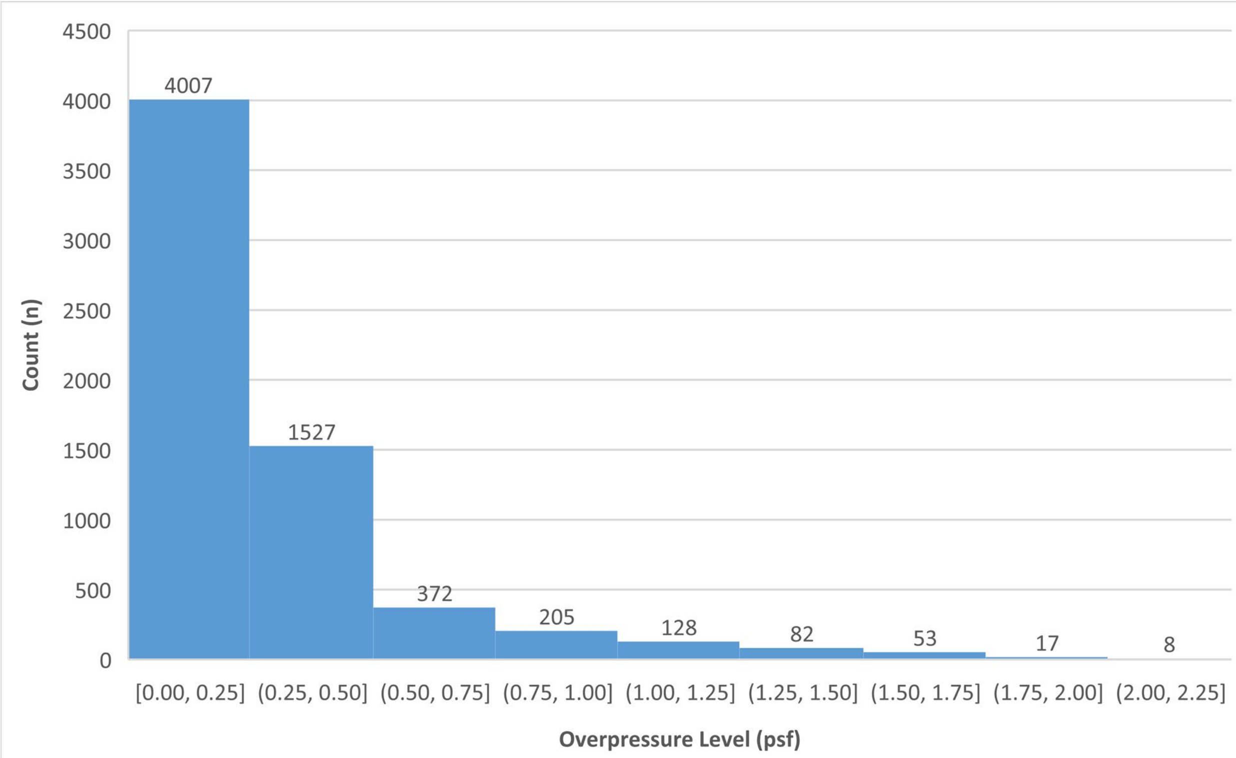

Figure 5.1-17. Distribution of PCBoom sonic boom modeling results within 10 km of SNPL localities shown in Figure Figure 4.11-4.

Visual Disturbance (Light Emissions)

Little research on the effect of light emissions to SNPL is available. The National Aeronutics and Space Administration's Visible Infrared Imaging Radiometer Suite (VIIRS) provides some insight into nighttime lighting levels. Simons et al. (2021) evaluated the effects of artificial light at night on SNPL in southern California. Although Simons et al. reported that the likelihood of plover roosting sites declined significantly at 50 millilux (mlx), and goes on to assert that "it has therefore been found that exposure to [artificial light at night] to be a significant stressor for these beach dependent species." The conclusion of causation is unsubstantiated. In the discussion, the authors themselves recognize that the study is limited because it is correlational; however, do not discuss the potential correlates of light pollution nor note that their conclusion is weakly supported. The correlates of light pollution include all of the additional stressors associated with urbanization, including, but not limited to, use of beaches at day and night by humans and pets and vehicles, beach grooming, invasive plant species that alter habitat quality, and urban predators (cats, dogs, racoons, rats, crows, etc.). These factors, especially when considered in combination, significantly degrade plover nesting habitat and should have been analyzed or at least acknowledged as potentially significant stressors that could very well explain presence of plover nesting.

Although the light levels modeled and analyzed in Simons et al. are presented in illumination units (mlx) and not directly comparable to the artificial light measurements in the VIIRS dataset (presented in radiance units), one can indirectly compare the two by cross walking sites from Simons et al. to the VIIRS dataset An evaluation of three sites from Simons et al. that appeared to be the lowest illuminance values in Southern California where plovers currently nest (Sites A near Port Hueneme, B near Point Dume, and C at San Onofre). These same sites were searched on lightpollutionmap.info to obtain their radiance values. Although Simons' gradient legend is difficult to discern, the sites that were clearly "very purple" as presented from Simons et al. These sites appear to be less than 50 mlx. These sites were compared to the VIIRS radiance measurements for South Surf Beach. Sites A, B, and C are generally much higher in radiance than for South Surf. From that, one can infer that the illuminance values for South Surf are also lower than these sites and thus South Surf is darker than these other sites.

Table 5-1. Comparison of illuminance and radiance artificial light levels between Southern California sites presented in Simons et al. 2021 and South Surf Beach.

Site	Illuminance Estimated Range* Threshold = 50 mlx	Radiance Range^
A (Port Hueneme)	1 to 50	12 to 22.5
B (Point Dume)	1 to 50	1.6 to 6.5
C (San Onofre)	1 to 50	2.5 to 10.4
South Surf	N/A	0.5 to 3.4

Notes: * Estimated from Simons et al 2021; ^ VIIRS DNB (NASA BRDF) data retrieved from https://lighttrends.lightpollutionmap. info.

A review of the VIIRS dataset doe not support a statistically significant increase in radiance levels at south Surf Beach. Figure 5.1-18 shows SLC-4 launch frequency plotted on top of VIIRS data for the same time period from 2012 to 2024. The plot shows that recent VIIRS radiance levels are within the range of levels measured previously when there were no or very few launches, thus the radiance levels at South Surf are not unanticipated nor unprecedented. Additionally, there is no statistical correlation apparent between the number of launches each year and radiance levels which would suggest that launch cadence is not affecting radiance levels.

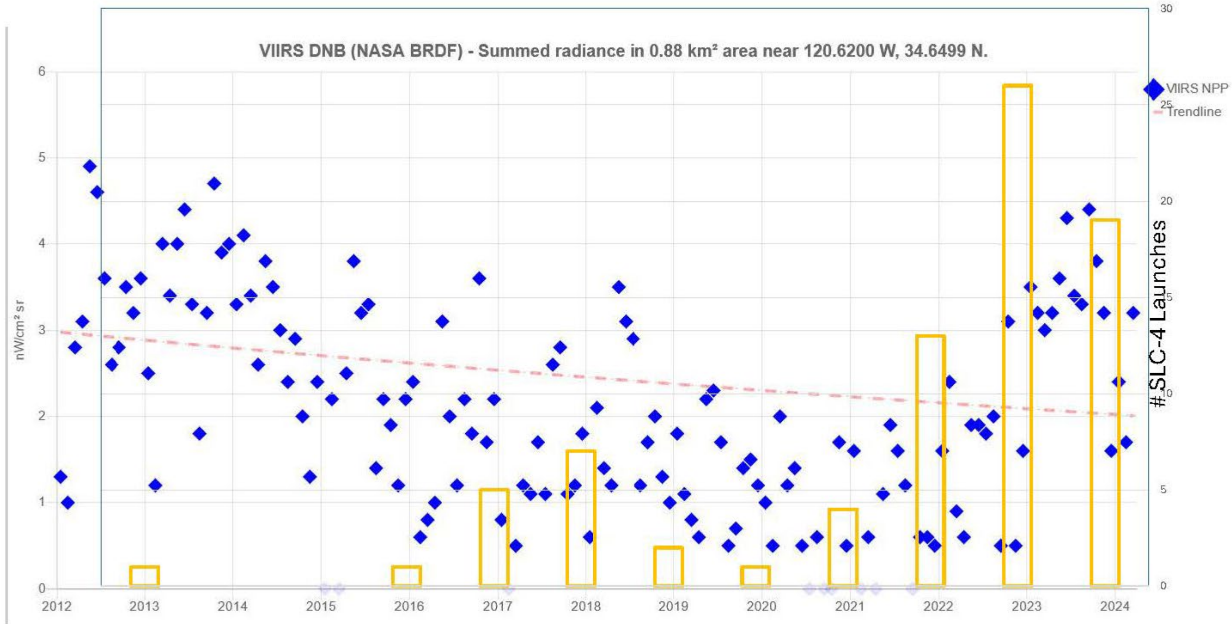

Figure 5.1-18. VIIRS data plotted with number of launches (2012-2024).

To look at this more closely, for the period from January 2023 through March 2024, the radiance levels are trending downward (see figure below). For this period, the number of launches each month, as well as the number of night time launches each month, with the monthly VIIRS radiance levels, were examined and summarized in the table below.

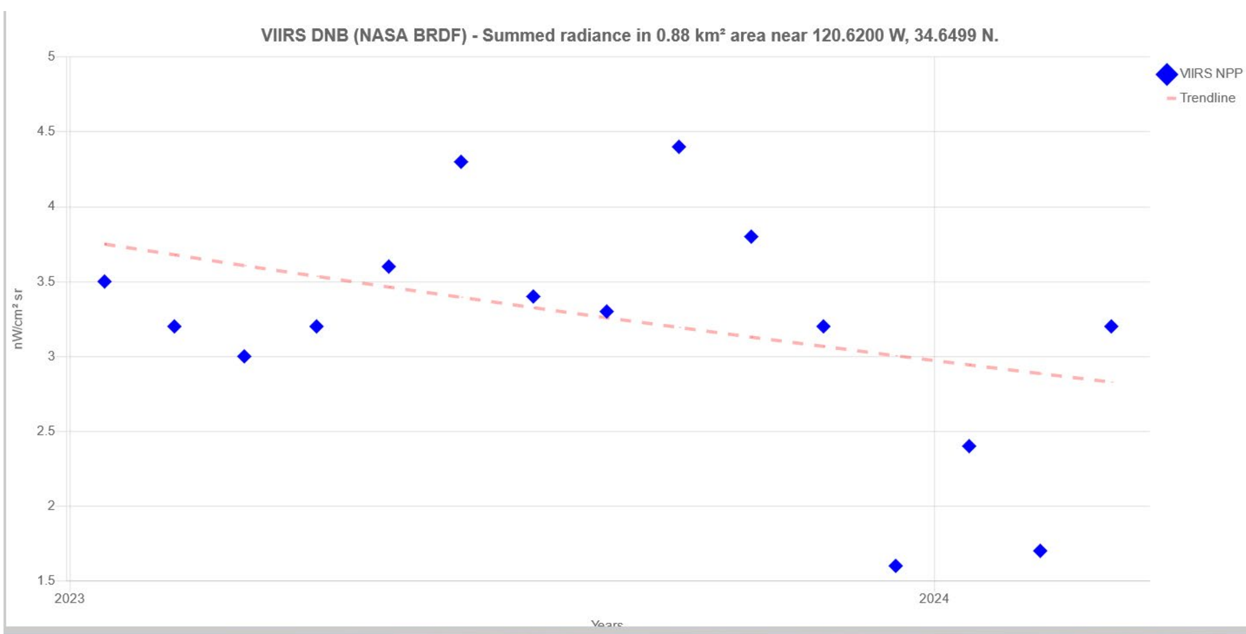

Figure 5.1-19. VIIRS data plotted with number of launches (2012-2024).

Table 5-2. SLC-4 Launches (2023-March 2024)

Month	Total Launches/month	Night Launches/month	Radiance Level
Jan-23	2	1	3.5
Feb-23	1	0	3.2
Mar-23	2	0	3.0
Apr-23	3	1	3.2
May-23	3	1	3.6
Jun-23	2	1	4.3
Jul-23	2	1	3.4
Aug-23	2	2	3.3
Sep-23	3	2	4.4
Oct-23	3	3	3.8
Nov-23	2	2	3.2
Dec-23	3	2	1.6
Jan-24	4	4	2.4
Feb-24	3	1	1.7
Mar-24	3	2	3.2

The number of launches each month was weakly and negatively correlated to the monthly radiance levels ($r = -0.29$) for this two-year dataset of launches. Furthermore, the number of nighttime launches each month was even weaker and also negatively correlated ($r = -0.10$). The weak and negative correlations strongly suggest that there is no relationship between launch cadence and the measured VIIRS radiance values at South Surf. The VIIRS radiance values measured at South Surf are low compared to any other sandy beach habitat in southern California and lower than beaches that currently support nesting plovers throughout this area. This is in fact a relatively dark beach with little light pollution, thus no significant adverse effects are expected due to light pollution. Additionally, as discussed in Section 2.3, a Light Management Plan would be prepared to reduce potential light impacts at SLC-4 and SLC-6.

Conclusion

VSFB has determined that the Proposed Action may affect, and is likely to adversely affect, the SNPL on VSFB. Individuals nesting, roosting, and foraging in the action area on VSFB are likely to be distressed by visual disturbance, noise, and overpressures from launch and landing activities. These disturbances may startle SNPL or disrupt foraging or breeding activities. If launch and landing occur during the breeding season (approximately March through September), brooding birds may startle and flush which could potentially damage eggs and leave eggs or chicks unattended. Unattended eggs and chicks may become vulnerable to exposure or predation.

Frequent exposure to sound and overpressure may cause effects that are not immediately evident and may cause reduced numbers of nesting adults or reduced productivity in the action area over time.

VSFB would perform geospatial analysis to monitor the impacts of noise from the Proposed Action and other launch programs on Base to assess any potential adverse impacts on the species at VSFB as the launch frequency reaches full tempo (Section 2.3.7). If adverse effects are found, VSFB would mitigate those effects by increasing predator management efforts on VSFB (Section 2.3.7) to comply with the DAF's sections 7(a)(1) and 7(a)(2) obligations under the ESA. Mitigation activities would align with the SNPL Recovery Plan (USFWS 2007) and 5-year review (USFWS 2019) with the goal of achieving no net loss to the species.

5.1.12 California Least Tern

Physical Impacts

No ground disturbing activities would occur within or near LETE habitat; therefore, the Proposed Action would have no direct physical impacts on LETE or LETE habitat.

Noise and Visual Disturbance

Noise Impacts in the VSFB Area

If missions are performed when LETE are present (approximately 15 April through 15 August), LETE at the Purisima colony would receive launch engine noise of approximately 108 dB L_{max} during up to 50 Falcon 9 launches per year from SLC-4 (Figure 4.12-1). During up to 12 first stage landings at SLC-4W per year, the Purisima colony would receive landing engine noise of approximately 115 dB L_{max}. During static fire at SLC-4, which typically occur 1 to 3 days prior to launch, noise levels at the Purisima colony would be approximately 102 dB L_{max}. During SLC-4 first stage landing events, overpressures are expected to be between 1 and 3 psf from a sonic boom (Figure 4.12-2). However, these overpressure levels could be higher or lower based on atmospheric conditions at the time of landing.

Based on the existing monitoring observations, the audible and visual components of the Proposed Action (i.e., launch, landing, sonic boom, and vehicle lift off) could cause LETE to respond behaviorally. This stimulus could trigger a startle response that alerts predators to nest locations and causes temporary (minutes) abandonment of nests. The proposed environmental protection measures (Section 2.3.8) would be employed to characterize impacts on LETE as a result of launch-related noise events.

At VSFB, LETE monitoring has been conducted for five Delta II launches from SLC-2 on north VSFB. SLC-2 is 0.4 mi from the Purisima Point nesting colony. LETE responses to launch noise have varied. Pre- and post-launch monitoring of non-breeding LETE for the 7 June 2007 Delta II COSMO-1 launch and monitoring of nesting LETE during the 20 June 2008 Delta II OSTM and 10 June 2011 Delta II AQUARIUS launches did not document any mortality of adults, young, or eggs, or any abnormal behavior resulting from launches (MSRS 2007a, 2008b, 2011). However, Delta II launches from SLC-2 in 2002 and 2005, when terns were arriving at the colony, may have caused temporary or permanent emigration from the colony because there was decreased attendance following the launches (Robinette et al. 2003; Robinette & Rogan 2005). These data imply that LETE response to noise relates to timing with the nesting cycle. For instance, at the beginning of the nesting season when LETE are arriving at the breeding colony, the adults seem to be more disturbed, but once courtship and nest-tending begins, the adults are more resilient.

On 12 June 2019, LETE response was documented during a SpaceX Falcon 9 launch with first stage landing at SLC-4 on VSFB. The landing produced a 2.7 psf sonic boom, as measured at the Purisima LETE colony. LETE response to the launch and boost-back landing was documented via pre- and post-launch monitoring and video recording during the launch event. LETE response during the launch was difficult to determine since birds flushed before sonic boom impact. All LETE returned to their nests minutes after the launch event. One LETE egg was found to be damaged. The damaged LETE egg was from a one egg clutch and was inspected when it was a week past hatch date. The cause and timing of the damage to the egg was inconclusive (Robinette & Rice 2019).

Monitoring of the LETE colony was also performed for the 12 June 2022 SpaceX Falcon 9 launch with first stage landing at SLC-4W. A 1.1 psf sonic boom was recorded at the colony. There were no differences in overall bird abundance or nest attendance before and after the launch and landing. Video monitoring showed the reaction of incubating LETE ranged from alert and minor looking around to a startle effect (i.e., calm before the boom, with a jolt and quick head movements looking around when the boom hit; Robinette & Rice 2022b).

In 2023, monitoring over the entire season showed no significant difference in incubation rates before and after launches (Robinette, et al., in prep.). Video footage of incubating LETE during Falcon 9 launches in 2023 (n=7) showed that 100% of LETE reacted, 43% flushed off nests, and all flushed birds returned to nest within 45 seconds (Robinette, et al., in prep.). Video footage of incubating LETE for Falcon 9 launches with SLC-4 landings (n=5) showed that 100% reacted, 100% startled, 40% hunkered, 40% flushed, and all returned to nest within 45 seconds.

In contrast to infrequent, acute noise which tends to cause a startle responses (Francis & Barber 2013), the scientific literature shows that the effects of frequent noise disturbance on bird species vary greatly. Reviewed in Francis and Barber (2013), response to noise disturbances in wildlife depends on how frequent and predictable the noise is, acuteness, overlap with biologically relevant sounds, and overlap with animals hearing sensitivity range. Chronic (i.e., sustained) noise can impact a variety of behaviors important to reproduction and fitness (Francis & Barber 2013). In birds, sustained, chronic noise, such as that produced by traffic, wind turbines, and gas/oil fields, has been shown to correlate to a variety of negative effects, including changes in levels of stress hormones and stress physiology (Kleist et al. 2018; Zollinger et al 2019), acoustic cue masking (Francis et al. 2011a; Francis & Barber 2013), changes in breeding behavior (Goudie & Jones 2004; Swaddle & Page 2007; Alquezar et al. 2020), changes in territorial behavior and aggression (Goudie & Jones 2004; Mockford & Marshall 2009; Wolfenden et al. 2019; Passos et al. 2020), impacts on reproduction and nest success (Halfwerk et al. 2011; Kleist et al. 2018; Zollinger et al. 2019), and declines in bird abundance (Francis et al. 2011b; McClure et al. 2013; Mejia et al. 2019; Rosa & Koper 2022), all of which have implications for survival and fitness (Francis & Barber 2013).

In many species, however, research has shown a lack of effect of chronic noise and evidence of habituation. It should, therefore, not be assumed that chronic noise exposure in birds is necessarily associated with the negative impacts listed above or that closely related species, or even individuals, will respond similarly. Yorzinski and Hermann (2016) found that peafowl (*Pavo cristatus*) exposed to continuous white noise showed no preference for roosting near or away from the noise source. Walthers and Barber (2020) found that traffic noise was not associated with stress indicators in nestling European starlings (*Sturnus vulgaris*). Similarly, stress physiology and immune function in nestling tree swallows (*Tachycineta bicolor*) was not altered when exposed to continuous white noise. Although Meillere et al. (2015) found differences in predator vigilance in house sparrows (*Passer domesticus*) exposed to traffic noise, they found no effect of the chronic exposure on reproductive performance. In response to loud, frequent, but non-sustained aircraft noise, a study of domestic turkeys (*Meleagris gallopavo domesticus*) showed they quickly acclimated to the noise (Bradley et al. 1990). Conomy et al. (1998) found that black duck (*Anas rubripes*) reactions to jet noise declined with exposure, but wood duck (*Aix sponsa*) reactions did not change. Aircraft noise was also shown not to have a significant effect on physiological stress in nestling tree sparrows (*Passer montanus*; Redondo et al. 2021).

The effect of increasing noise disturbances on LETE will be uncertain based on the scientific literature. However, none of these studies in the scientific literature are directly comparable to the noise impacts of the Proposed Action. Launch engine noise and sonic booms are acute, non-sustained, and unpredictable. It is more similar to aircraft noise disturbances studied in the literature, yet would be relatively much less frequent. Beyond the launch monitoring efforts performed by the DAF, discussed above, there are almost no studies on the effects of rocket launch on birds.

Noise Impacts in Eastern Santa Barbara, Ventura, and Los Angeles Counties

An estimated 100% of missions with easterly trajectories are predicted to impact a LETE population in eastern Santa Barbara, Ventura, and Los Angeles Counties. To estimate the potential levels of these sonic booms, a frequency distribution of potential sonic boom levels was constructed by overlaying a 10-km buffer of LETE localities onto the PCBoom model output described in Section 2.2.4 and as depicted in Figure 4.12-3. Of the sonic booms predicted to impact within 10 km of a LETE locality, 96% of the boom levels were predicted to be less than 1.0 psf, and 99.9% were predicted to be less than 2.0 psf (Figure 5.1-20). Given that sonic booms greater than 1.0 psf would be very unlikely to impact LETE populations and the lack of any coupled visual stimuli, sonic booms created during missions with easterly trajectories are discountable thus not expected to have an adverse effect on LETE.

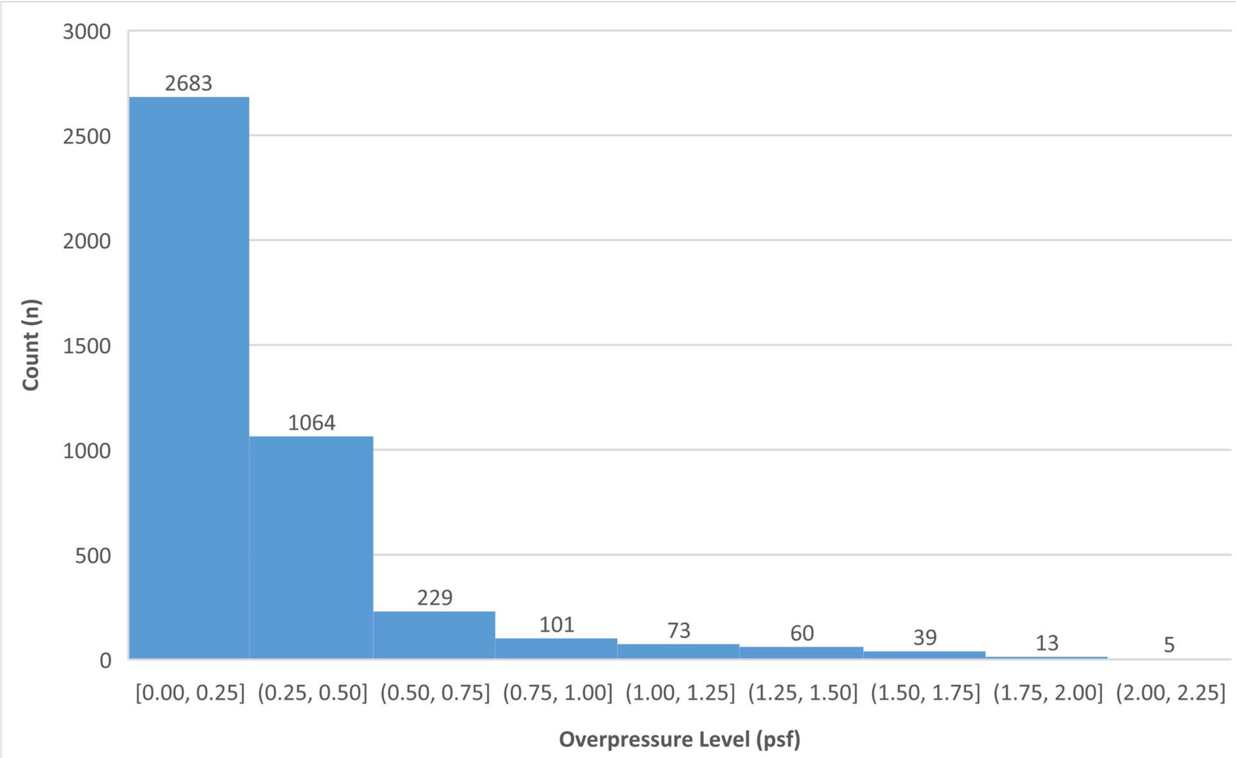

Figure 5.1-20. Distribution of PCBoom sonic boom modeling results within 10 km of LETE localities shown in Figure 4.12-3.

Conclusion

VSFB has determined that the Proposed Action may affect, and is likely to adversely affect, the LETE on VSFB. Individuals nesting, roosting, and foraging in the action area are likely to be distressed by visual disturbance, noise, and overpressures from launch and landing activities. These disturbances may startle LETE or disrupt foraging or breeding activities. If launch and landing occur during the breeding season (approximately April through August), brooding birds may startle and flush which could potentially damage eggs and leave eggs or chicks unattended. Unattended eggs and chicks may become vulnerable to exposure or predation. Frequent exposure to sound and overpressure may cause effects that are not immediately evident and may cause reduced numbers of nesting adults or reduced productivity in the action area over time.

VSFB would monitor the impacts of noise from the Proposed Action to assess any potential adverse impacts on the species at VSFB as the launch frequency increases and reaches full tempo (Section 2.3.8). If adverse effects are found, VSFB would mitigate those effects by increasing predator management efforts on VSFB (Section 2.3.8) to comply with the DAF's sections 7(a)(1) and 7(a)(2) obligations under the ESA. Mitigation activities would align with the LETE Recovery Plan (USFWS 1985b) and 5-year review (USFWS 2020) with the goal of achieving no net loss to the species.

5.1.13 California Condor

Physical Impacts

No ground disturbing activities would occur within or near California condor habitat; therefore, the Proposed Action would have no direct physical impacts on California condor or condor habitat.

Noise and Visual Disturbance

Noise Impacts in the VSFB Area

It has been difficult to analyze the effect human disturbance could have on California condors. Generally, California condors are less tolerant of human disturbances near nesting sites than at roosting sites. The species is described as being “keenly aware of intruders” and may be alarmed by loud noises from distances greater than 1.6 mi. In addition, the greater the disturbance in either noise level or frequency, the less likely the condor would be to nest nearby. As such, USFWS typically requires isolating roosting and nesting sites from human intrusion (USFWS 1996). Noise from a launch coupled with visual disturbance could cause a startle response and disrupt behavior if a condor is within the Action Area.

Although launch noise, sonic booms, and visual disturbance may cause a startle response and disrupt behavior, the likelihood of a condor being present during these activities is extremely low and, therefore, the effect of the Proposed Action would be discountable.

Noise Impacts in Eastern Santa Barbara, Ventura, and Los Angeles Counties

An estimated 30% of missions with easterly trajectories are predicted to impact a California condor population in eastern Santa Barbara, Ventura, and Los Angeles Counties. To estimate the potential levels of these sonic booms, a frequency distribution of potential sonic boom levels was constructed by overlaying a 10-km buffer of California condor localities onto the PCBoom model output described in Section 2.2.4 and as depicted in Figure 4.13-1. Of the sonic booms predicted to impact within 10 km of a California condor locality, 98% of the boom levels were predicted to be less than 1.0 psf, and 99.7% were predicted to be less than 2.0 psf (Figure 5.1-21). Given that sonic booms greater than 1.0 psf would be very unlikely to impact California condor populations and the lack of any coupled visual stimuli, sonic booms created during missions with easterly trajectories are discountable thus not expected to have an adverse effect on California condors.

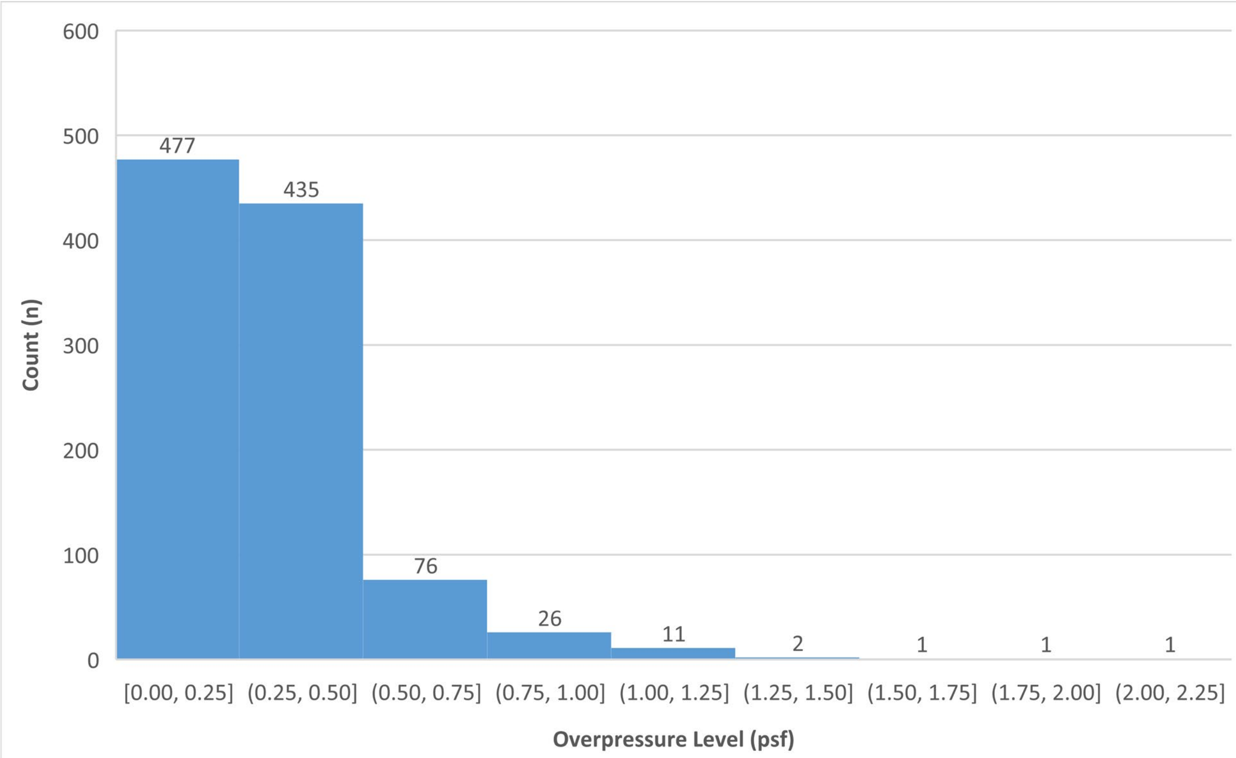

Figure 5.1-21. Distribution of PCBoom sonic boom modeling results within 10 km of California condor localities shown in Figure 4.13-1.

Conclusion

The overall likelihood of a California condor occurring at VSFB during a launch, landing, or static fire event is extremely unlikely, hence, discountable. Additionally, the likelihood that missions with an easterly trajectory generate a sonic boom greater than 1.0 psf that would impact California condor localities is very low. Therefore, VSFB has determined that Proposed Action may affect, but is not likely to adversely affect, the California condor. The DAF will coordinate with the USFWS and Ventana Wildlife Society to monitor for condor presence at VSFB prior to launches.

5.1.14 Coastal California Gnatcatcher

Physical Impacts

No ground disturbing activities would occur within or near CAGN habitat; therefore, the Proposed Action would have no direct physical impacts on CAGN or CAGN habitat.

Noise Impacts

Noise Impacts in the VSFB Area

There would be no noise impacts to CAGN in the VSFB area.

Noise Impacts in Eastern Santa Barbara, Ventura, and Los Angeles Counties

An estimated 94% of missions with easterly trajectories are predicted to impact a CAGN population in eastern Santa Barbara, Ventura, and Los Angeles Counties. To estimate the potential levels of these sonic booms, a frequency distribution of potential sonic boom levels was constructed by overlaying a 10-km buffer of CAGN localities onto the PCBoom model output described in Section 2.2.4 and as depicted in Figure 4.14-1. Of the sonic booms predicted to impact within 10 km of a CAGN locality, 99% of the boom levels were predicted to be less than 1.0 psf, and 99.9% were predicted to be less than 2.0 psf (Figure 4.14-1). Given that sonic booms greater than 1.0 psf would be very unlikely to impact CAGN populations and the lack of any coupled visual stimuli, sonic booms created during missions with easterly trajectories are discountable thus not expected to have an adverse effect on CAGN.

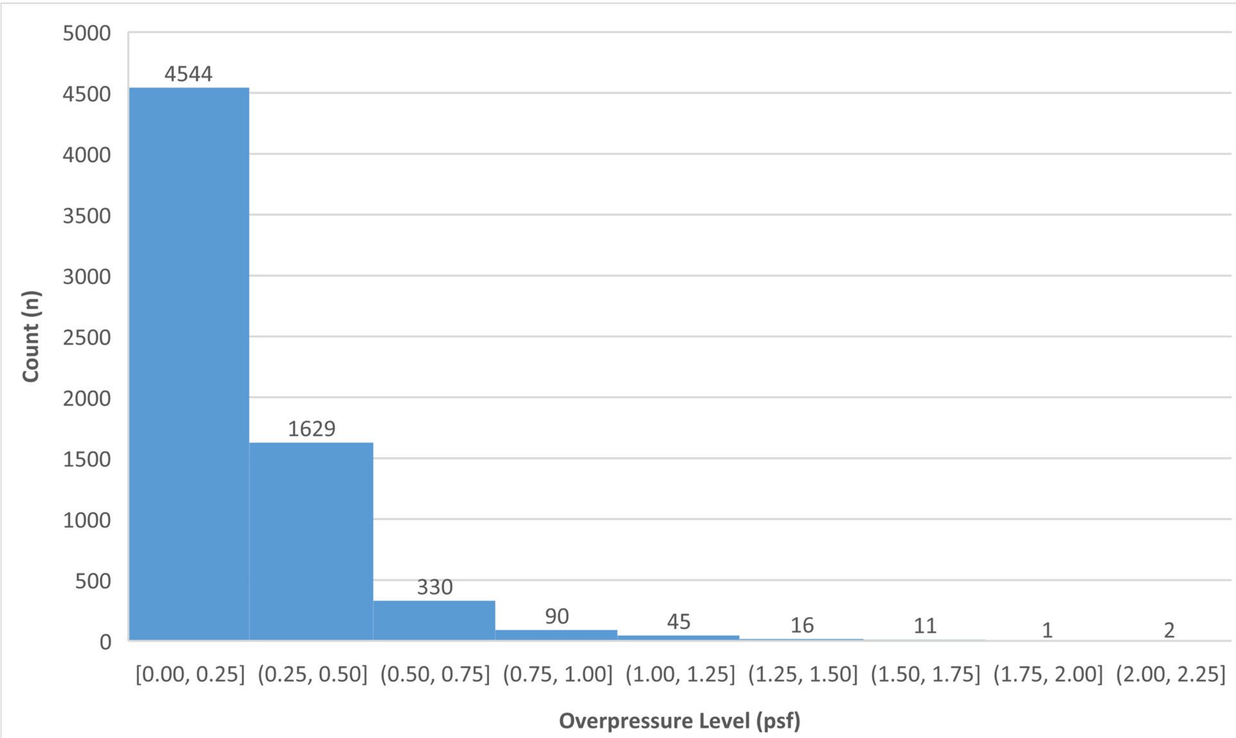

Figure 5.1-22. Distribution of PCBoom sonic boom modeling results within 10 km of CAGN localities shown in Figure 4.14-1.

Conclusion

The likelihood that missions with an easterly trajectory generate a sonic boom greater than 1.0 psf that would impact CAGN localities is very low. Therefore, VSFB has determined that Proposed Action may affect, but is not likely to adversely affect, the CAGN.

5.1.15 Light-footed Ridgeway's Rail

Physical Impacts

No ground disturbing activities would occur within or near RIRA habitat; therefore, the Proposed Action would have no direct physical impacts on RIRA or RIRA habitat.

Noise Impacts

Noise Impacts in the VSFB Area

There would be no noise impacts to RIRA in the VSFB area.

Noise Impacts in Eastern Santa Barbara, Ventura, and Los Angeles Counties

An estimated 98% of missions with easterly trajectories are predicted to impact a RIRA population in eastern Santa Barbara, Ventura, and Los Angeles Counties. To estimate the potential levels of these sonic booms, a frequency distribution of potential sonic boom levels was constructed by overlaying a 10-km buffer of RIRA localities onto the PCBoom model output described in Section 2.2.4 and as depicted in Figure 4.15-1. Of the sonic booms predicted to impact within 10 km of a RIRA locality, 97% of the boom levels were predicted to be less than 1.0 psf, and 99.9% were predicted to be less than 2.0 psf (Figure 5.1-23). Given that sonic booms greater than 1.0 psf would be very unlikely to impact RIRA populations and the lack of any coupled visual stimuli, sonic booms created during missions with easterly trajectories are discountable thus not expected to have an adverse effect on RIRA.

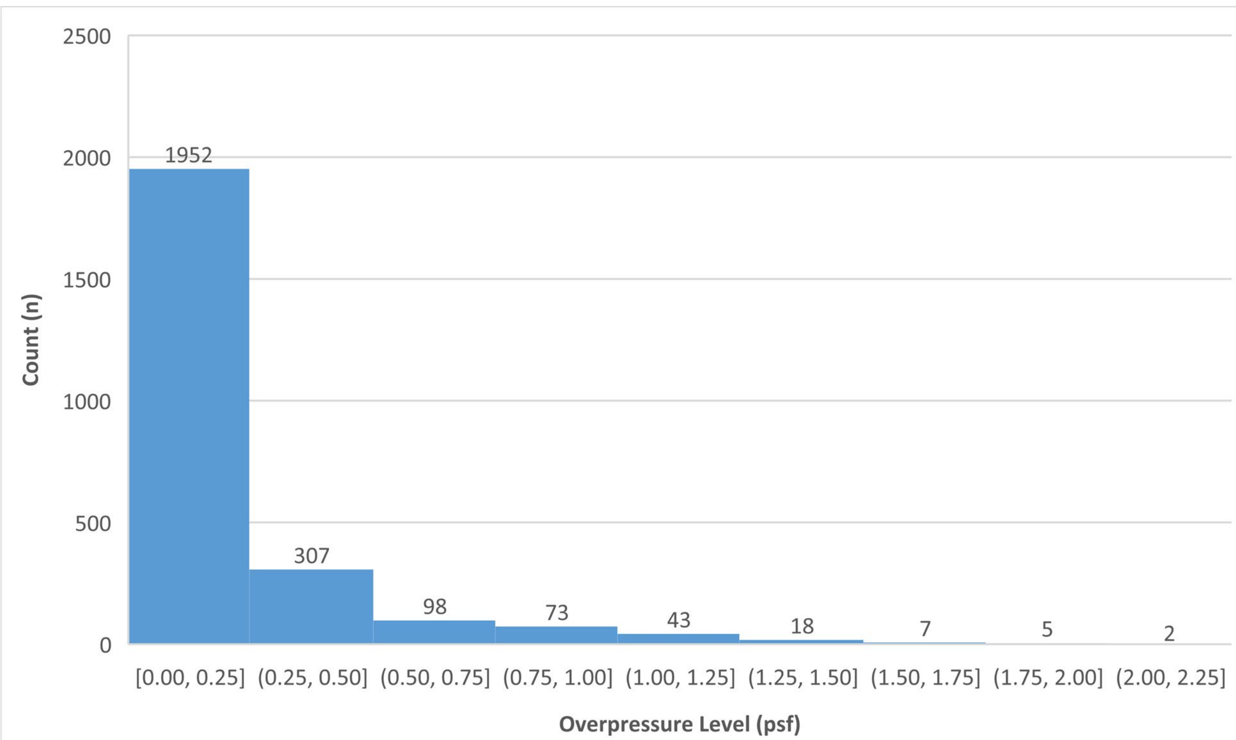

Figure 5.1-23. Distribution of PCBoom sonic boom modeling results within 10 km of RIRA localities shown in Figure 4.15-1.

Conclusion

The likelihood that missions with an easterly trajectory generate a sonic boom greater than 1.0 psf that would impact RIRA localities is very low. Therefore, VSFB has determined that Proposed Action may affect, but is not likely to adversely affect, the RIRA.

5.1.16 Southern Sea Otter

Physical Impacts

No ground disturbing activities would occur within or near southern sea otter habitat; therefore, the Proposed Action would have no direct physical impacts on southern sea otter or southern sea otter habitat.

Noise and Visual Disturbance

Areas directly offshore of SLC-4 would receive visual disturbance and noise levels of less than 130 dB L_{max} during up to 50 Falcon 9 launches from SLC-4 per year and approximately 110 dB L_{max} during up to 12 first stage landing at SLC-4W (Figure 4.16-1). During static fire events, noise directly off the coast of SLC-4 would be less than 125 dB L_{max} and there would be no associated visual disturbance. Landing at SLC-4W would also generate a sonic boom directly offshore that expected to range from 1 to 5 psf (Figure 4.16-2). Otters are only occasionally observed along the coast between Purisima Point and Point Arguello transiting through the area between suitable habitat to the north and south. Beginning at the Boat Dock and continuing south along Sudden Flats, the inshore habitat supports expansive kelp beds and a relatively high density of otters. Noise levels would reach between 100 and 110 dB L_{max} during up to 50 Falcon 9 launches from SLC-4 per year and less than 80 dB L_{max} during up to 12 first stage landing each year at SLC-4W in these areas. Sonic booms during up to 12 SLC-4W landings per year are expected to range from 1 to 3 psf along Sudden Flats.

Exceptionally little sound is transmitted between the air-water interface; thus, in-air sound, whether from launch, landing, or sonic boom, would not have a significant effect on submerged animals (Godin 2008). In addition, according to Ghoul & Reichmuth (2014), "Under water, hearing sensitivity [of sea otters] was significantly reduced when compared to sea lions and other pinniped species, demonstrating that sea otter hearing is primarily adapted to receive airborne sounds." This study suggested that sea otters are less efficient than other marine carnivores at extracting noise from ambient noise (Ghoul & Reichmuth 2014). Therefore, the potential impact of underwater noise caused by in-air sound would be discountable.

Extensive launch monitoring has been conducted for sea otters on both north and south VSFB, with pre- and post-launch counts and observations conducted at rafting sites immediately south of Purisima Point for numerous Delta II launches from SLC-2 and one Taurus launch from Launch Facility-576E and at the rafting sites off of Sudden Flats for two Delta IV launches from SLC-6. No abnormal behavior, mortality, or injury of effects on the population has ever been documented for sea otter as a result of launch-related noise and visual disturbance (SRS Technologies, Inc. 2006b, 2006d, 2006e, 2006f, 2006g, 2006i, 2006k, 2006l; MSRS 2007a, 2007b, 2007c, 2008a, 2008b, 2009d; 2021c). More recently, for the SpaceX Falcon 9 SAOCOM launch and landing on 7 October 2018, sea otters were monitored during pre- and post-launch surveys on south VSFB (MSRS 2018d). The sonic boom received at the otter monitoring location was estimated at 0.71 psf and the maximum landing engine noise at this location was estimated at 99.5 dB L_{max}. Count totals of both pups and adults were similar before and after the launch and there was no discernable impact on otters on south VSFB. Additionally, otters were monitored during four

Falcon 9 launches from SLC-4 during March 2023 and there were no discernible impacts on overall southern sea otter numbers at the monitoring site (MSRS, in. prep.).

The lack of any demonstrated impact from launches on populations off the coast of Sudden Ranch is likely because there is little overlap in the hearing sensitivity of otters (primarily 2 to 22 kHz) and launch engine noise, which is primarily below 250 Hz, with moderate energy to 2 kHz range, and little energy above 2 kHz, as discussed below. While a 2-psf sonic boom is approximately 135 dB (unweighted), it is likely that most of that acoustic energy from the sonic boom is not heard by sea otters anyway. Similarly, the frequency spectrum of a 1.5-psf sonic boom (recorded at San Nicolas Island on 12 December 2014) has little overlap with the hearing curve of a sea otter (Ghoul & Reichmuth 2014; Figure 5.1-22). Most of the sonic boom energy is less than 250 Hz, well below the region of best sensitivity of the sea otter (2–22.6 kHz; Figure 5.1-24). While the sea otter would likely hear the sonic boom, it would only be responding to acoustic energy that is above 250 Hz and total sound levels much less than 135 dB. As the sonic boom increases in pressure, it is likely that more energy would be detected by the sea otter, most notably in frequencies higher than 250 Hz; however, sonic booms produced by first stage booster landings at SLC-4W have typically been less than 2 psf in otter habitat.

Additionally, if disturbed, otters typically dive under the water and therefore minimize potential noise exposure. As noted in Section 2.2.4, landing noise follows launch by approximately 5 to 7 minutes and typically occurs slightly before the sonic boom impacts land. Therefore, any individuals that flee into water as a result of launch disturbance would reduce their likelihood of being exposed to the landing engine noise and sonic boom due to the attenuation of sound in water (Godin 2008). As a result, there would not be an opportunity for chronic noise exposure in otters.

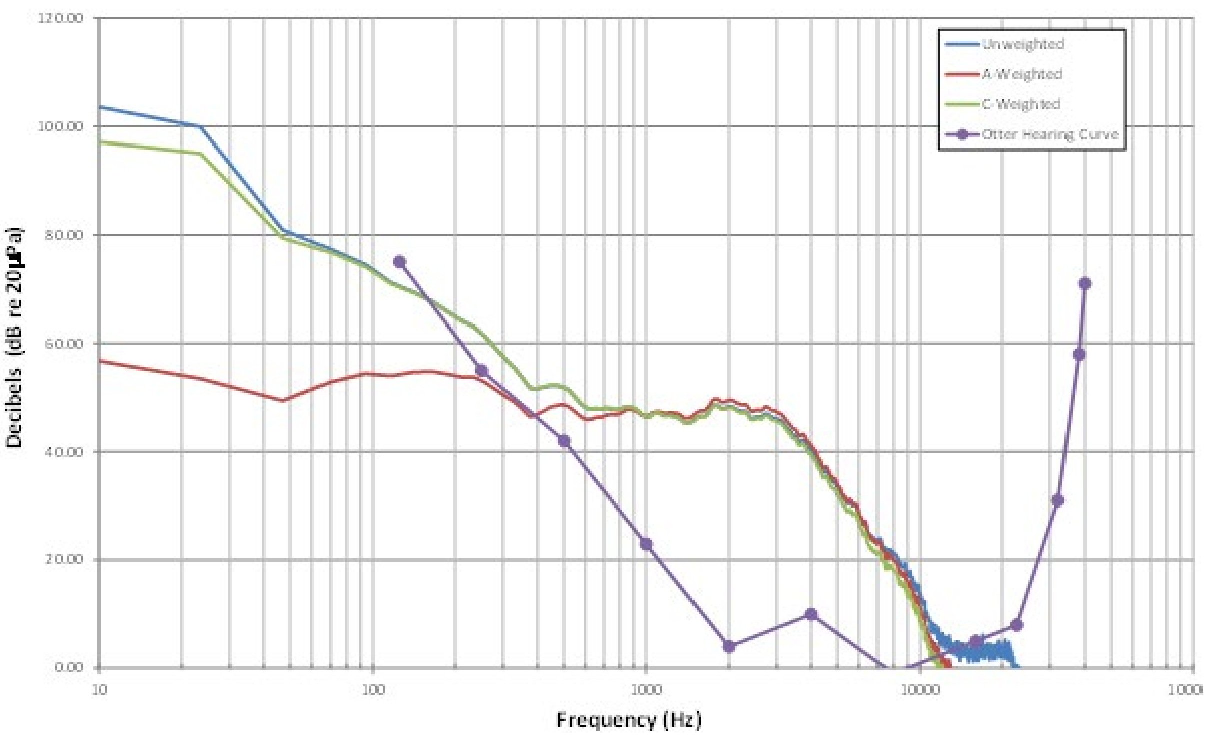

Figure 5.1-24. Sonic boom spectrum and sea otter hearing sensitivity curve.

To determine how much rocket engine noise otters would be able to sense, a frequency-weighting filter was developed for sea otters. Ghoul & Reichmuth (2014) developed an audiogram for the northern sea otter (*Enhydra lutris kenyoni*; Figure 5.1-25). Following methods established in Southall et al. (2019), this audiogram was used to derive an auditory weighting function to serve as a frequency-specific filter to quantify how noise may be perceived by otters, given its spectral content (Figure 5.1-26), and how that would relate to the spectral characteristics of an otter's potential susceptibility to noise. Weighting functions are used to de-emphasize noise at frequencies where susceptibility is lower and emphasize noise at frequencies where sensitivity is greater.

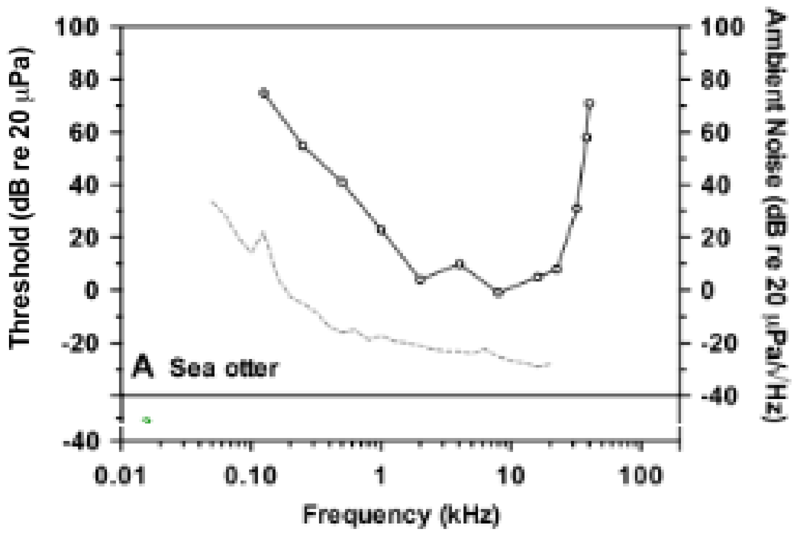

Figure 5.1-25. Northern sea otter audiogram (solid dotted line; source: Ghoul & Reichmuth 2014).

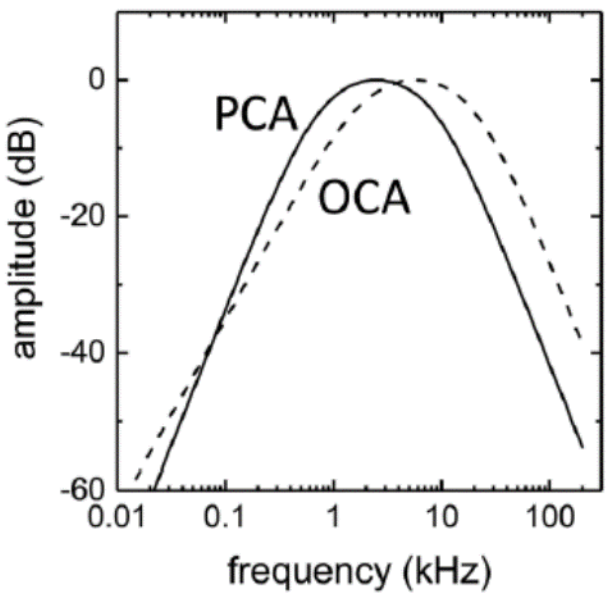

Figure 5.1-26. Sea otter derived auditory weighting function (dotted line; OCA = other carnivores in-air and is appropriate for otters; PCA = phocids in-air; Source: Southall et al. 2019).

To determine the resultant level of in-air noise that is potentially perceived by a sea otter during launch, the otter weighting function was applied to the timewave form recording of the June 2022 Falcon 9 SARah-1 launch. The unfiltered time waveform had a frequency spectra with an unweighted peak level of approximately 110 dB L_{max} (Figure 5.1-27). After applying the otter weighting function, the peak level was approximately 70 dB L_{max} (Figure 5.1-27), which by comparison to human hearing sensitivity is equivalent to the sound level of a household washing machine. Therefore, the perceived noise during rocket launches under the Proposed Action would be significantly less than the unweighted modeling results of between 100 and 110 dB L_{max} at Sudden Ranch would suggest.

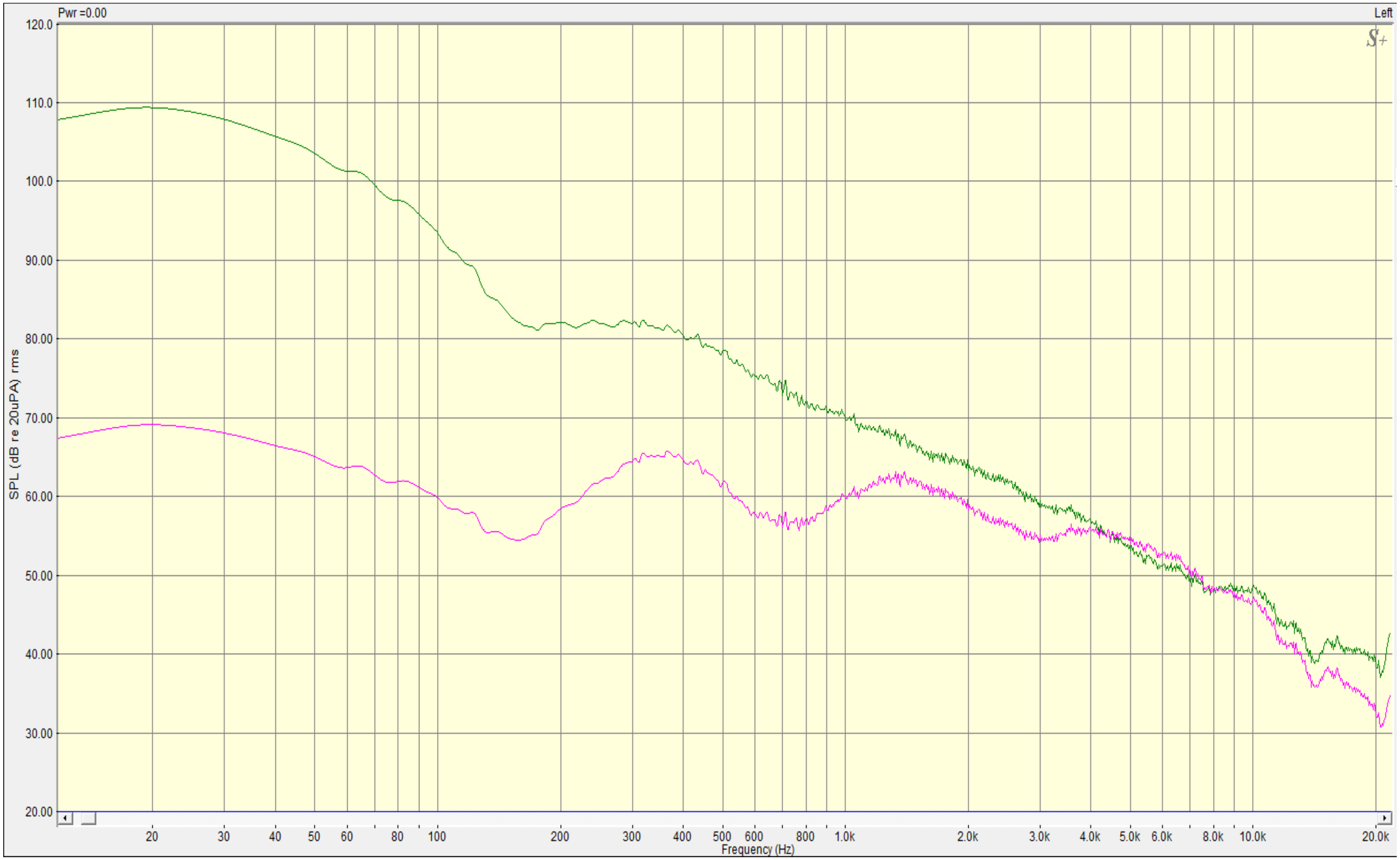

Figure 5.1-27. Launch peak noise level comparison of unweighted (green) versus otter-weighted (purple) decibels (note: time waveform recording from the June 2022 Falcon 9 SARah-1 launch).

Finally, otters have also been shown to quickly acclimate to disturbances from boats, people, and harassment devices (air horns). Davis et al. (1988) conducted a study of northern sea otter's reactions to various underwater and in-air acoustic stimuli. The purpose of the study was to identify a means to move sea otters away from a location in the event of an oil spill. Anthropogenic sound sources used in this behavioral response study included truck air horns and an acoustic harassment device (10 to 20 kHz at 190 dB) designed to keep dolphins and pinnipeds from being caught in fishing nets. The authors found that the sea otters often remained undisturbed and quickly became tolerant of the various sounds. When a fleeing response occurred as a result of the harassing sound, sea otters generally moved only a short distance (328 to 656 ft [100 to 200 m]) before resuming normal activity (Davis et al. 1988).

Curland (1997), studying the southern sea otter, also found that they may acclimate to disturbance. The author compared otter behavior in areas with and without human-related disturbance (e.g., kayaks, boats, divers, planes, sonic booms, and military testing at Fort Ord) near Monterey, California. Otters spent more time traveling in areas with disturbance compared to those without disturbance; however, there was no significant differences in the amount of time spent resting, foraging, grooming, and interacting, suggesting that the otters were becoming acclimated to regular disturbances from a variety of sources (Curland 1997). Extensive launch monitoring of sea otters on VSFB has shown that disturbance from rockets is not a primary driver of sea otter behavior or use of the habitat along Sudden Flats and has not had any apparent long-term consequences on populations, potentially indicating that this population has acclimated to launch activities. Therefore, any impacts as a result of noise (launch, landing, and sonic boom) or visual disturbance are expected to be limited to minor behavioral disruption and insignificant.

Conclusion

Because there is very little overlap in the hearing sensitivity of otters and noise produced during rocket launches and landings, otters would perceive very little noise during launch activities and VSFB has determined that impacts on southern sea otter would be insignificant as a result of the Proposed Action, including the collective effects of increased launch activities at VSFB. Therefore, the Proposed Action may affect, but is not likely to adversely affect, the southern sea otter off the coast of VSFB.

5.2 Direct and Indirect Effects on Critical Habitat

5.2.1 Tidewater Goby

The potential sonic boom footprint from missions with easterly trajectories overlaps Critical Habitat Units SB-8, 9, 10, 11, and 12, VEN-1, 2, 3, and 4, and LA-1, 2, 3, and 4 (Figure 4.1-1). Sonic boom would not affect substrates, submerged and emergent aquatic vegetation, or the presence of sandbars at lagoons or estuaries. The Proposed Action would have no ground disturbing activities within any of these units and would thus not affect any of the PCEs listed in Section 4.1.4. Therefore, the Proposed Action would have no effect on Critical Habitat for this species.

5.2.2 Unarmored Threespine Stickleback

The USFWS has not designated Critical Habitat for the UTS. Therefore, the Proposed Action would have no effect on Critical Habitat for this species.

5.2.3 California Tiger Salamander

The Action Area includes the following designated Critical Habitat Units 1, 2, 3, 4, 5, and 6 for the Santa Barbara DPS of the CTS (Figure 4.3-1 and Figure 4.3-2). The Proposed Action would have no ground disturbing activities or impacts on water quality within Critical Habitat therefore no measurable impacts on vegetation, hydrology, habitat structure, or any other physical features of habitat. Maximum noise engine noise levels would range from approximately 100 dB L_{max} to approximately 108 dB L_{max} during launches and landings and potentially receive sonic booms of 1 to 1.5 psf during landings, which would not be expected to appreciably diminish habitat quality, including vegetation, prey base, or degradation of habitat structure. Therefore, the Proposed Action would have no effect on Critical Habitat for this species.

5.2.4 California Red-Legged Frog

The Action Area includes the following designated Critical Habitat units for the CRLF: STB-2, STB-4, STB-5, and STB-6 (Figure 4.4-1 and Figure 4.4-2). The potential sonic boom footprint from missions with easterly trajectories overlaps STB-7, VEN-1, VEN-2, VEN-3, and LOS-1 (Figure 4.4-6). The Proposed Action would have no ground disturbing activities or impacts on water quality within Critical Habitat therefore no measurable impacts on vegetation, hydrology, habitat structure, or any other physical features of habitat. Units STB-2, STB-4, STB-5 and STB-6 would receive engine noises levels ranging from 100 dB L_{max} to approximately 115 dB L_{max} during launches and landings and potentially receive sonic booms of 1 to 2.5 psf during landings. Units STB-7, VEN-1, VEN-2, VEN-3, and LOS-1 would receive sonic booms that would rarely exceed 1.0 psf. These noise impacts would not be expected to appreciably diminish habitat quality, including vegetation, prey base, or degradation of habitat structure. Therefore, the Proposed Action would have no effect on Critical Habitat for this species.

5.2.5 Western Spadefoot

The USFWS has not designated Critical Habitat for the western spadefoot. Therefore, the Proposed Action would have no effect on Critical Habitat for this species.

5.2.6 Southwestern Pond Turtle

The USFWS has not designated Critical Habitat for the SWPT. Therefore, the Proposed Action would have no effect on Critical Habitat for this species.

5.2.7 Marbled Murrelet

The Action Area does not overlap MAMU Critical Habitat. Therefore, the Proposed Action would have no effect on Critical Habitat for this species.

5.2.8 Southwestern Willow Flycatcher

The Action Area includes the designated Critical Habitat along the Santa Ynez River east of Lompoc (Figure 4.9-1 and Figure 4.9-2). Additionally, in the region potentially impacted by sonic booms during missions with easterly trajectories, Critical Habitat has been designated in the upper Santa Ynez River, the Ventura River, and the Santa Clara River drainage in Ventura and Los Angeles Counties (Figure 4.9-3). The Proposed Action would have no ground disturbing activities or impacts on water quality within Critical Habitat therefore no measurable impacts on vegetation, hydrology, habitat structure, or any other physical features of habitat. Critical Habitat along the Santa Ynez River would receive engine noises levels of approximately 100 dB L_{max} to 106 dB L_{max} during Falcon 9 launches from SLC-4, less than 100 dB L_{max} during SLC-4 first stage landings, and up to 100 dB L_{max} during SLC-4 static fire events. During SLC-4 first stage landing events, sonic boom level would be approximately 1 psf during landings. Sonic booms produced during missions with easterly trajectories would rarely be above 1.0 psf in Critical Habitat at the upper Santa Ynez River, the Ventura River, and the Santa Clara River drainage in Ventura and Los Angeles Counties. These noise impacts are not expected to appreciably diminish habitat quality, including vegetation, prey base, or degradation of habitat structure. Therefore, the Proposed Action would have no effect on Critical Habitat for this species.

5.2.9 Least Bell's Vireo

In the region potentially impacted by sonic booms during missions with easterly trajectories, Critical Habitat has been designated in the upper Santa Ynez River in eastern Santa Barbara County and the Santa Clara River drainage in Ventura and Los Angeles Counties (Figure 4.10-3). There are no activities under the Proposed Action that would impact essential physical and biological features or riparian woodland vegetation. Therefore, the Proposed Action would have no effect on Critical Habitat for this species.

5.2.10 Western Snowy Plover

The Action Area includes portions of Santa Rosa Island which are designated Critical Habitat for the SNPL (Figure 4.11-3). Although the frequency of booms impacting Santa Rosa Island has been low (approximately 15 percent of launches), these areas may potentially receive sonic booms of up to 5 psf. Additionally, in the region potentially impacted by sonic booms during missions with easterly trajectories, the Action Area includes various Critical Habitat unites along the coast of eastern Santa Barbara, Ventura, and Los Angeles Counties (Figure 4.11-4). The Proposed Action does not include any ground disturbance within Critical Habitat nor would it appreciably diminish the species' prey base or any other physical features of habitat. Therefore, the Proposed Action would have no effect on Critical Habitat for this species.

5.2.11 California Least Tern

The USFWS has not designated Critical Habitat for LETE. Therefore, the Proposed Action would have no effect on Critical Habitat for this species.

5.2.12 California Condor

The potential sonic boom footprint from missions with easterly trajectories overlaps the Sisquoc-San Rafael, Matilija, and Sespe-Piru Critical Habitat units (Figure 4.13-1). The Critical Habitat designation for California condor did not include a description of Physical and Biological Features; however, no ground disturbing activities under the Proposed Action would in designated Critical

Habitat for this species and sonic booms greater than 1.0 psf would be very rare. Therefore, the Proposed Action would have no effect on Critical Habitat for this species.

5.2.13 California Gnatcatcher

The potential sonic boom footprint from missions with easterly trajectories overlaps Unit 13 in western Los Angeles and Ventura Counties (Figure 4.14-1). There are no ground disturbing activities under the Proposed Action. Therefore, the Proposed Action would have no effect on Critical Habitat for this species.

5.2.14 Light-footed Clapper Rail

The USFWS has not designated Critical Habitat for RIRA. Therefore, the Proposed Action would have no effect on Critical Habitat for this species.

5.2.15 Southern Sea Otter

The USFWS has not designated Critical Habitat for the southern sea otter. Therefore, the Proposed Action would have no effect on Critical Habitat for this species.

5.3 Collective Effects

In addition to direct and indirect effects, the DAF analyzed the collective effects of launch-related noise impacts on ESA-listed species on VSFB per prior USFWS requests. For each species, the DAF considered the potential effect of overlapping noise impacts from multiple launch programs. Several new launch programs have recently been, or will soon be, initiated. Of these launch programs, those that will have noise impacts on Honda Creek, Bear Creek, and/or the Santa Ynez River of at least 100 dB L_{max} include Phantom Daytona-E (SLC-8) and Minotaur (SLC-8), which have completed the National Environmental Policy Act (NEPA) approval process, and Phantom Daytona-E/Laguna-E (SLC-5), ULA Vulcan (SLC-3), Blue Origin New Glenn (SLC-9), and the Proposed Action, which are projected to receive NEPA approval over the next several years; however, not to exceed the 110 total allowable basewide rocket launches, as set under the PBO and SLD 30 direction.

5.3.1 California Red-legged Frog

If all of these programs, including the Proposed Action, achieve full launch tempo (estimated in 2028 to 2030), not to exceed the 110 total allowable basewide rocket launches, as set under the PBO and SLD 30 direction, the total number of annual noise events (launch, static fire, landing) of at least 100 dB L_{max} would be 200 at Bear Creek, 225 at Honda Creek, 102 at Jalama Creek, and 170 at the Santa Ynez River (Note: Falcon 9 launch with landing at SLC-4W was treated a single noise event in these totals because launch and landing occur within minutes of each other). Although this type of disturbance is not directly comparable to those available from the scientific literature, it is reasonably likely that, in addition to being startled by these launch events, as launch tempo increases on VSFB, the frequency of disturbance could potentially result in chronic levels of stress hormone responses in CRLF, impacts on habitat occupancy, reduced breeding, and lower immunity in individuals. These in turn could reduce reproduction success, survival, and fitness, and cause individuals to leave the area, resulting in population level effects.

The monitoring program (see Section 2.3.2) that would be implemented to track CRLF habitat occupancy, breeding behaviors, and tadpole densities in Lower Honda Creek as the frequency of launch and static fire under the Proposed Action increases will also produce data that will enable the collective effects of launch-related noise from an increase in tempo across VSFB which will be assessed and mitigated under a programmatic base wide strategy using the same approach described in Section 2.3.2.

5.3.2 Western Snowy Plover

At full launch tempo under the Proposed Action and other current and reasonably foreseeable launch programs, up to 235 noise events (launch, static fire, landing) above 100 dB L_{max} would affect SNPL at South Surf Beach annually. As discussed above, the launch noise levels perceived by SNPL (levels weighted for presumed SNPL hearing sensitivity) would be substantially less than the unweighted peak values. There are no thresholds in the literature that predict what level of noise disturbance would cause impacts on stress physiology, behavior, reproduction, survival, or factors related to fitness. As the launch tempo on VSFB increases, SNPL may habituate to the increased disturbances, or may develop chronic levels of stress hormones, changes in habitat use, impacts to reproduction and nest success, as well as the other negative factors discussed above, which are related to fitness, and may result in population level effects.

The effect of increasing noise disturbances on SNPL will be uncertain based on the scientific literature. However, none of the scientific literature studies are directly comparable to the noise impacts of the Proposed Action. Launch engine noise and sonic booms are acute, non-sustained, and unpredictable. The monitoring program (see Section 2.3.7) that would be implemented to monitor SNPL nesting and the noise environment as the frequency of launch, static fire, and landing under the Proposed Action increases will also produce data that will enable the collective effects of launch-related noise from an increase in tempo across VSFB which will be assessed and mitigated under a programmatic base wide strategy using the same approach described in Section 2.3.7.

5.3.3 California Least Tern

At full launch tempo under the Proposed Action and other current and reasonably foreseeable launch programs, approximately 176 launch noise events above 100 dB L_{max} would affect LETE at the colony or Santa Ynez River mouth annually. Since only a portion of these would occur during nesting season (April to August), it is reasonable to estimate that noise events would be spaced approximately evenly (~15 noise events above 100 dB L_{max} per month) resulting in ~73 noise events during LETE nesting season per year. As discussed above, the launch noise levels perceived by LETE (levels weighted for presumed LETE hearing sensitivity) would be substantially less than the unweighted peak values. There are no thresholds in the literature that predict what level of noise disturbance would cause impacts on stress physiology, behavior, reproduction, survival, or factors related to fitness. As the launch tempo on VSFB increases, LETE may habituate to the increased disturbances, or may develop chronic levels of stress hormones, changes in habitat use, impacts on reproduction and nest success, as well as the other negative factors discussed above, which are related to fitness, and may result in population level effects.

The monitoring program (see Section 2.3.8) that would be implemented to study LETE breeding effort, nest fates, and fledging success while recording patterns of habitat use through the season as the frequency of launch, static fire, and landing under the Proposed Action increases will also produce data that will enable the collective effects of launch-related noise from an increase in tempo across VSFB which will be assessed and mitigated under a programmatic base wide strategy using the same approach described in Section 2.3.8.

5.4 Cumulative Effects

Cumulative effects are defined in 50 C.F.R. § 402.02 as "those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the Action Area of the Federal action subject to consultation." Reasonable, foreseeable, future federal actions, and potential future federal actions, that are unrelated to the Proposed Action, are not considered in the analysis of cumulative effects because they would require separate consultation pursuant to Section 7 of the ESA. There are no known cumulative effects related to the Proposed Action.

5.5 Interrelated and Interdependent Effects

Under USFWS's regulations, interrelated actions are "those that are part of a larger action and depend on the larger action for their justification." Interdependent actions are "those that have no independent utility apart from the action under consideration" (50 C.F.R. § 402.02). There are no interrelated or interdependent actions related to the Proposed Action.

6 Conclusion

SpaceX proposes to increase the Falcon annual launch cadence at VSFB from 36 launch events per year at SLC-4 to 50 per year. SpaceX would continue to land up to 12 first stage recoveries per year at SLC-4W and would continue to recover first stages downrange on offshore landing locations in the Pacific Ocean. SpaceX would also redevelop SLC-6 to accommodate the Falcon program and a new landing zone. This Proposed Action would result in increases in airborne noise and visual disturbance during launches, static fire, and landing events within the Action Area, as well as potential physical impacts during construction.

After reviewing the Proposed Action, including the proposed avoidance, minimization, monitoring, and mitigation measures (Section 2.3), the DAF has come to the conclusions which are summarized in Table 6.0-1.

Table 6.0-1. Federally listed species with potential to occur in Santa Barbara County and summary of effects determinations.

Common Name	Scientific Name	Federal Listing	Critical Habitat	Effects Determinations for the Proposed Action
Tidewater Goby	*Eucyclogobius newberryi*	Endangered	No Effect	May affect, not likely to adversely affect.
Unarmored Threespine Stickleback	*Gasterosteus aculeatus williamsoni*	Endangered	Not designated	May affect, not likely to adversely affect.
California Tiger Salamander	*Ambystoma californiense*	Endangered	No Effect	May affect, not likely to adversely affect.
California Red-legged Frog	*Rana draytonii*	Threatened	No Effect	**May affect, likely to adversely affect.**
Arroyo Toad	*Anaxyrus californicus*	Endangered	No Effect	May affect, not likely to adversely affect.
Western Spadefoot	*Spea hammondii*	Unlisted	N/A	May affect, not likely to adversely affect.
Southwestern Pond Turtle	*Actinemys pallida*	Unlisted	N/A	**May affect, likely to adversely affect.**
Marbled Murrelet	*Brachyramphus marmoratus*	Threatened	Designated, no overlap with Action Area	May affect, not likely to adversely affect.

Common Name	Scientific Name	Federal Listing	Critical Habitat	Effects Determinations for the Proposed Action
Southwestern Willow Flycatcher	*Empidonax traillii extimus*	Endangered	No Effect	May affect, not likely to adversely affect.
Least Bell's Vireo	*Vireo bellii pusillus*	Endangered	Designated, no overlap with Action Area	May affect, not likely to adversely affect.
Western Snowy Plover	*Charadrius nivosus*	Threatened	No Effect	**May affect, likely to adversely affect.**
California Least Tern	*Sternula antillarum browni*	Endangered	Not designated	**May affect, likely to adversely affect.**
California Condor	*Gymnogyps californianus*	Endangered	No Effect	May affect, not likely to adversely affect.
California Gnatcatcher	*Polioptila californica californica*	Threatened	No Effect	May affect, not likely to adversely affect.
Light-footed Clapper Rail	*Rallus obsoletus levipes*	Endangered	Not designated	May affect, not likely to adversely affect.
Southern Sea Otter	*Enhydra lutris nereis*	Threatened	Not designated	May affect, not likely to adversely affect.

7 Literature Cited

Alquezar, R.D., R.H. Macedo, J. Sierro, and D. Gill. 2020. Lack of consistent responses to aircraft noise in dawn song timing of bird populations near tropical airports. Behavioral Ecology and Sociobiology 74(88). 12 pp.

Ball, M.L., McCreedy, C., Geupel, G.R., and D. Robinette. 2012. Protocol-level Southwestern Willow Flycatcher Surveys of the Santa Ynez River and San Antonio Creek: 2012 Breeding Season. Unpublished Report, PRBO Conservation Science, Petaluma, CA.

Barry, S., and B. Shaffer. 1994. The Status of the California Tiger Salamander (*Ambystoma californiense*) at Lagunita: A 50-Year Update. The Journal of Herpetology: 28(2): 159-164.

Baumberger, K. 2013. Uncovering a Fossorial Species: Home Range and Habitat Preference of the Western Spadefoot, *Spea hammondii* (Anura: Pelobatidae), in Orange County Protected Areas. M.S. Thesis, California State University, Fullerton, Fullerton, CA.

Bee, M.A., and E.M. Swanson. 2007. Auditory masking of anuran advertisement calls by road traffic noise. Animal Behaviour 74: 1765–1776.

Bellefleur, D., P. Lee, and R.A. Ronconi. 2009. The impact of recreational boat traffic on Marbled Murrelets (*Brachyramphus marmoratus*). Journal of Environmental Management 90(1): 531-538.

Belli, J.P. 2015. Movements, Habitat Use, and Demography of Western Pond Turtles in an Intermittent Central California Stream. Master's Thesis, San Jose State University, California. 110 pp.

Bradley, F., C. Brook, and A.E. Bowles. 1990. Effects of low-altitude aircraft overflights on domestic turkey poults. BBN Laboratories, Inc., Canoga Park, Ca. Prepared for Noise and Sonic Boom Impact Technology Program, Wright-Patterson Air Force Base, Ohio. 145 pp.

Brattstrom, B.H., and M.C. Bondello. 1983. Effects of off-road vehicle noise on desert vertebrates. Pages 167-206 *in* R.H. Webb and H.G. Wilshore, eds. Environmental effects of off-road vehicles. Impacts and management in arid regions. Springer-Verlag, New York.

Brown, H.A. 1967. Embryonic temperature adaptations and genetic compatibility in two allopatric populations of the spadefoot toad, *Scaphiopus hammondii*. Evolution 21(4): 742-761.

Burgess, R.C. 1950. Development of spade-foot toad larvae under laboratory conditions. Copeia 1950:49–51.

Bury, R.B., and D.J. Germano. 2008. *Actinemys marmorata* (Baird and Girard 1852)—Western Pond Turtle, Pacific Pond Turtle. In A.G.J. Rhodin, P.C.H. Pritchard, P.P. van Dijk, R.A. Samure, K.A. Buhlmann, and J.B. Iverson (eds.), Conservation Biology of Freshwater Turtles and Tortoises: A Compilation Project of the IUCN/SSC Tortoise and Freshwater Turtle Specialist Group, pp. 1.1–1.9. Chelonian Monograph No. 5. Chelonian Research Foundation, Lunenburg, MA.

California Department of Fish and Wildlife (CDFW). 2024. California Natural Diversity Database (CNDDB) Management Framework. California Department of Fish and Wildlife.

Capranica, R.R., and A.J.M. Moffat. 1975. Selectivity of the peripheral auditory system of spadefoot toads (*Scaphiopus couchi*) for sounds of biological significance. Journal of Comparative Physiology 100: 231-249.

Christopher, S.V. 1996. Reptiles and amphibians of Vandenberg Air Force Base. A focus on sensitive aquatic species. National Biological Services, California Science Center, Piedras Blancas Research Station, San Simeon, CA. University of California, Museum of Systematics and Ecology, Report No. 4. 145 pp. + Appendices.

Christopher, S.V. 2002. Sensitive amphibian inventory at Vandenberg Space Force Base, Santa Barbara County, California, summary of preliminary results and site maps Appendix A Field Survey Data. Prepared for 30 CES/CEI.

Christopher, S.V. 2018. A review and case study of California red-legged frog (*Rana draytonii*) movement patterns in terrestrial habitats. Prepared for 30 CES/CEI. Cook, D. 1997. Biology of the California red-legged frog: a synopsis. Transactions of the Western Section of the Wildlife Society 33(1997): 79-82.

Collins, P.W. 2006. Results of surveys for California tiger salamanders (*Ambystoma californiense*) on Vandenberg Air Force Base, Santa Barbara County, California. Santa Barbara Natural History Technical Reports No. 4.

Conomy, J.T., J.A. Dubovsky, J.A. Collazo, and W.J. Fleming. 1998. Do Black Ducks and Wood Ducks Habituate to Aircraft Disturbance? The Journal of Wildlife Management 62(3): 1135-1142.

Cook, D.G., P.C. Trenham, and P.T. Northen. 2006. California tiger salamander (*Ambystoma californiense* in an urban landscape. Northwestern Naturalist 87(3): 215-224.

Cromwell, G., and C.C. Faunt. 2024. Estimated Effects of a Proposed Increase in Groundwater Pumping at Vandenberg Space Force Base, Santa Barbara County, California. Prepared by the U.S. Geological Survey California Water Science Center. Prepared for the U.S. Space Force, Vandenberg Space Force Base, California.

Cunnington, G.M., and Fahrig, L. 2010. Plasticity in the vocalizations of anurans in response to traffic noise. Acta Oecologica 36: 463–470.

Curland, J. M. 1997. Effects of disturbance on sea otters (*Enhydra lutris*) near Monterey, California. Master’s Thesis. San Jose State University, California. 47 pp.

Davis, R., T. Williams, and F. Awbrey. 1988. Sea Otter Oil Spill Avoidance Study. Minerals Management Service: 76.

Delay, S.J., O. Urquhart, and J.D. Litzgus. 2023. Wind farm and wildfire: spatial ecology of an endangered freshwater turtle in a recovering landscape. Canadian Journal of Zoology 00: 1-22. https://doi.org/10.1139/cjz-2023-0100

DiGaudio, R., N.E. Seavy, M. Holmgren, M. Ball, G.R. Geupel, and D. Robinette. 2011. Trends in Riparian Bird Abundance on Vandenberg Air Force Base: 1998 to 2011. Unpublished Report, PRBO Conservation Science, Petaluma, California. 53 pp.

Dimmitt, M.A., and R. Ruibal. 1980. Environmental correlates of emergence in spadefoot toads (*Scaphiopus*). Journal of Herpetology 14:21–29.

Dooling, R.J., and A.N. Popper. 2007. The effects of highway noise on birds. Prepared for The California Department of Transportation, Division of Enivronmental Analysis. Environmental Bioacoustics LLC, Rockville, MD. 74 pp.

eBird. 2023. eBird: An online database of bird distribution and abundance [web application]. eBird, Cornell Lab of Ornithology, Ithaca, New York. Available: http://www.ebird.org. (Accessed: 15 November 2023).

ESA PWA. 2010. An Assessment of Potential Restoration Actions to Enhance the Ecological Functions of the Lower Santa Ynez River Estuary. Prepared for Audubon California, California Coastal Conservancy, the Nature Conservancy, California Department of Fish and Game, US. Fish and Wildlife Service, and Vandenberg Air Force Base. 142 pp.

Farmer, C., S.I. Rothstein, and M.A. Holmgren. 2003. The Distribution and Abundance of Southwestern Willow Flycatchers on the Lower Santa Ynez River, California. Studies in Avian Biology 26: 30-35.

Fay, R.R. 1988. Hearing in vertebrates: a psychophysics databook. Hill-Fay Associates, Winnetka, IL. 621 pp.

Feaver, P.E. 1971. Breeding Pool Selection and Larval Mortality of Three California Amphibians: *Ambystoma tigrinum californiense* (Gray), *Hyla regilla* (Baird and Girard), and *Scaphiopus hammondi* (Girard). M.S. Thesis, Fresno State College, Fresno, CA.

Fellers, G.M., A.E. Launer, G. Rathbun, S. Bobzien, J. Alvarez, D. Sterner, R.B. Seymour, and M. Westphal. 2001. Overwintering tadpoles in the California red-legged frog (*Rana aurora draytonii*). Herpetological Review 32(3): 156-157.

Francis, C.D., and J.R. Barber. 2013. A framework for understanding noise impacts on wildlife: an urgent conservation priority. Fronteirs in Ecology and the Environment 11(6): 305-313.

Francis, C.D., C.P. Ortega, and A. Cruz. 2011a. Noise Pollution Filters Bird Communities Based on Vocal Frequency. PlosONE 6(11): e27052.

Francis, C.D., J. Paritsis, C.P. Ortega, and A. Cruz. 2011b. Landscape patterns of avian habitat use and nest success are affected by chronic gas well compressor noise. Landscape Ecology 26: 1269–1280.

Geist, N.R., Z. Dallara, and R. Gordon. 2015. The role of incubation temperature and clutch effects in development and phenotype of head-started western pond turtles (*Emys marmorata*). Herpetological Conservation and Biology 10 (Symposium): 489-503.

Ghoul, A., and C. Reichmuth. 2014. Hearing in the sea otter (*Enhydra lutris*): auditory profiles for an amphibious marine carnivore. Journal of Comparative Physiology. doi:10.1007/s00359-014-0943-x.

Godin, O. 2008. Sound transmission through water–air interfaces: new insights into an old problem. Contemporary Physics 49(2): 105-123.

Goudie, R.I., and I.L. Jones. 2004. Dose-response relationships of harlequin duck behaviour to noise from low-level military jet over-flights in central Labrador. Environmental Conservation 31(4): 289-298.

Griffith Wildlife Biology. 2022. Least Bell's vireo range expansion surveys in Monterey, San Luis Obispo, Santa Barbara, and Ventura Counties California in 2022. Interim Programmatic Report Narrative, National Fish and Wildlife Foundation Project# 67287. Prepared for Ventura Audubon Society. 32 pp.

Halfwerk, W., L.J.M. Holleman, C. Lessells, and H. Slabbekoorn. 2011. Negative impact of traffic noise on avian reproductive success. Journal of Applied Ecology 48: 210–219.

Holland, D.C. 1991. The western pond turtle: habitat and history. Final Report. Prepared for U.S. Department of Energy Bonneville Power Administration Environment, Fish, and Wildlife, Portland, Oregon. 303 pp.

Holmgren, M.A., and P.W. Collins. 1999 Final report on the disturbance and habitat associations of six bird species of special concern at Vandenberg Air Force Base, Santa Barbara County, California. Prepared for Vandenberg Air Force Base, 30 CES/CEVPN, Natural Resources, Vandenberg Air Force Base, California. Santa Barbara Museum of Natural History Monographs No. 1, Studies in Biodiversity No. 1. 204 pp.

iNaturalist. 2023. *Spea hammondii* Western Spadefoot Charts. https://www.inaturalist.org/taxa/26702-Spea-hammondii. Accessed 12/12/2023.

Jennings, M.R., and M.P. Hayes. 1994. Amphibian and reptile species of special concern in California. Report to the California Department of Fish and Game, Inland Fisheries Division, Rancho Cordova, California. pp. 12-16.

Kaiser, K., D.G. Scofield, M. Alloush, R.M. Jones, S. Marczak, K. Martineau, M.A. Oliva, and P.M. Narins. 2011. When sounds collide: the effect of anthropogenic noise on a breeding assemblage of frogs in Belize, Central America. Behaviour 148: 215–232.

Kaiser, K., J. Devito, C.G. Jones, A. Marentes, R. Perez, L. Umeh, R.M. Weickum, K. McGovern, E.H. Wilson, and W. Saltzman. 2015. Effects of anthropogenic noise on endocrine and reproductive function in White's treefrog, *Litoria caerulea*. Conservation Physiology 3(1): p.cou061-cou061.

Kleist, N.J., R.P. Guralnick, A. Cruz, C.A. Lowry, and C.D. Francis. 2018. Chronic anthropogenic noise disrupts glucocorticoid signaling and has multiple effects on fitness in an avian community. PNAS 115 (4) E648-E657.

Konishi, M. 1970. Comparative neurophysiological studies of hearing and vocalizations in songbirds. Zeitschrift fur vergleichend Physiologie 66: 257-272.

Kruger, D.J.D., and L.H. Du Preez. 2016. The effect of airplane noise on frogs: a case study on the Critically Endangered Pickersgill's reed frog (*Hyperolius pickersgilli*). Ecological Research 31(3): 393-405.

Kus, B. 2002. Least Bell's Vireo (*Vireo bellii pusillus*). In the Riparian Bird Conservation Plan: A Strategy for Reversing the Decline of Riparian-associated Birds in California. California Partners in Flight. http://www.prbo.org/calpif/htmldocs/species/riparian/least_bell_vireo.htm.

Lafferty, K.D., C.C. Swift, and R.F. Ambrose. 1999. Extirpation and recolonization in a metapopulation of an endangered fish, the tidewater goby. Conservation Biology 13(6): 1447-1453.

Lehman, P.E. 2020. The birds of Santa Barbara County, California. Revised edition, June 2020. Available at http://www.sbcobirding.com/lehmanbosbc.html

Lengagne, T. 2008. Traffic noise affects communication behaviour in a breeding anuran, *Hyla arborea*. Biological Conservation 141: 2023–2031.

Lewis, E., and P. Narins. 1985. Do Frogs Communicate with Seismic Signals? Science 227(4683): 187-189.

Loredo, I., and D. Van Vuren. 1996. Reproductive ecology of a population of the California tiger salamander. Copeia 1996: 895–901.

ManTech SRS Technologies, Inc. 2007a. Biological Monitoring of Southern Sea Otters, California Brown Pelicans, Western Snowy Plovers, and California Least Terns for the 7 June 2007 Delta II COSMO-1 Launch from Vandenberg Space Force Base, California. ManTech SRS Technologies, Inc., Lompoc, California. 24 pp.

ManTech SRS Technologies, Inc. 2007b. Biological Monitoring of California Brown Pelicans and Southern Sea Otters for the 14 December 2006 Delta II NROL-21 Launch from Vandenberg Space Force Base, California. SRS Technologies Systems Development Division, Lompoc, California. 21 pp.

ManTech SRS Technologies, Inc. 2008a. Biological Monitoring of Western Snowy Plovers for the 13 March 2008 Atlas V NROL-28 Launch from Vandenberg Space Force Base, California. ManTech SRS Technologies, Inc., Lompoc, California. 18 pp.

ManTech SRS Technologies, Inc. 2008b. Biological Monitoring of Southern Sea Otters, California Brown Pelicans, Western Snowy Plovers, and California Least Terns for the 20 June 2008 Delta II OSTM Launch from Vandenberg Space Force Base, California. ManTech SRS Technologies, Inc., Lompoc, California. 29 pp.

ManTech SRS Technologies, Inc. 2008c. Biological Monitoring of Southern Sea Otters and California Brown Pelicans for the 6 September 2008 Delta II GeoEye-1 Launch from Vandenberg Space Force Base, California. Lompoc, California: ManTech SRS Technologies, Inc., Lompoc, California.

ManTech SRS Technologies, Inc. 2009a. Status of the unarmored threespine stickleback (*Gasterosteus aculeatus williamsoni*) in San Antonio and Cañada Honda creeks, Vandenberg Air Force Base, California. 10 February 2009.

ManTech SRS Technologies, Inc. 2009b. Occurrence of the Amphibian Pathogen, Batrachochytrium dendrobatidis, in Ranids of Vandenberg Air Force Base, California. Prepared for 30 CEV/CEVNN.

ManTech SRS Technologies, Inc. 2009c. Biological Monitoring of Western Snowy Plovers for the 18 October 2009 Atlas V DMSP-18 Launch from Vandenberg Air Force Base, California. ManTech SRS Technologies, Inc., Lompoc, California. 18 pp.

ManTech SRS Technologies, Inc. 2009d. Biological Monitoring of Southern Sea Otters and California Brown Pelicans for the 8 October 2009 Delta II Worldview-II Launch from Vandenberg Air Force Base, California. ManTech SRS Technologies, Inc., Lompoc, California. 22 pp.

ManTech SRS Technologies, Inc. 2010a. Biological monitoring of western snowy plovers for the 22 April 2010 Minotaur IV HTV-2A Demo launch from Vandenberg Air Force Base, California. ManTech SRS Technologies, Inc., Lompoc, California. 16 pp.

ManTech SRS Technologies, Inc. 2010b. Biological monitoring of western snowy plovers for the 20 September 2010 Atlas V NROL-41 launch from Vandenberg Air Force Base, California. ManTech SRS Technologies, Inc., Lompoc, California. 17 pp.

ManTech SRS Technologies Inc. 2011. Biological Monitoring of Southern Sea Otters, California Least Terns and Western Snowy Plovers for the 10 June 2011 Delta II Aquarius Launch, Vandenberg Air Force Base, California. ManTech SRS Technologies, Inc., Lompoc, California.

ManTech SRS Technologies, Inc. 2013. Monitoring of the western snowy plovers for the 28 August 2013 Delta IV Heavy NROL-65 launch from Vandenberg Air Force Base, California. ManTech SRS Technologies, Inc., Lompoc, California. 9 pp.

ManTech SRS Technologies, Inc. 2014a. Assessment of California Red-Legged Frog Habitat, Population Status, and Chytrid Fungus Infection on Vandenberg Air Force Base, California. ManTech SRS Technologies, Inc., Lompoc, California. 83 pp.

ManTech SRS Technologies, Inc. 2014b. Baseline Surveys for California Red-Legged Frog, Tidewater Goby, and Southern Steelhead at the 13th Street Bridge on Vandenberg Air Force Base, California. Prepared for 30 CES/CEIEA. June 2014. 44 pp.

ManTech SRS Technologies, Inc. 2015. Vernal Pool Fairy Shrimp (*Branchinecta lynchi*) Wet Season Surveys 2014. ManTech SRS Technologies, Inc., Lompoc, California. 118 pp.

ManTech SRS Technologies, Inc. 2016a. California Red-Legged Frog Habitat Assessment, Population Status, and Chytrid Fungus Infection in Cañada Honda Creek and San Antonio West Bridge Area on Vandenberg Space Force Base, California. Unpublished report. 51 pp.

ManTech SRS Technologies, Inc. 2016b. Tiger Salamander Surveys at Vandenberg Air Force Base, California 2014-2016. ManTech SRS Technologies, Lompoc, California. 20 pp.

ManTech SRS Technologies, Inc. 2016c. Vernal Pool Fairy Shrimp (*Branchinecta lynchi*) Wet Season Surveys 2015 – 2016, Wetland Delineations, and Habitat Assessments of Select Pools. ManTech SRS Technologies, Lompoc, California. 138 pp.

ManTech SRS Technologies, Inc. 2017a. Biological Assessment for Launch, Boost-Back and Landing of the Falcon 9 First Stage at SLC-4, Vandenberg Air Force Base, California. ManTech SRS Technologies, Lompoc, California. 65 pp.

ManTech SRS Technologies, Inc. 2017b. Vernal Pool Fairy Shrimp (*Branchinecta lynchi*) Surveys 2016 – 2017. Prepared for 30 CES/CEIEA. 41 pp.

ManTech SRS Technologies, Inc. 2018a. California red-legged frog habitat assessment, population status, and chytrid fungus infection in Cañada Honda Creek, Cañada del Jolloru, and seasonal pools on Vandenberg Air Force Base, California. Submitted to 30th Civil Engineer Squadron, Environmental Flight, Natural Resources Section (30 CES/CEIEA), Vandenberg Air Force Base, California.

ManTech SRS Technologies, Inc. 2018b. Post-Construction Biological Monitoring for 13th Street Bridge Replacement at Vandenberg Air Force Base, California. Prepared for 30 CES/CEIEA. 26 November 2018. 43 pp.

ManTech SRS Technologies, Inc. 2018c. Vernal Pool Fairy Shrimp (*Branchinecta lynchi*) Surveys 2017 – 2018. Prepared for 30 CES/CEIEA. 14 pp.

ManTech SRS Technologies, Inc. 2018d. Biological Monitoring of Southern Sea Otters and California Red-legged Frogs for the 7 October 2018 SpaceX Falcon 9 SAOCOM Launch and Landing at Vandenberg Space Force Base, California. Prepared for 30 CES/CEIEA. 27 December 2018. 15 pp.

ManTech SRS Technologies, Inc. 2019. Vernal Pool Fairy Shrimp (*Branchinecta lynchi*) Surveys 2018 – 2019. Prepared for 30 CES/CEIEA. 15 pp.

ManTech SRS Technologies, Inc. 2020. Environmental DNA survey to detect rare aquatic amphibians on Vandenberg Air Force Base, California. Prepared for 30 CES/CEIEA. 127 pp.

ManTech SRS Technologies, Inc. 2021a. California Red-Legged Frog Habitat Assessment, and Population Status on San Antonio Terrace and Assessment of Select Aquatic Features on Vandenberg Space Force Base, California in 2020. October 2021. 85 pp.

ManTech SRS Technologies, Inc. 2021b. Vernal Pool Fairy Shrimp (*Branchinecta lynchi*) Surveys 2019 – 2020. Prepared for 30 CES/CEIEA. 22 pp.

ManTech SRS Technologies, Inc. 2021c. Biological Monitoring of Southern Sea Otters and California Red-legged Frogs for the 21 November 2020 SpaceX Falcon 9 Sentinel 6A Mission at Vandenberg Space Force Base, California. January 2021. 12 pp.

ManTech SRS Technologies, Inc. 2022a. 2021 surveys for rare aquatic amphibians on Vandenberg Space Force Base, California using environmental DNA techniques. Prepared for 30 CES/CEIEA. 127 pp.

ManTech SRS Technologies, Inc. 2022b. Assessment of California Red-Legged Frog Population Status and Habitat in Shuman Creek in 2021 on Vandenberg Air Force Base, California. Prepared for 30 CES/CEIEA. 127 pp.

ManTech SRS Technologies, Inc. 2022c. Vernal Pool Fairy Shrimp (*Branchinecta lynchi*) Surveys 2020 – 2021. Prepared for 30 CES/CEIEA. 32 pp.

ManTech SRS Technologies, Inc. 2022d. Vernal Pool Fairy Shrimp (*Branchinecta lynchi*) Surveys 2021 – 2022. Prepared for 30 CES/CEIEA. 18 pp.

ManTech SRS Technologies, Inc. 2022e. Biological Monitoring of California Red-legged Frogs for the 2 February 2022 SpaceX Falcon 9 NROL-87 Mission at Vandenberg Space Force Base, California.

ManTech SRS Technologies, Inc. 2023a. Spring Canyon California Red-Legged Frog Habitat Assessment – 2023, Vandenberg Space Force Base, California. Prepared for 30 CES/CEIEA. 161 pp.

ManTech SRS Technologies, Inc. 2023b. Biological Monitoring of Southern Sea Otters and California Red-legged Frogs for the 16 December 2022 SpaceX SWOT Mission at Vandenberg Space Force Base, California.

ManTech SRS Technologies, Inc. 2023c. California Red-Legged Frog Habitat Assessment and Population Status on Vandenberg Space Force Base, California in 2022. Prepared for 30 CES/CEIEA. 126 pp.

ManTech SRS Technologies, Inc. In Prep. Vernal Pool Fairy Shrimp (*Branchinecta lynchi*) Surveys 2022 – 2023.

McClure, C.J.W., H.E. Ware, J. Carlisle, G. Kaltenecker, and J.R. Barber. 2013. An experimental investigation into the effects of traffic noise on distributions of birds: avoiding the phantom road. Proceedings of the Royal Society B: 20132290. http://dx.doi.org/10.1098/rspb.2013.2290.

Meier, J., and R. Thompson. 2009. Lightning Climatology for the WFO Los Angeles/Oxnard, California County Warning Area. National Weather Service Forecast Office, Los Angeles/Oxnard, California.

Mejia, E.C., C.J.W. McClure, and J.R. Barber. 2019. Large-scale manipulation of the acoustic environment can alter the abundance of breeding birds: Evidence from a phantom natural gas field. Journal of Applied Ecology 56:2091–2101.

Mockford, E.J., R.C. and Marshall. 2009. Effects of urban noise on song and response behaviour in great tits. Proceedings of the Royal Society B 276: 2979–2985.

Morey, S.R., and D.A. Guinn. 1992. Activity patterns, food habits, and changing abundance in a community of vernal pool amphibians. Pages 149–158 in: D. Williams, S. Byrne, and T. A. Rado, editors. Endangered and sensitive species of the San Joaquin Valley, California. The California Energy Commission, Sacramento, California.

Nafis, G. 2023. A Guide to the Amphibians and Reptiles of California (On-line). Accessed 6 December 2023 at http://www.californiaherps.com/salamanders/pages/a.californiense.html.

National Aeronautics and Space Administration. 2024. Radiance Trents of Surf Beach. VIIRS – NASA's VIIRS/NPP Lunar BRDF-Adjusted Nighttime lights yearly. Available at https://www.lighttrends.lightpollutionmap.info/.

Nelson, D.V., H. Klinck, A. Carbaugh-Rutland, C.L. Mathis, A.T. Morzillo, and T.S. Garcia. 2017. Calling at the highway: The spatiotemporal constraint of road noise on Pacific chorus frog communication. Ecology and Evolution 7: 429–440.

Oelze, M.L., W.D. O'Brien, and R.G. Darmody. 2002. Measurement of Attenuation and Speed of Sound in Soils. Soil Science Society of America Journal (66): 788-796.

Park, J., and Y. Do. 2022. Wind turbine noise behaviorally and physiologically changes male frogs. Biology 11(4): 516-534.

Parris, K.M., M. Velik-Lord, and J.M.A. North. 2009. Frogs call at a higher pitch in traffic noise. Ecology and Society 14(1): 25. Available at http://www.ecologyandsociety.org/vol14/iss1/art25/.

Passos, M.F.O., M.V. Beirão, A. Midamegbe, R.H.L. Duarte, R.J. Young, and C.S. de Azevedo. 2020. Impacts of noise pollution on the agonistic interactions of the saffron finch (*Sicalis flaveola* Linnaeus, 1766). Behavioural Processes 180: 104222.

Redondo, I., J. Muriel, C. de Castro Diaz, J.I. Aguirre, D. Gill, and L. Perez-Rodriguez. 2021. Influence of growing up in the city or near an airport on the physiological stress of tree sparrow nestlings (*Passer montanus*). European Journal of Wildlife Research 67: 68.

Reese, D.A., and H.H. Welsh, Jr. 1998. Habitat Use by Western Pond Turtles in the Trinity River, California. The Journal of Wildlife Management 62(3): 842-853.

Riedman, M., and J. Estes. 1990. The sea otter (*Enhydra lutris*): behavior, ecology, and natural history. Washington, D.C.: U.S. Fish and Wildlife Service Biological Report 90(14).

Robinette, D., and R. Ball. 2013. Monitoring of Western Snowy Plovers on South Surf Beach, Vandenberg Space Force Base, Before and After the 29 September 2013 SpaceX Falcon 9 Launch. Point Blue Conservation Science. Vandenberg Field Station. 22 October 2013.

Robinette, D. P., N. Collier, A. Brown, and W. J. Sydeman. 2003. Monitoring and management of the California Least Tern colony at Purisima Point, Vandenberg Air Force Base, 2002. Unpublished Report. Stinson Beach, CA: Point Reyes Bird Observatory.

Robinett, D., and J. Howar. 2010. Monitoring and management of the California Least Tern colony at Purisima Point, Vandenberg Air Force Base, 2009. Petaluma, California: Unpublished Report, PRBO Conservation Science.

Robinette, D.P., and J.K. Miller. 2017a. Monitoring of Western Snowy Plovers on South Surf Beach and California Least Terns at the Sana Ynez River Estuary, Vandenberg Air Force Base, Before and after the 25 June 2017 Falcon 9 Iridium Next 11-20 Launch. Petaluma, California: Point Blue Conservation Science.

Robinette, D.P., and J.K. Miller. 2017b. Monitoring of Western Snowy Plovers on Surf South Beach, Vandenberg Air Force Base, Before and after the 24 August 2017 SpaceX Falcon9 Formosat 5 Launch. Petaluma, California: Point Blue Conservation Science.

Robinette, D.P., and E. Rogan. 2005. Monitoring and management of the California Least Tern colony at Purisima Point, Vandenberg Air Force Base, 2005. Unpublished Report. Stinson Beach, CA: Point Reyes Bird Observatory.

Robinette, D.P., J.K. Miller, and A.J. Howar. 2016. Monitoring and Management of the Endangered California Least Tern and the Threatened Western Snowy Plover at Vandenberg Space Force Base, 2016. Petaluma, California: Point Blue Conservation Science.

Robinette, D., and E. Rice. 2019. Monitoring of California Least Terns and Western Snowy Plovers on Vandenberg Space Force Base during the 12 June 2019 SpaceX Falcon 9 Launch with “Boost-Back”. Petaluma, California: Point Blue Conservation Science.

Robinette, D., and E. Rice. 2022a. Monitoring of Western Snowy Plovers on Vandenberg Space Force Base during the 17 April 2022 SpaceX Falcon 9 NROL-85 Launch with “Boost-Back”. Petaluma, California: Point Blue Conservation Science.

Robinett, D., and E. Rice. 2022b. Monitoring of California Least Terns and Western Snowy Plovers on Vandenberg Space Force Base during the 18 June 2022 SpaceX Falcon 9 Launch and First Stage Landing at SLC-4. Petaluma, California: Point Blue Conservation Science.

Robinette, D., E. Rice, A. Fortuna, J. Miller, L. Hargett, and J. Howar. 2021. Monitoring and management of the endangered California least tern and the threatened western snowy plover at Vandenberg Space Force Base, 2021. Unpublished Report, Point Blue Conservation Science, Petaluma, CA.

Robinette, et al. *In Prep.* Monitoring of California Least Terns and Western Snowy Plovers on Vandenberg Space Force Base during the 2023 Breeding Season during SpaceX Falcon 9 Launch and First Stage Landing at SLC-4. Petaluma, California: Point Blue Conservation Science.

Rodrıguez-Prieto, I., and E. Fernandez-Juricic. 2005. Effects of direct human disturbance on the endemic Iberian frog *Rana iberica* at individual and population levels. Biological Conservation 123: 1-9.

Rosa, P., and N. Koper. 2022. Impacts of oil well drilling and operating noise on abundance and productivity of grassland songbirds. Journal of Applied Ecology 59:574–584.

Schou, C.P.E., A.L. Levengood, and D.A. Potvin. 2021. Limited effects of traffic noise on behavioural responses to conspecific mating calls in the eastern sedge frog *Litoria fallax*. Acta Ethologica 24(3): 217-226.

Seavy, N.E., M.A. Holmgren, M.L. Ball, and G. Geupel. 2012. Quantifying riparian bird habitat with orthophotography interpretation and field surveys: Lessons from Vandenberg Air Force Base, California. Journal of Field Ornithology.

Simmons, D.D., R. Lohr, H. Wotring, M.D. Burton, R.A. Hooper, and R.A. Baird. 2014. Recovery of otoacoustic emissions after high-level noise exposure in the American bullfrog. Journal of Experimental Biollogy 217(9): 1626–1636. doi: 10.1242/jeb.090092.

Simon et al. (2021). Determing the Effects of Artificial Light at Night on the Distributions of Western Snowy Plovers (*Charadrius nivosus nivosus*) and California Grunion (*Leuresthes tenuis*) in Southern California. Journal of Coastal Research (2022) 38(2): 302-309.

Southall, B., J. Finneran, C. Reichmuth, P. Nachtigall, D. Ketten, A. Bowles, W. Ellison, D. Nowacek, and P. Tyack. 2019. Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects. Aquatic Mammals 45(2) 125-232.

Southern Sierra Research Station. 2017. Southwestern Willow Flycatcher Protocol Surveys of the Santa Ynez River and San Antonio Creek: 2017 Breeding Season. Prepared for Center for Environmental Management of Military Lands, Colorado State University, Fort Collins, Colorado, and 30 CEA/CEIEA, Vandenberg Air Force Base, California. 23 pp.

SRS Technologies, Inc. 2001. Acoustic Measurements of the 8 September 2001 Atlas IIAS MLV-10 Launch and Quantitative Analysis of Behavioral Responses of Pacific Harbor Seals, Western Snowy Plovers and California Brown Pelicans on Vandenberg Air Force Base, and Selected Pinnipeds on San Miguel Island, California.

SRS Technologies, Inc. 2002. Analysis of Behavioral Responses of California Brown Pelicans and Southern Sea Otters for the 18 October 2001 Delta II Quickbird2 Launch from Vandenberg Space Force Base, California. SRS Technologies technical report submitted to the United States Space Force.

SRS Technologies, Inc. 2004. 13th Street Bridge Retrofit Summary of Monitoring Activities August 25, 2003 -February 9, 2004 Vandenberg Air Force Base California.

SRS Technologies, Inc. 2006a. Biological Monitoring of Southern Sea Otters, California Brown Pelicans, and Western Snowy Plovers for the 28 April 2006 Delta II Cloudsat & CALIPSO Launch from Vandenberg Space Force Base, California. SRS Technologies technical report submitted to the United States Space Force and the U.S. Fish and Wildlife Service, 11 October 2006.

SRS Technologies, Inc. 2006b. Quantitative Analysis of Behavioral Responses of Western Snowy Plovers and California Brown Pelicans to the 2 December 2003 Atlas IIAS MLV-14 Launch from Vandenberg Air Force Base, California.

SRS Technologies, Inc. 2006c. Results from Water Quality and Beach Layia Monitoring, and Analysis of Behavioral Responses of Western Snowy Plovers to the 19 October 2005 Titan IV B-26 Launch from Vandenberg Space Force Base, California. SRS Technologies technical report submitted to the United States Space Force.

SRS Technologies, Inc. 2006d. Analysis of Behavioral Responses of Southern Sea Otters, California Least Terns, and Western Snowy Plovers to the 20 April 2004 Delta II Gravity Probe B Launch from Vandenberg Space Force Base, California. SRS Technologies technical report submitted to the United States Space Force. 12 pp.

SRS Technologies, Inc. 2006e. Analysis of Behavioral Responses of California Brown Pelicans, Western Snowy Plovers and Southern Sea Otters to the 15 July 2004 Delta II AURA Launch from Vandenberg Space Force Base, California. SRS Technologies technical report submitted to the United States Space Force. 13 pp.

SRS Technologies, Inc. 2006f. Analysis of Behavioral Responses of Southern Sea Otters, California Brown Pelicans, and Western Snowy Plovers to the 20 May 2005 Delta II NOAA-N Launch from Vandenberg Space Force Base, California. SRS Technologies technical report submitted to the United States Space Force. 15 pp.

SRS Technologies, Inc. 2006g. Biological Monitoring of Southern Sea Otters, California Brown Pelicans, and Western Snowy Plovers for the 28 April 2006 Delta II Cloudsat & CALIPSO Launch from Vandenberg Space Force Base, California. SRS Technologies technical report submitted to the United States Space Force and the U.S. Fish and Wildlife Service, 11 October 2006. 18 pp.

SRS Technologies, Inc. 2006h. Quantitative analysis of behavioral responses of western snowy plover and California brown pelicans to the 2 December 2003 Atlas IIAS MLV-14 Launch from Vandenberg Air Force Base, California. SRS Technologies technical report submitted to the United States Space Force. 15 pp.

SRS Technologies, Inc. 2006i. Analysis of behavioral responses of California brown pelicans, southern sea otters, and western snowy plovers to the 20 May 2004 Taurus ROCSAT-2 launch from Vandenberg Air Force Base, California. SRS Technologies technical report submitted to the United States Space Force. 18 pp.

SRS Technologies, Inc. 2006j. Analysis of behavioral responses of western snowy plovers to the 14 April 2006 Minotaur COSMIC launch from Vandenberg Air Force Base, California. SRS Technologies technical report submitted to the United States Space Force. 12 pp.

SRS Technologies, Inc. 2006k. Biological monitoring of southern sea otters, California brown pelicans, and western snowy plovers, and water quality and acoustic monitoring for the 27 June 2006 Delta IV NROL-22 launch from Vandenberg Air Force Base, California. SRS Technologies technical report submitted to the United States Space Force. 44 pp.

SRS Technologies, Inc. 2006l. Biological Monitoring of Southern Sea Otters, California Brown Pelicans, Gaviota Tarplant, and El Segundo Blue Butterfly, and Water Quality Monitoring for the 4 November 2006 Delta IV DMSP-17 Launch from Vandenberg Space Force Base, California. SRS Technologies Systems Development Division, Lompoc, California. 40 pp.

Stebbens, W.C. 1983. The Acoustic Sense of Animals. Cambridge, Massachusetts: Harvard University Press.

Stebbins, R.C. 1972. California amphibians and reptiles. Univ. California Press, Berkeley. 152 pp.

Stebbins, R.C. 1985. A Field Guide to Western Reptiles and Amphibians. Houghton Mifflin Company.

Stebbins, R.C., and S.M. McGinnis. 2012. Field guide to amphibians and reptiles of California: revised edition. University of California Press.

Storer, T.I. 1925. A synopsis of the amphibia of California. University of California Publications in Zoology 27:1-342.

Strachan, G., M. McAllister, and C.J. Ralph. 1995. Marbled murrelet at-sea and foraging behavior. Chapter 23 *in* Ralph, C. J., Hunt, G.L., Jr., Raphael, M.G., Piatt, J.F. (eds.): Ecology and conservation of the marbled murrelet. USDA Forest Service General Technical Report PSW-152.

Sun, J.W.C., and P.M. Narins. 2005. Anthropogenic sounds differentially affect amphibian call rate. Biological Conservation 121: 419-427.

Swaddle, J.P., and L.C. Page. 2007. High levels of environmental noise erode pair preferences in zebra finches: implications for noise pollution. Animal Behaviour 74: 363–368.

Sweet, S.S., J.P. LaBonte, and M.L. Ball. 2008. Evaluation of potential California tiger salamander (*Ambystoma californiense*) occurrence on Vandenberg Air Force Base: Phase I - wetland evaluations. Cheadle Center for Biodiversity and Ecological Restoration, University of California, Santa Barbara. Prepared for 30 CEV/CEVNN.

Sweet, S.S., J.P. LaBonte, and M.L. Ball. 2010. Evaluation of potential tiger salamander (*Ambystoma* spp.) occurrence on Vandenberg Air Force Base: Phase II – field surveys. Cheadle Center for Biodiversity and Ecological Restoration, University of California, Santa Barbara. Prepared for 30 CES/CEANC.

Swenson, R.O. 1999. The ecology, behavior, and conservation of the tidewater goby, *Eucyclogobius newberryi*. Environmental Biology of Fishes 55: 99-119.

Swift, C.C. 1999. Special-Status Fish Species Survey Report for San Antonio Creek, Vandenberg Air Force Base, California. Prepared for 30 CES/CEVPC, Vandenberg Air Force Base, California. 26 pp.

Swift, C.C., P. Duangsitti, C. Clemente, K. Hasserd, and L. Valle. 1997. Final Report Biology and Distribution of the Tidewater Goby, *Eucyclogobius newberryi*, on Vandenberg Space Force Base, Santa Barbara County, California. Department of Biology Loyola Marymount University, Los Angeles, California. 76 pp.

Swift, C.C., J.L. Nelson, C. Maslow, and T. Stein. 1989. Biology and distribution of the tidewater goby, *Eucyclogobius newberryi* (Pisces: Gobiidae) of California. Natural History Museum of Los Angeles County, No. 404.

Tatarian, P.J. 2008. Movement Patterns of California Red-legged Frogs (*Rana draytonii*) in an Inland California Environment. Herpetological Conservation and Biology 3(2): 155-169.

Tennessen, J.B., S.E. Parks, and T. Langkilde. 2014. Traffic noise causes physiological stress and impairs breeding migration behaviour in frogs. Conservation Physiology 2(1): cou032. Available at https://doi.org/10.1093/conphys/cou032.

Ting, C., J. Garrelick, and A. Bowles. 1997. An analysis of the response of sooty tern eggs to sonic boom overpressures. Prepared for the United States Air Force Research Laboratory. 7 pp.

Trenham, P.C., H.B. Shaffer, W.D. Koenig, and M.R. Stromberg. 2000. Life history demographic variation in the California tiger salamander (*Ambystoma californiense*). Copeia 2000: 365–377.

Troïanowski, M., N. Mondy, A. Dumet, C. Arcanjo, and T. Lengagne. 2017. Effects of traffic noise on tree frog stress levels, immunity, and color signaling. Conservation Biology 31(5): 1132–1140.

U.S. Air Force. 2021. Integrated Natural Resources Management Plan, Vandenberg Air Force Base.

U.S. Fish and Wildlife Service. 1985a. Revised Unarmored Threespine Stickleback Recovery Plan. U.S. Fish and Wildlife Service, Portland, Oregon.

U.S. Fish and Wildlife Service. 1985b. Recovery Plan for the California Least Tern, *Sterna antillarum brownii*. U.S. Fish and Wildlife Service, Portland, Oregon.

U.S. Fish and Wildlife Service. 1996. California Condor Recovery Plan, Third Revision. Portland, Oregon: U.S. Fish and Wildlife Service.

U.S. Fish and Wildlife Service. 1997. Marbled Murrelet Recovery Plan. U.S. Fish and Wildlife Service, Portland, Oregon.

U.S. Fish and Wildlife Service. 1998. Draft Recovery Plan for the Least Bell's Vireo (*Vireo bellii pusillus*). . U.S. Fish and Wildlife Service, Portland, Oregon.

U.S. Fish and Wildlife Service. 2002a. Declining Amphibian Population Task Force's code of practice. Available: https://www.fws.gov/southwest/es/NewMexico/documents/

SP/Declining_Amphibian_Task_Force_Fieldwork_Code_of_Practice.pdf..

U.S. Fish and Wildlife Service. 1999. Arroyo southwestern toad (*Bufo microscaphus californicus*) recovery plan. U.S. Fish and Wildlife Service, Portland, Oregon. vi + 119 pp.

U.S. Fish and Wildlife Service. 2002a. Recovery Plan for the California red-legged frog (*Rana aurora draytonii*). Portland, Oregon.

U.S. Fish and Wildlife Service. 2002b. Final Recovery Plan Southwestern Willow Flycatcher (*Empidonax traillii extimus*). Prepared by Southwestern Willow Flycatcher Recovery Team Technical Subgroup. August 2002. 229 pp.

U.S. Fish and Wildlife Service. 2003. Final Revised Recovery Plan for the Southern Sea Otter (*Enhydra lutris nereis*). Portland, Oregon.

U.S. Fish and Wildlife Service. 2005. Recovery Plan for Tidewater Goby (*Eucyclogobius newberry*). Portland, Oregon.

U.S. Fish and Wildlife Service. 2007. Recovery Plan for the Pacific Coast Population of the Western Snowy Plover (*Charadrius alexandrinus nivosus*). Sacramento, California.

U.S. Fish and Wildlife Service. 2009. Marbled Murrelet (*Brachyramphus marmoratus*) 5-Year Review. Lacy, Washington.

U.S. Fish and Wildlife Service. 2010. Biological Opinion for the Modification and Operation of Space Launch Complex 4 East for the Falcon 9 Space Vehicle Program at Vandenberg Air Force Base, Santa Barbara County, California (8-8-10-F-38). Ventura Fish and Wildlife Office, Ventura, California. 10 December 2010.

U.S. Fish and Wildlife Service. 2011. Reinitiation of the Biological Opinion for the Modification and Operation of Space Launch Complex 4 East for the Falcon 9 Space Vehicle Program at Vandenberg Air Force Base, Santa Barbara County, California (8-8-1 l-F-32R). Ventura Fish and Wildlife Office, Ventura, California. 24 June 2011.

U.S. Fish and Wildlife Service. 2014a. Biological Opinion for In-Flight Abort Test and Improvements to Space Launch Complex 4 West (SLC-4W), Vandenberg Air Force Base, Santa Barbara County, California (8-8-l4-F-41). Ventura Fish and Wildlife Office, Ventura, California. 22 December 2014.

U.S. Fish and Wildlife Service. 2014b. Concurrence letter for Space Launch Complex 4 East, Vandenberg Air Force Base, Santa Barbara County, California. Ventura Fish and Wildlife Office, Ventura, California. 29 August 2014.

U.S. Fish and Wildlife Service. 2014c. 2014 Summer Window Survey Results for Snowy Plovers on the U.S. Pacific Coast.

U.S. Fish and Wildlife Service. 2015a. Concurrence letter for SpaceX Boost-Back Landing Operations, Space Launch Complex 4 West, Vandenberg Air Force Base, Santa Barbara County, California. Ventura Fish and Wildlife Office, Ventura, California. 2 July 2015.

U.S. Fish and Wildlife Service. 2015a. Biological Opinion on the Beach Management Plan and Water Rescue Training at Vandenberg Air Force Base (2014-2018) (8-8-12-F-11R).

U.S. Fish and Wildlife Service. 2015b. Southern Sea Otter (*Enhydra lutris nereis*) 5-Year Review: Summary and Evaluation. Ventura, California: U.S. Fish and Wildlife Service.

U.S. Fish and Wildlife Service. 2016. Recovery plan for the Santa Barbara County Distinct Population Segment of the California tiger salamander (*Ambystoma californiense*). Ventura, California: U.S. Fish and Wildlife Service, Southwest Region.

U.S. Fish and Wildlife Service. 2017a. Biological Opinion on the Launch, Boost-Back and Landing of the Falcon 9 First Stage at SLC-4 at Vandenberg Air Force Base, Santa Barbara County, California (20 17-F-0480). 12 December 2017.

U.S. Fish and Wildlife Service. 2017b. California Condor Recovery Program. Retrieved from Our Programs Pacific Southwest Region: https://www.fws.gov/cno/es/CalCondor/Condor.cfm

U.S. Fish and Wildlife Service. 2017c. 2016 Summer Window Survey for Snowy Plovers on U.S. Pacific Coast with 2005-2016. Available at https://www.fws.gov/arcata/es/birds/WSP/plover.html.

U.S. Fish and Wildlife Service. 2018. Biological Opinion for the Erosion Protection System Maintenance at the San Antonio Road West Bridge, Vandenberg Air Force Base, Santa Barbara County, California (2016-F-0103).

U.S. Fish and Wildlife Service. 2019. 5-Year review for the Pacific coast population of the western snowy plover (*Charadrius nivosus nivosus*). Arcata Fish and Wildlife Office, Arcata, California.

U.S. Fish and Wildlife Service. 2020. California least tern (*Sternula antillarum browni*) 5-year review: Summary and Evaluation. Carlsbad Fish and Wildlife Office, Carlsbad, California.

U.S. Fish and Wildlife Service. 2022. Vandenberg Space Force Base, SpaceX, change in launch number, personal communication (email) from Chris Diel (Ventura Field Office, USFWS) to Samantha Kaisersatt (CEIEA, VSFB). 13 October 2022.

U.S. Fish and Wildlife Service. 2023a. Reinitiation of the Biological Opinion on the Launch, Boost-Back, and Landing of the Falcon 9 First Stage at Space Launch Complex 4 (SLC-4) at Vandenberg Space Force Base, Santa Barbara County, California (2017-F-0480).

U.S. Fish and Wildlife Service. 2023b. Endangered and threatened wildlife and plants; threatened species status with Section 4(d) Rule for the northwestern pond turtle and southwestern pond turtle. 88 FR 68370-68399. 30 pp.

U.S. Fish and Wildlife Service. *In Prep*. Draft Conservation Strategy for California red-legged frog. Ventura Field Office.

U.S. Fish and Wildlife Service and National Marine Fisheries Service. 1998. Endangered Species Consultation Handbook Procedures for Conducting Consultation and Conference Activities Under Section 7 of the ESA. U.S. Fish and Wildlife Service and National Marine Fisheries Service.

U.S. Geological Survey Western Ecological Resource Center. 2017. Annual California Sea Otter Census: 2017 Census Summary Shapefile. Retrieved 16 October 2020, from https://www.sciencebase.gov/catalog/item/5601b6dae4b03bc34f5445ec.

U.S. Geological Survey Western Ecological Resource Center. 2018. Annual California Sea Otter Census: 2018 Census Summary Shapefile. Retrieved 16 October 2020, from https://www.sciencebase.gov/catalog/item/5601b6dae4b03bc34f5445ec.

U.S. Geological Survey Western Ecological Resource Center. 2020. Annual California Sea Otter Census: 2019 Census Summary Shapefile. Retrieved 16 October 2020, from https://www.sciencebase.gov/catalog/item/5601b6dae4b03bc34f5445ec.

Ventana Wildlife Society. 2017. California Condor #760 aka "Voodoo". Retrieved 28 March 2017, from MYCONDOR.ORG: http://www.mycondor.org/condorprofiles/condor760.html.

Ventre, C.S., Myles, M.M., and I.L. Ver. 2002. Measurements of the Reflection Factor of Flat Ground Surfaces. Prepared for National Aeronautics and Space Administration, Cambridge Massachusetts.

Walthers, A.R., and C.A. Barber. 2020. Traffic noise as a potential stressor to offspring of an urban bird, the European Starling. Journal of Ornithology 161: 459-467.

Wang, T., L., H. Li, J. Cui, X. Zhai, H. Shi, and J. Wang. 2019a. Auditory brainstem responses in the red-eared slider *Trachemys scripta* elegans (Testudoformes: Emydidae) reveal sexually dimorphic hearing sensitivity. Journal of Comparative Physiology A 205: 847–854. https://doi.org/10.1007/s00359-019-01372-y

Wang, J., H. Li, T. Wang, B. Chen, J. Cui, and H Shi. 2019b. Developmental plasticity of hearing sensitivity in red-1 eared slider *Trachemys scripta elegans*. bioRxiv. https://doi.org/10.1101/825968

Washington State Department of Transportation. 2012. Washington State Department of Transportation Biological Assessment Guidance. Olympia, WA: Washington State Department of Transportation.

Wever, E.G. 1978. The reptile ear, its structure and function. Princeton, NJ: Princeton University Press The Reptile Ear. Volume 5348 in the series Princeton Legacy Library. https://doi.org/10.1515/9780691196664

Wolfenden, A.D., H. Slabbekoorn, K. Kluk, and S.R. de Kort. 2019. Aircraft sound exposure leads to song frequency decline and elevated aggression in wild chiffchaffs. Journal of Applied Ecology 88:1720–1731.

Yorzinski, J.L., and F.S. Hermann. 2016. Noise pollution has limited effects on nocturnal vigilance in peahens. PeerJ 4:e2525; DOI 10.7717/peerj.2525.

Zollinger, S.A., A. Dorado-Correa, W. Goymann, W. Forstmeier, U. Knief, A.M. Bastidas-Urrutia, and H. Brumm. 2019. Traffic noise exposure depresses plasma corticosterone and delays offspring growth in breeding zebra finches. Conservation Physiology 7(1): coz056; doi:10.1093/conphys/coz056.

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Federally Listed Species Monitoring and Mitigation Plan for the Launch, Boost-Back, and Landing of the Falcon 9 at Space Launch Complex 4 at Vandenberg Space Force Base, California

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ACRONYMS AND ABBREVIATIONS

cm	centimeter(s)
CRLF	California red-legged frog
D2	Kestrel Drop 2
DAF	Department of the Air Force
DATF	Declining Amphibian Task Force
GPS	global positioning system
kHz	kilohertz
LETE	California least tern
m	meter(s)
mm	millimeter(s)
MSRS	ManTech SRS Technologies, Inc.
SD	secure digital or standard deviation
SLC-4	Space Launch Complex 4
SLM	sound level meter
SM2	Wildlife Acoustics Song Meter 2
SNPL	western snowy plover
SVL	snout-vent length
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VSFB	Vandenberg Space Force Base

1 Introduction

On 21 March 2023, the United States Fish and Wildlife Service (USFWS) issued a biological opinion (BO; 2022-0013990-S7-001; USFWS 2023) for the Department of the Air Force's (DAF) proposed increase in cadence of launches of authorization of the Space Exploration Technologies Corporation's (SpaceX) Falcon 9 at Space Launch Complex 4 (SLC-4) on Vandenberg Space Force Base (VSFB; Figure 1.1-1). The BO analyzed the potential effects on the federally endangered California least tern (LETE; *Sterna antillarum browni*), California condor (*Gymnogyps californianus*), unarmored threespine stickleback (*Gasterosteus aculeatus williamsoni*), and tidewater goby (*Eucyclogobius newberryi*), and the federally threatened California red-legged frog (CRLF; *Rana draytonii*), marbled murrelet (*Brachyramphus marmoratus*), western snowy plover (SNPL; *Charadrius nivosus nivosus*), and southern sea otter (*Enhydra lutris nereis*), in accordance with section 7 of the Endangered Species Act of 1973, as amended. The USFWS determined that the proposed action "may affect but is not likely to adversely affect" the California condor, marbled murrelet, unarmored threespine stickleback, tidewater goby, and southern sea otter and "may affect, and is likely to adversely affect" the CRLF, SNPL, and LETE. Under term and condition #8 of the BO, the USFWS required the DAF to develop a mitigation and monitoring plan that details how the project's effects on CRLF, SNPL, and LETE will be monitored and assessed, identifies thresholds that would trigger mitigation, how mitigation acreages would be calculated, and identifies specific quantifiable 5-year success criteria. This plan is intended to address that requirement of the BO.

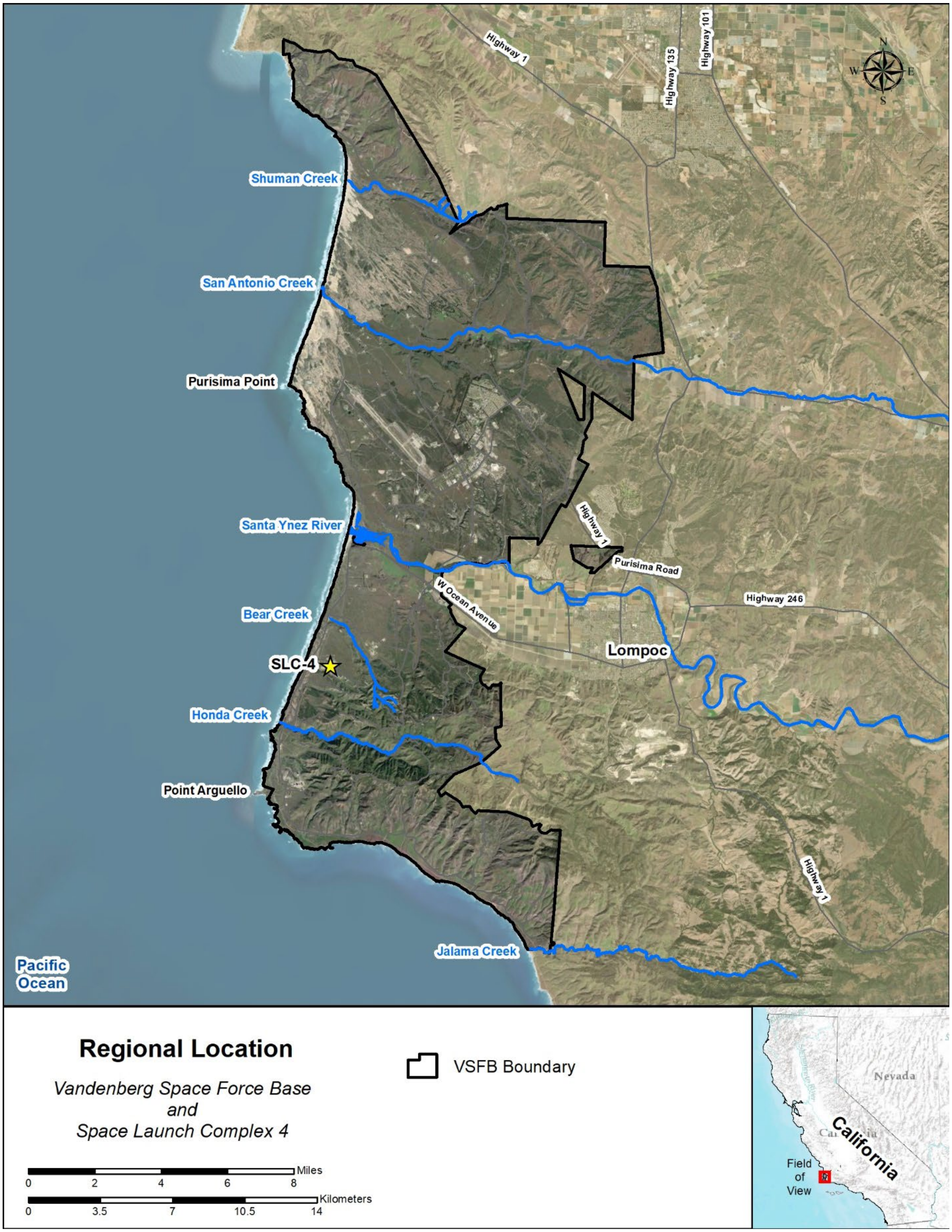

Figure 1.0-1. Regional location of SLC-4.

2 California Red-legged Frog Monitoring and Mitigation

2.1 California Red-legged Frog Monitoring

2.1.1 Pre-Project Baseline

2.1.1.1 Honda Creek

Protocol surveys and habitat assessments of lower Honda Creek (the approximate area potentially affected by launch engine noise and sonic boom) between 2013 and 2022 have documented between 1 to 12 adult CRLF in this section, with an average annual high number of 7.2 adults. In 2016, between 0 and 9 post-metamorphic CRLF and 3 egg masses were observed during quarterly surveys of the lower Honda Creek (ManTech SRS Technologies, Inc. [MSRS] 2016). The Canyon Fire in 2016 followed by scouring flows in the winter of 2016–2017 removed most of the pool habitat formerly occupied by CRLF in this section (MSRS 2018a). As a result, a maximum of only one CRLF was observed during quarterly surveys of lower Honda Creek in 2017 (MSRS 2018a). In addition, no calling, egg masses, or CRLF tadpoles were observed in lower Honda Creek during the quarterly night surveys or seine surveys during 2017 (MSRS 2018a). Most recently, however, biologists monitoring a culvert repair project at lower Honda Creek documented 10 adult CRLF and 13 egg masses in 2022 (MSRS 2023). Although the observations in 2022 were not the result of protocol surveys, it is reasonable to estimate a maximum of at least 10 adult CRLF in lower Honda Creek and conclude that the average annual high number of 7.2 adults (Table 2.1-2) observed during protocol surveys within this stretch is a reasonable expectation in the future.

Table 2.1-1: Annual high number of adults detected on Lower Honda Creek* during protocol night surveys.

Survey Date	Adults Detected	Start Time	End Time	Total Time
7/17/2013	9	21:00	23:18	2:18
5/3/2016	9	20:30	1:49	5:19
6/23/2017	1	20:50	22:36	1:46
8/18/2020	10	20:23	21:59	1:36
1/25/2022	7	18:24	19:50	1:36
Average	**7.2**			**2:31**

* Lower Honda Creek survey stretch begins downstream at estuary (34.608208°, -120.637200°) and ends at a waterfall (34.605609, -120.628571)

2.1.1.2 Bear Creek

The most recent thorough protocol survey efforts of Bear Creek were performed in 2013. A total of 13 post-metamorphic CRLF (1.0 CRLF per surveyor-hour) were observed within the limited hydrated portions of the creek (MSRS 2014). Habitat assessments conducted during the same year determined that Bear Creek did not contain high quality CRLF habitat due to a nearly complete absence of suitable breeding habitat (MSRS 2014). Although in good rainfall years it may be a productive breeding location, as evidenced by 5 egg masses observed in 2002 and 15 metamorphs observed in 2000 (Christopher 2002). Drought conditions persisted from 2013 through 2022, which likely worsened CRLF habitat quality in Bear Creek during this period. In 2023, above average rainfall levels rehydrated portions of Bear Creek, including the basin at the western terminus of the creek.

Biologists performed a night survey of this basin in April 2023, but only detected Baja California tree frogs (*Pseudacris hypochondriaca*) despite suitable CRLF habitat. Given the protracted drought conditions from 2013 to 2022, new surveys and habitat assessments of Bear Creek will be performed in 2023-2024 to re-evaluate habitat quality and the CRLF population size in order to establish baseline conditions. However, because baseline conditions would be established during high levels of launch activity, if declines in Honda Creek are observed, the DAF would assume similar declines/habitat degradation are occurring in Bear Creek and would implement mitigation 2:1 (see Section 2.2). If no declines are observed in Honda Creek, then the DAF will assume no declines in Bear Creek.

2.1.1.3 Santa Ynez River

Quarterly protocol night surveys of the Santa Ynez River on VSFB, performed from winter 2014 through fall 2015, documented between 4 and 13 adult CRLF per survey, with an average of 8.5 adult CRLF per survey. The majority of these observations were within an agricultural runoff channel on the southeastern side of the 13th Street Bridge (MSRS 2016). Upstream of the bridge, from approximately 200 meters (m) east of the bridge to the base boundary, only one adult CRLF was detected in the stretch of the Santa Ynez River extending from during the 2015 survey efforts. Only one additional adult CRLF has been detected within this stretch during survey efforts in 2008 (MSRS 2009). Detection rates during these surveys on the lower stretch, which included the agricultural channel, varied between 0.8 to 12 CRLF detected per surveyor-hour. In July 2015, the population for larval CRLF on VSFB in the lower Santa Ynez River was estimated at 8,769, based on data collected from the seine netting (MSRS 2016). Note that the USFWS BO misinterpreted the results of the 2015 surveys and mistakenly estimated adult population size at 3,654 individuals based on the survey results for <u>larval</u> CRLF (USFWS 2023, page 43).

The 13th Street Bridge was replaced during a two-year construction effort from August 2016 to October 2017. During this project the agricultural runoff channel was almost entirely removed. The channel was reconstructed at the end of the project, with efforts made to recreate the deep pools the channel had included prior to construction. Sedimentation of the drainage from off-base agricultural fields quickly decreased the depth of these pools to approximately 6 inches on average. During monthly night surveys of the area impacted by bridge replacement project from November 2017 through October 2018, between 0 and 5 adult (average 1.25) CRLF were observed per survey, with an overall average of 0.47 adult CRLF per surveyor-hour (MSRS 2018b). Most CRLF were observed in the main channel of the Santa Ynez River, with very low numbers within the agricultural runoff channel. Although up to 5 CRLF were detected calling in 2018, no tadpoles were observed during seine surveys in July 2018 (MSRS 2018b). The lower number of observations and detection rates suggests that the loss of the agricultural channel impacted the CRLF population in the area surrounding the bridge. As of 2022, the habitat in the agricultural channel remained shallow and completely filled with emergent vegetation (A. Abela, pers. comm.). Therefore, we estimate the most current population baseline to be 5 adult CRLF in the lower Santa Ynez River.

2.1.2 Population Monitoring Surveys

CRLF survey areas are depicted in Figure 2.1-1. Quarterly night surveys for CRLF and spring tadpole surveys of lower Honda Creek, Bear Creek, and the Santa Ynez River will be conducted to compare baseline CRLF occupancy data collected over the past 10 years and assess if there are any changes in CRLF habitat occupancy, breeding behavior (calling), and breeding success (egg mass and tadpole densities). The Space Force will record and measure the following during the surveys:

a) CRLF detection density following the same survey methods conducted previously at these sites and throughout VSFB;
b) CRLF locations and breeding evidence (e.g., calling, egg masses);
c) environmental data during surveys (temperature, wind speed, humidity, and dewpoint) to determine if environmental factors are affecting CRLF detection or calling rates;
d) annual habitat assessments to measure flow rates, stream morphology, depths, quantify suitable occupied habitat and sediment to determine if any changes in CRLF metrics are associated with other environmental factors, such as drought;
e) and, locations and densities of co-occurring anurans, including bullfrogs (*Lithobates catesbeianus*) and Baja California tree frogs (*Pseudacris hypochondriaca*).

Nighttime spot-lighting surveys will be conducted by USFWS-qualified biologists quarterly along set survey stretches that have been routinely surveyed in past efforts, ranging in length from approximately 500 to 1,700 m, at Honda Creek, Bear Creek, and the Santa Ynez River (Figure 2.1-1). These stretches were selected because of the availability of prior data collected on these same stretches in the same manner as being proposed in this plan. One of these surveys will be conducted each year during peak breeding season (typically November through April, depending on rainfall. Surveys will begin at least 20 minutes after dark. The survey time, air temperature, relative humidity, and wind speeds will be recorded at the start and the end of each survey. The start and end points of each survey will be marked with a handheld Garmin global positioning system (GPS) device. During surveys, biologists will visually scan for frogs with high-powered waterproof flashlights (Underwater Kinetics® C8 eLED plus or equivalent). In shallow water, surveyors will travel in pairs on foot, moving slowly in single file, separated by approximately 3.0 to 6.0 m. The lead surveyor will scan the water and banks ahead to spot frog "eye shine" while also scanning the sides for frogs hidden in vegetation. The second surveyor will focus primarily on banks and previously traversed areas to the rear while avoiding illumination of the lead surveyor. Frogs that dive prior to detection by the lead surveyor frequently resurface once surveyors have passed and are detected by the second surveyor.

When a frog is located, the surveyor will move as close as necessary to positively identify species, estimate snout-vent length (SVL) in millimeters (mm), and identify sex of adult frogs (when possible). CRLF will be divided into age classes based on SVL according to Table 2.1-2. The location of each frog will be recorded using a GPS unit. Breeding behaviors, such as amplexus or calling, and egg masses will be noted when observed. These survey data will be used to calculate CRLF detection density (number of individuals per survey hour) following the same survey methods conducted previously at these sites and throughout VSFB. A relative index of population density will be calculated based on the number of adult frogs per surveyor hour. Metamorphic CRLF (metamorphs) will not be included in this estimate since timing of metamorphosis can vary from year to year, and a sudden influx of large numbers of metamorphs could skew results when making year-to-year comparisons. Therefore, the number of metamorphs observed will be reported separately. The CRLF population density index will be compared to the established CRLF baseline occupancy data at each feature (see Section 2.1.1). The Space Force will provide the Service original data used to establish California red-legged frog baseline occupancy data as well as data from future annual survey efforts appended to the annual report.

In order to assess breeding success at each site, aquatic surveys will be conducted in the survey stretches depicted in Figure 2.1-1. A beach seine, appropriately sized for capturing amphibian larvae and small fish (3 or 5-m wide x 2-m tall net with 0.6-centimeter [cm] mesh) to perform drag transects.

To sample each reach, select areas suitable for CRLF breeding will be enclosed with block nets to prevent animals from leaving the survey area. Two surveyors will move the seine into position and drag the seine through the water. The dimensions of the area sampled will be recorded. Seining will continue until most animals are determined to have been captured. To prevent the escape of animals during drags, surveyors will take care to ensure that the bottom of the seine maintains good contact with the bottom of the creek while ensuring the top of the net does not fall below the surface.

All vertebrates captured will be identified, measured, and tallied into size categories (0 to 1- cm, 1 to 2-cm, 2 to 3-cm, 3 to 4-cm, etc.). Amphibian larvae developmental stages will also be recorded. In addition, larvae will be inspected for any signs of deformities. If any deformities are observed, the number of larvae affected will be recorded and a representative sample will be photographed prior to release. Captured animals will be temporarily housed in five-gallon buckets. All native species will be released following quantification; non-native species will be dispatched.

Table 2.1-2. Age class and corresponding SVL for VSFB ranids.

Age Class	California Red-legged Frog	American Bullfrog
Metamorph	SVL < 40 mm and tail ≤ 10 mm	SVL < 60 mm and tail ≤ 10 mm
Juvenile	SVL ≥ 40 mm and < 70 mm	SVL ≥ 60 mm and < 100 mm
Adult	SVL ≥ 70 mm	SVL ≥ 100 mm

All biologists will follow the Declining Amphibian Populations Task Force fieldwork code of practice (DATF 2019) to avoid conveying diseases between work sites and will clean all equipment between use following protocols that are also suitable for aquatic reptiles.

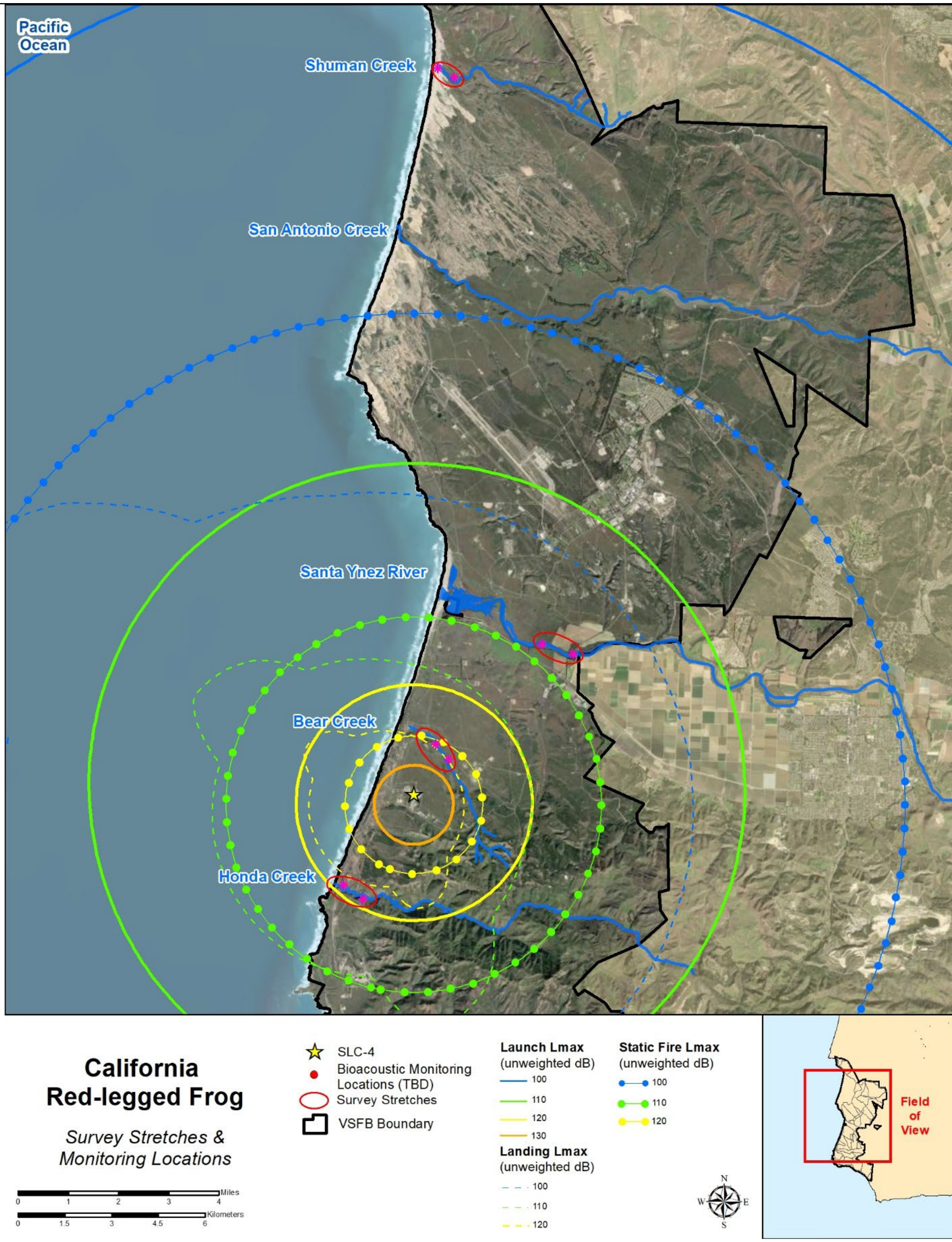

Figure 2.1-1. California red-legged frog survey stretches and bioacoustic monitoring locations. (Note: final bioacoustic monitoring locations will be based on field assessments and observations of breeding activity)

2.1.3 Bioacoustic Monitoring

To characterize and analyze impacts of Falcon 9 launch, static fire, and SLC-4W landing noise events on calling behavior during the breeding season, bioacoustic sound recorders (Song Meter 2 [SM2], Wildlife Acoustics, Inc., Maynard, Massachusetts, www.wildlifeacoustics.com) will be used to passively study the effects of sonic booms on CRLF calling behavior at two suitable breeding locations each, in Honda Creek, Bear Creek, and the Santa Ynez River. The locations and suitability of breeding habitat can be affected by storms, beaver activities, and other natural factors during and between breeding seasons. As a result, CRLF breeding and calling locations may fluctuate during the course of the breeding season and between years. Therefore, pre-surveys will be conducted to assess where suitable breeding habitat exists and calling CRLF are observed at the beginning of the breeding season (typically 30 November to 1 April). The SM2 recorders will be placed at these locations initially, but may be moved a short distance during the season if breeding activity shifts to different areas. The recorders would not be moved if CRLF leave a breeding location and the location is still suitable for breeding. In this case, additional SM2 recorders would be placed at any new breeding locations and continue to be maintained at the location where breeding ceased.

The SM2 units will be programmed to record to a Secure Digital (SD) 128 gigabyte card in .wav format and in stereo. The SM2 units will record continuously during the monitoring period using a sample rate of 24 kilohertz (kHz). The units will be set to the default of 16 dB gain, which is a good compromise between detecting weaker signals from animals further away, while avoiding clipping of louder sounds; however, this may be adjusted in order to improve data quality if necessary. Continuous recording at the study sites affected by noise will allow baseline call parameters (signal rate, call frequency, amplitude, call timing, call duration) to be established and enable assessment of the potential short- and long-term effects that may result from increasing frequency of Falcon 9 noise events. Because environmental factors can affect these call parameters, each SM2 unit will be paired with a temperature and humidity data logger (Kestrel Drop 2 [D2], Nielsen-Kellerman Company, Boothwyn, Pennsylvania, https://kestrelinstruments.com). The D2 data loggers record temperature and relative humidity every 10 minutes over the course of the entire monitoring period to enable calling parameters to be analyzed with environmental data. Dew point will be calculated for use in the analyses using the following formula:

$$T_s = (b \times \alpha(T,RH)) / (a - \alpha(T,RH))$$

where:

T_s – Dew point (in degrees Celsius);

T – Temperature (in degrees Celsius);

RH - Relative humidity of the air;

a and b are the Magnus coefficients (a = 17.625 and b = 243.04 °C; and $\alpha(T,RH) = \ln(RH/100) + aT/(b+T)$

The SD cards in the units will be routinely collected and changed so that the .wav files can be uploaded to a computer and both channels analyzed using Kaleidoscope Pro 5.4.6 Software (Kaleidoscope; Wildlife Acoustics, Inc.). Kaleidoscope software is designed to scan sound files and automatically recognize noise patterns based on specified signal detection parameters (frequency range in hertz [Hz], length of detection in seconds, and gap between detections in seconds). Kaleidoscope pulls each “detection” (sound patterns that meet the parameters) into separate files that can be reviewed individually for positive and false detections. It further creates clusters of those files that have similar patterns and attributes to enable rapid review of similar types of sounds.

In order to set signal detection parameters that would reliably detect CRLF while minimizing false positives, MSRS has completed scans of the acoustic files from prior bioacoustic monitoring efforts at Honda Creek and Shuman Creek. Kaleidoscope created more than 100 clusters which were manually inspected by a biologist adept in recognizing various CRLF calls. Of those, 12 clusters contained CRLF calls. The biologist used the attributes of those clusters to set signal detection parameters that would reliably detect the variety of CRLF calls. The maximum and minimum frequency ranges were set to 250 to 3,200 Hz, minimum and maximum length of detection was set to 0.1 to 7.5 seconds, and the maximum inter-syllable gap was set to 0.35 seconds. All audio files from each unit will be scanned using these parameters. Each detection will be manually reviewed to verify positive CRLF and remove false detections until the biologists are confident that Kaleidoscope is reliably detecting CRLF calls. In addition, the DAF will adapt analytical methods outlined in Kruger and Du Preez (2016) and Higham et al. (2021) to analyze changes in spectral and temporal properties of CRLF calls immediately before and after Falcon 9 noise events. Finally, the DAF will attempt to estimate chorus size (number of calling frogs) from the recordings. But, given the small size of pools on Honda Creek, lack of pools on Bear Creek, and annual changes to habitat features on the Santa Ynez River, estimates of chorus size are not likely to be a good parameter to rely on to identify changes in populations.

Bioacoustic monitoring data will be analyzed in relation to results from annual breeding surveys and quarterly population surveys, and, to a lesser extent, chorus size estimates, to determine if any short- and long-term changes in CRLF habitat use or population sizes are related to the observed call parameters.

2.2 California Red-legged Frog Mitigation

2.2.1 California Red-legged Frog Mitigation Threshold Criteria

Mitigation for potential impacts to CRLF populations will be performed if:

1) CRLF occupancy, calling rate, or tadpole densities decline from baseline (see Section 2.1.1, Pre-project Baseline) by 15 percent or more; and
2) the 15 percent decline from baseline continues for two consecutive years.

If these threshold criteria are met and cannot confidently be attributed to other natural- or human-caused catastrophic factors, not related to the project, that may eliminate or significantly degrade suitable habitat, the DAF will mitigate for these impacts. The DAF will review the suspected cause of decline with the USFWS and reach agreement. If the cause of declines is determined to be inconclusive, the DAF will implement mitigation described below. Examples of potential catastrophic scenarios include the following:

1) Fire, unrelated to project activities or launch operations, that directly impacts Honda Canyon and is demonstrated to degrade or eliminate breeding habitat.
2) Landslides or significant erosion events, unrelated to project activities or launch operations, that result in the elimination or degradation of CRLF breeding habitat.
3) Drought or climate impacts that quantifiably reduce available aquatic habitat further than what was available during existing baseline.
4) Flash flood events during the breeding season that are more significant than what was experienced during the existing baseline.

2.2.2 California Red-legged Frog Mitigation Actions

The DAF will create new suitable CRLF habitat (breeding and non-breeding aquatic habitat and suitable riparian canopy) at a 2:1 ratio (habitat enhanced: habitat affected) for adverse effects to occupied CRLF habitat. In the event declines are observed within surveyed areas (see Figure 2.1-1; Lower Honda Creek, Bear creek, Santa Ynez River) that surpass the identified threshold criteria (Section 2.2.1), the Space Force would use National Wetlands Inventory data that is located within the project's impact area (within 110 dB, 1.5 PSF contours) of each feature to calculate CRLF habitat acreage for purposes of mitigation. The Space Force would provide final mitigation acreage calculations to the Service for verification. Restoration would occur at the San Antonio Creek Oxbow Restoration Area, an established wetland mitigation site that is located outside of areas impacted by launch noise over 110 dB on VSFB (Figure 2.3-1). This abandoned tract of agricultural land (Figure 2.3-2) was historically occupied by riparian vegetation and is a suitable location to improve San Antonio Creek and provide breeding habitat for CRLF. Within a portion of the site where restoration has already been performed as mitigation for an unrelated project, CRLF survey performed on 18 April 2023 documented a wide range of CRLF age classes (with the majority of them being adults) utilizing the newly completed site (Figure 2.3-1). In addition, calling CRLF were observed. Therefore, this mitigation strategy is proven to be successful at creating suitable breeding habitat.

The mitigation would be conducted in the "expansion area" adjacent to the current restoration area (Figure 2.3 3). The method involves digging a channel that reaches ground water and using the spoils to create a berm that will be planted with willows (Figure 2.3-4). This method creates deep water aquatic habitat, suitable for CRLF breeding, and riparian woodland that simulate naturally occurring high-flow channels.

Actions taken within this area will include site preparation via herbicide application, plowing, container plant installation, seeding, willow pole planting (via water jet, hand-held power auger, or manually driving a steel rod into the ground), and watering via water truck. The mitigation actions for CRLF are included under an existing USFWS BO (2016-F-0103) and all applicable avoidance, minimization, and monitoring measures required under BO 2016-F-0103 would be implemented. Restoration efforts would commence the same year that threshold criteria were surpassed.

As indicated in the existing USFWS BO (2022-0013990-S7-001) should the Oxbow Restoration site's available acreage not fulfill mitigation requirements depicted above, the Space Force will provide additional restoration areas or alternative projects addressing CLRF recovery objectives located outside of project impact areas and coordinated with the Service to achieve requirements. Additional restoration areas or alternative projects will be coordinated within one month of surpassing threshold criteria and commence within the same year.

2.2.3 California Red-legged Frog Mitigation Success Criteria

Success criteria would be evaluated following protocol survey methods by performing quarterly night surveys, annual tadpole surveys, and habitat assessments of the mitigation site. These surveys would begin one year after initiation of the mitigation actions to allow time for the restoration actions to be performed and outplantings and willow poles to grow. Within 5 years or less from initiation of CRLF mitigation actions described above, the following success criteria are expected to be achieved:

1) Suitable aquatic and upland foraging habitat within the mitigation site;

2) Detection of post-metamorphic CRLF within the mitigation site following protocol survey methods. Within 5 years, CRLF abundance at mitigation sites would show increasing trends. Within 10 years, to ensure no net loss, mitigation sites will demonstrate species abundance comparable with impacted areas; and
3) Evidence of breeding activities (e.g., calling, detection of egg masses, detection of larvae).

If success is not achieved within 3 years or less, the DAF would begin coordination with the USFWS on additional adaptive mitigation. This would allow adequate time to develop and discuss additional measures to be implemented quickly should declines continue.

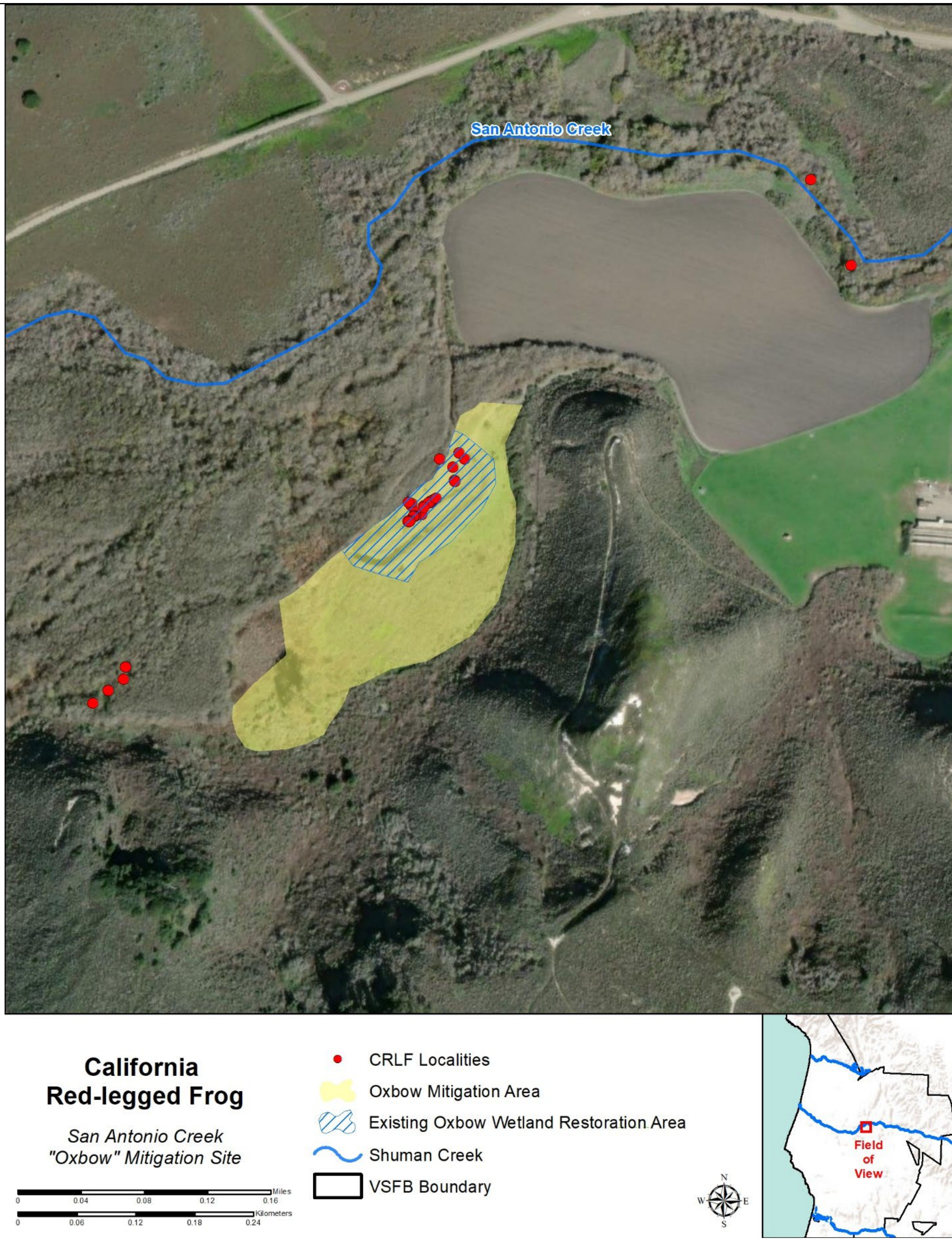

Figure 2.2-1. California red-legged frog "Oxbow" mitigation site.

Figure 2.2-2. Aerial view of San Antonio Creek "Oxbow" restoration site prior to restoration efforts that are currently being conducted.

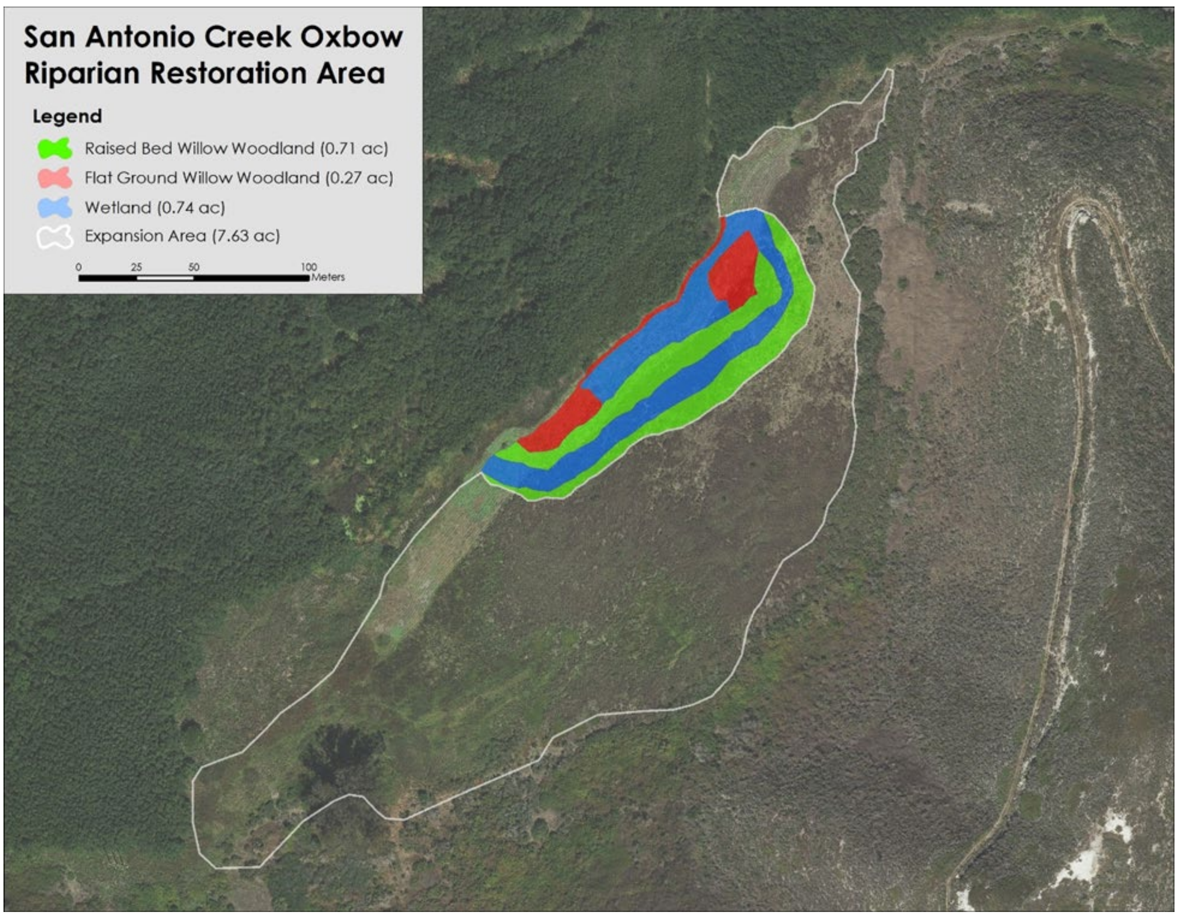

Figure 2.2-3. Current restoration efforts (blue, red, and green) and existing expansion area that would be restored at a 2:1 mitigation ratio.

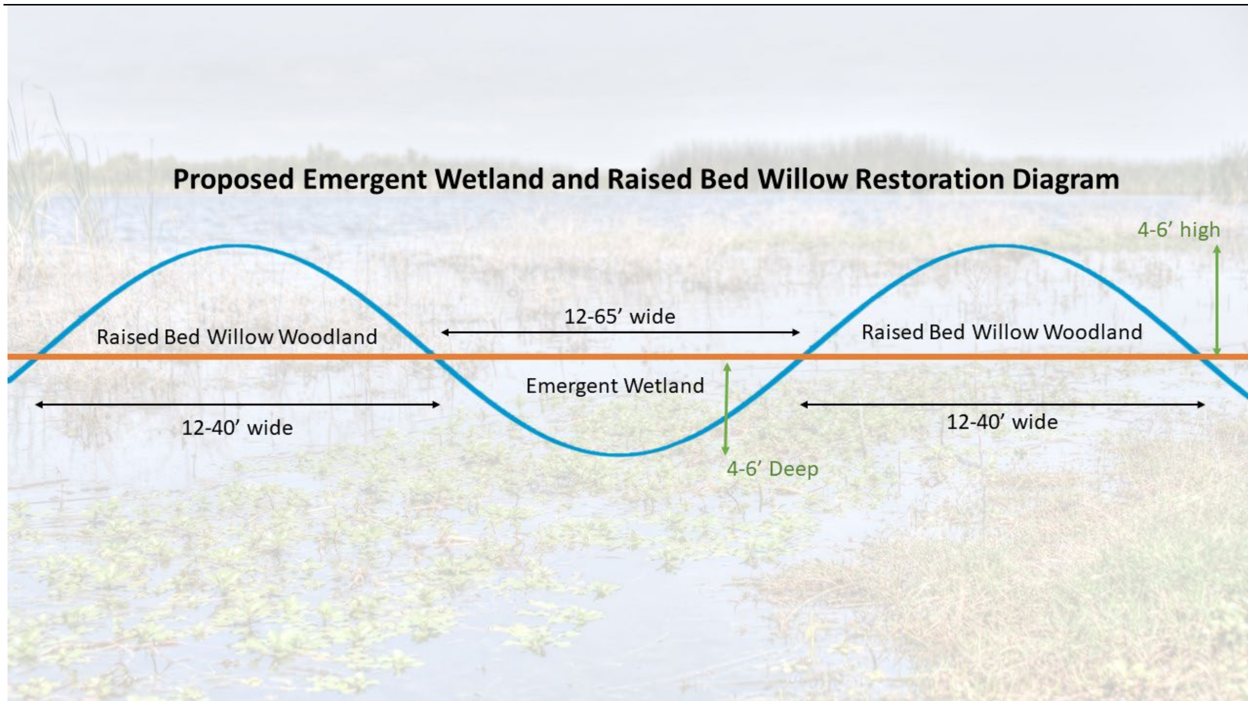

Figure 2.2-4. Contouring plan to successfully create CRLF habitat.

3 Western Snowy Plover Monitoring and Mitigation

3.1 Western Snowy Plover Monitoring

3.1.1 Pre-Project Baseline

Annual SNPL population and nest surveys have been performed since 1993. The breeding population size at VSFB was highly variable between 1994 and 2000, ranging from 78 adults in 1999 to 420 adults in 2004 (Robinette et al. 2015). Since 2007, the SNPL population has been relatively stable, with a mean of 245 adults and 345 nests between 2000 to 2016 (Robinette et al. 2023). The mean hatch rate from 1994 to 2022 was 45% (Robinette et al. 2023). The mean fledge rate from 1997 to 2022 was 36% (Robinette et al. 2023). All nest attempts have been recorded geographically enabling geospatial analyses to be performed for potential relationships between noise associated with rocket launches and nest locations and nest fates. Over the most recent 10 year period with relatively low levels of launches per year (2011-2020), the mean number of nest attempts within the 2 psf zone, displayed in Figure 3.1-1, was 117.3 ± 18.1 standard deviation (SD) or a 95% confidence interval of 106.1 to 128.5%. The hatching success rate within the 2 psf zone averaged 41.1% ± 14.1% SD or a 95% confidence interval of 32.3% to 49.8%.

3.1.2 Annual Population and Nest Surveys

Annual SNPL population and nest surveys will be conducted following the USFWS-approved *Monitoring Protocol for Western Snowy Plover on Vandenberg Air Force Base* (DAF 2011).

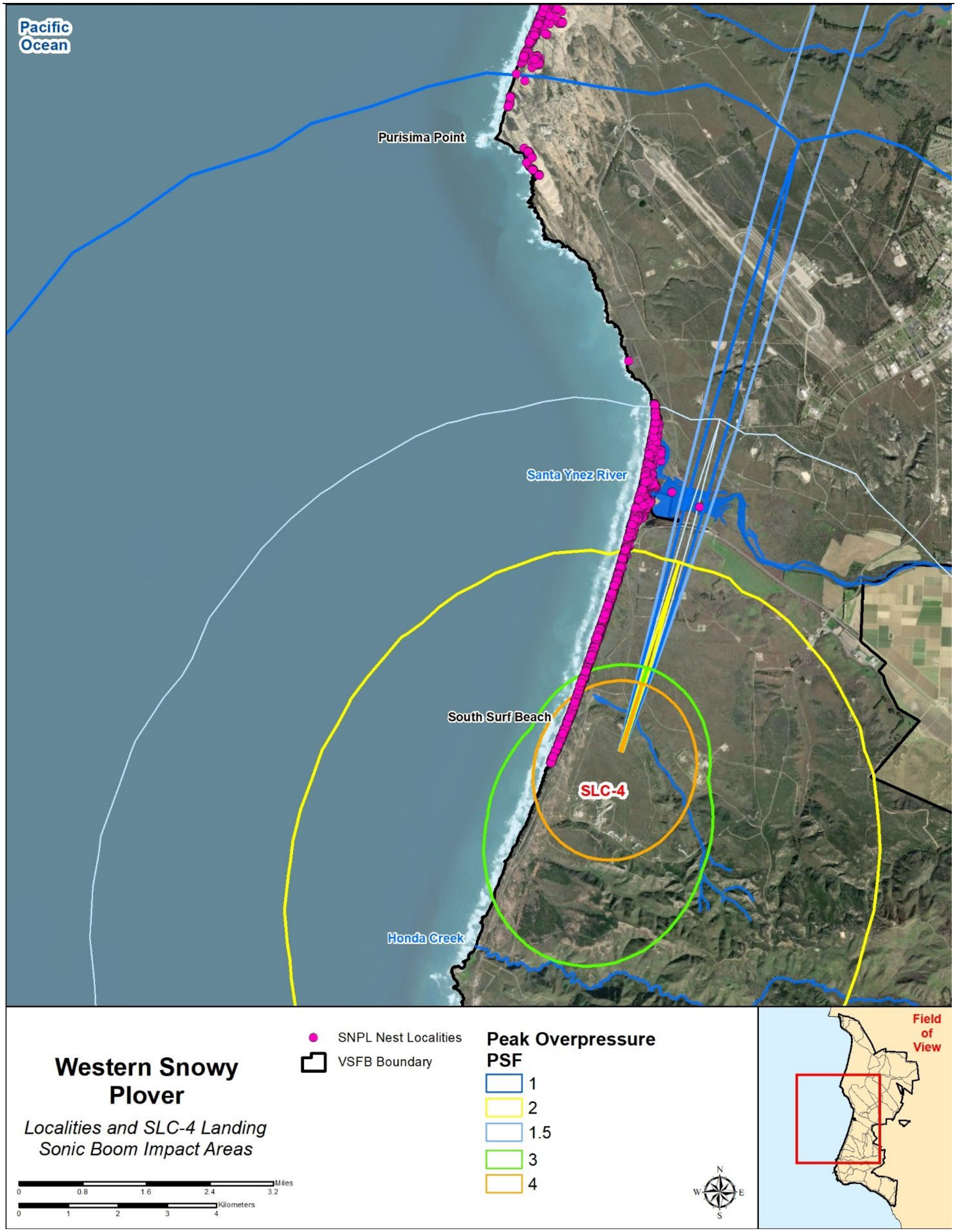

Figure 3.1-1. Western snowy plover nest records and sonic boom footprint.

3.1.3 Launch Monitoring

Motion triggered video cameras will be deployed to monitor active SNPL nests at South Surf Beach during the breeding season (1 March through 30 September) to determine potential impacts to nests due to launches and landings. The cameras will be placed in a manner that minimizes disturbance to nesting SNPL, as determined in the field based on the best judgement of a permitted biologist. Within the 4 psf zone, the DAF will monitor whichever is larger: 10 percent of active SNPL nests, or 4 active SNPL nests. Within the modeled 3 to 4 psf zone the DAF will monitor whichever is larger: 10 percent of active SNPL nests, or 2 active SNPL nests. Within the modeled 2 to 3 psf zone displayed, the DAF will monitor whichever the following is greater: 5 percent of active SNPL nests, or 4 active SNPL nests.

The DAF will also deploy landscape level camera monitoring in conjunction with individual nest cameras to document SNPL response to launch and sonic boom noise and overpressures. The landscape level camera(s) will be capable of long-term recording, time marking the moment of disturbance events, and deployed adjacent to areas of highest density nesting to best capture population level reaction. Camera installation and placement will be conducted by a USFWS approved biologist to ensure no additional effects would occur (i.e., perching for raptors).

The DAF will review the nest camera recordings as soon as possible.

3.1.4 Acoustic Monitoring

The DAF will utilize two approaches for acoustic monitoring. The first approach will characterize the acoustic environment at SNPL nesting areas at South Surf Beach. The DAF will conduct acoustic monitoring throughout the SNPL breeding season (1 March through 30 September) by placing a sound level meter (SLM) immediately inland of South Surf Beach to characterize the noise environment and any related launch and landing associated disturbance. The SLM station consists of a pelican case, external mic w/windscreen on a ground plate, and solar panel (Figure 3.1-2). The SLM stations will enable the DAF to quantify baseline peak and cumulative noise parameters and analyze how those parameters change as launch cadence increases.

The second approach will be used to quantify the overpressure (sonic boom) and engine noise levels generated during each launch and return flight of the Falcon 9 (only for return flights to VSFB). A SLM recording unit will be deployed at the SNPL monitoring location on South Surf Beach with a high-fidelity broad range microphone and pre-amplifier. The system allows for accurate measurements of rocket engine noise and sonic boom in a variety of parameters that will be used in analyses of both short-term and long-term effects of rocket noise.

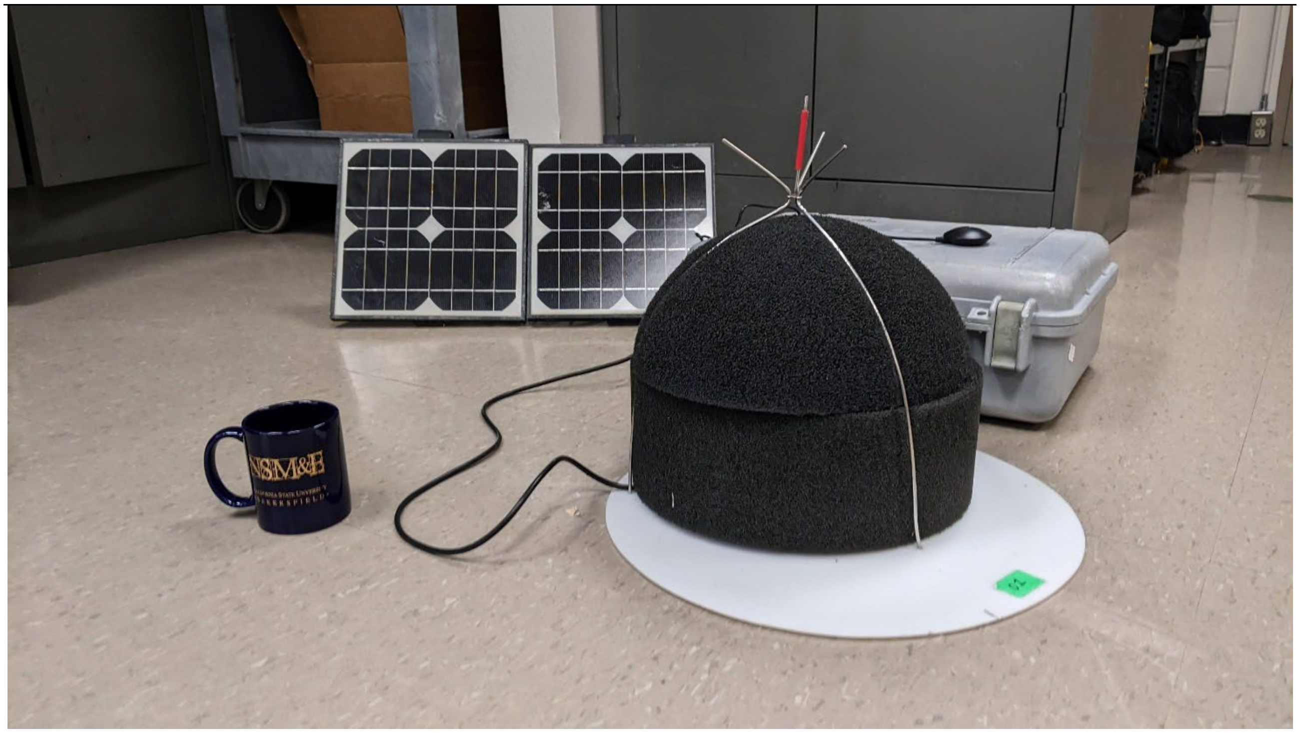

Figure 3.1-2. Acoustic environment station to be deployed at SNPL and LETE monitoring locations.

3.1.5 Geospatial Analysis

The DAF will augment the current SNPL monitoring program on VSFB by performing geospatial analysis of nesting activity on South Surf Beach to assess potential adverse effects from Falcon 9 noise events. As discussed above, the current basewide SNPL monitoring program estimates breeding effort, nest fates, and fledging success while recording patterns of habitat use throughout the season. The DAF will perform geospatial analysis to identify any spatial relationship in the SNPL population, nesting activity, and reproductive success that may result from cumulative effects of multiple launches and landings from SLC-4.

The DAF will leverage the existence of the long-term SNPL dataset at VSFB to examine whether there are any relationships between launch activities over the past two decades and the nesting ecology of the SNPL. Based on the cadence of launches since the early 2000s compared to prior decades, the last 20 years have been a quiet period for launches. This relatively quiet period will provide a baseline for shorebird nesting ecology. A baseline to which we can compare the expected increase in launch cadence over the next several years. During the baseline period of 2011-2020, nest density, hatch success, spatial distribution of nests [i.e., heatmap]) over time in response to rocket launches as well as investigating potential yearly lag effects, will be modeled. This effort will use the results of the data-validated sound environment modeling as inputs. Other covariates important to shorebird nesting (e.g., temperature, precipitation, nest depredation, habitat restoration, etc.) will be input to these models to help differentiate the potential effects of noise versus other factors. A variety of generalized linear regression (Hall et al. 2018; Nix et al. 2018; Hall et al. 2021; Ochoa et al. 2021) and machine learning approaches will be used in this effort.

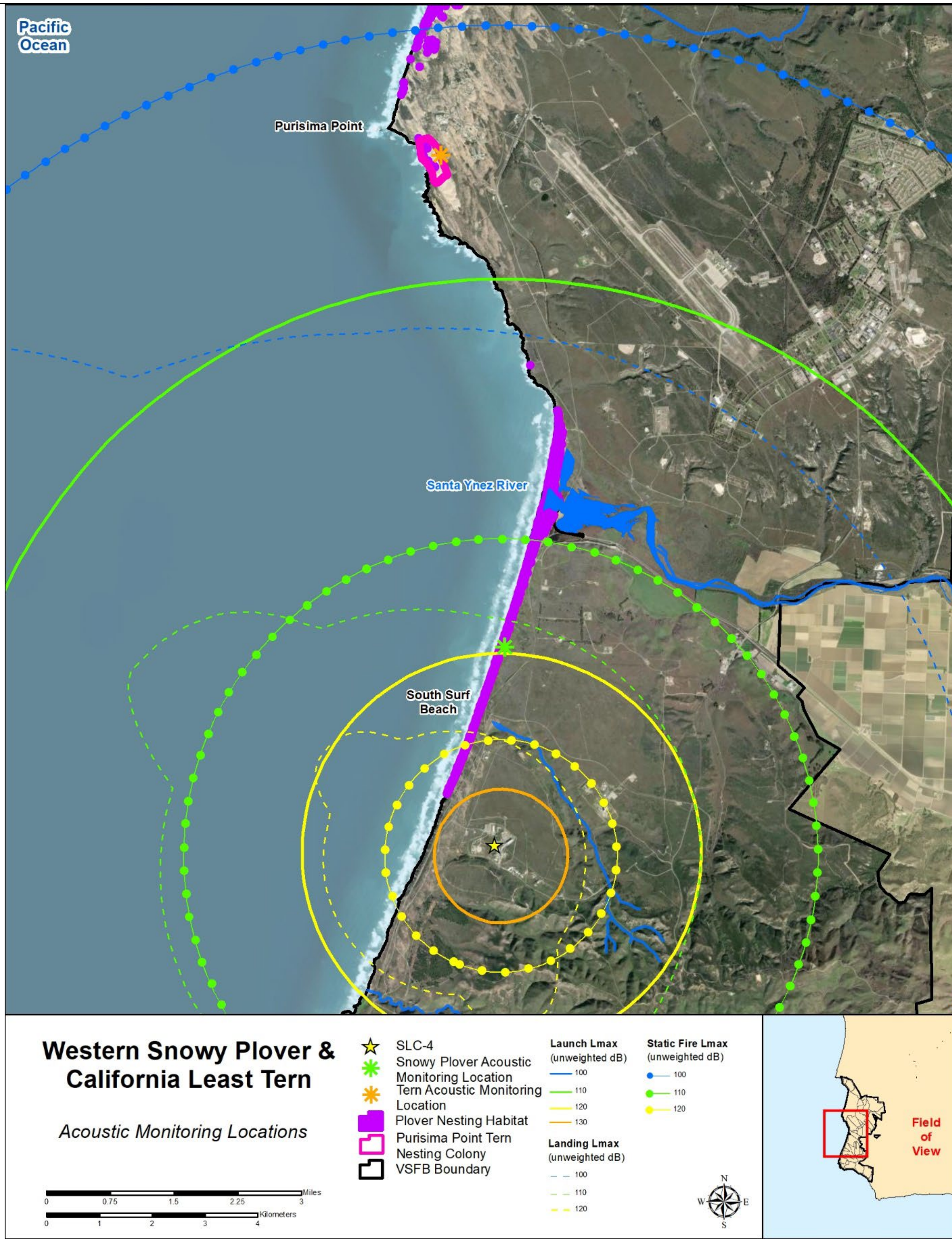

Figure 3.1-3. Western snowy plover and California least tern acoustic monitoring locations.

3.2 Western Snowy Plover Mitigation

3.2.1 Western Snowy Plover Mitigation Threshold Criteria

The threshold for the DAF to perform mitigation for negative impacts to SNPL are:

1) Geospatial analysis shows a statistically significant decline (defined as a decline greater than the baseline annual variation in these variables between 2011-2020 at South Surf Beach) in population or reproductive success, and
2) the decline from baseline maintains over two consecutive years within the areas impacted by noise from the Falcon 9.

A decline from baseline would be considered statistically significant if a Student's t-test revealed a significant negative difference in nest attempts, hatch rate, or basewide adult population compared to the baseline values of variation in these data (2011-2020, see Section 3.1.1) within the 2 psf zone at the alpha 0.05 level. The DAF may substitute non-parametric statistical tests if the data do not meet the assumptions of normality or a more powerful/appropriate scientifically accepted statistical approach is identified in coordination with the Service.

If the threshold criteria are met and cannot confidently be attributed to other natural- or human-caused catastrophic factors, not related to the Proposed Action, that may eliminate or significantly degrade suitable habitat (see potential scenarios described below), the DAF will mitigate for these impacts as discussed below. Examples of potential catastrophic scenarios include the following:

1) Significantly higher levels of tidal activity, predation, etc. as compared with the existing baseline and demonstrable across remainder of base population.
2) Significant avian disease demonstrable across the recovery unit.
3) Separate work activities (i.e., restoration efforts) not related to the project.

The DAF will review the supported cause of decline with the USFWS and reach agreement. If cause of declines is determined to be inconclusive, the DAF will implement the proposed mitigation.

3.2.2 Western Snowy Plover Mitigation Actions

Mitigation for potential impacts to the SNPL would involve increasing predator control efforts in the non-breeding season. Currently, the DAF funds three full-time staff to perform predator control efforts on VSFB during the breeding season. The DAF would add one full-time staff to continue these activities through the non-breeding season. These activities would include trapping, shooting, and tracking known predators of SNPL with particular focus on raven removal at and adjacent to VSFB beaches. The DAF would report predator removal efforts and success within an annual report.

3.2.3 Western Snowy Plover Mitigation Success Criteria

Within 5 years or less from initiation of SNPL mitigation actions described above, the threshold variables (nesting attempts and hatch rate within the 2 psf zone and basewide adult population) are expected to rebound to the 10-year baseline levels (2011-2020). These variables would be evaluated using the same statistical tests discussed in Section 3.2.1, above. The mitigation would meet the success criteria if these variables were not statistically significantly less than the 10-year baseline levels (2011-2020) at the alpha 0.05 level for two consecutive years. In the event declines are still observed across 3 years of SNPL mitigation consecutively, the USSF will coordinate with the USFWS in Year 3 on what additional actions would be planned after Year 5 to supplement predator control efforts.

4 California Least Tern Monitoring and Mitigation

4.1 California Least Tern Monitoring

4.1.1 Pre-Project Baseline

The pre-project baseline for LETE at VSFB has been established from 28 years of continual annual population and nest surveys. From 2001 to 2020, excluding 2002 and 2005 due to specific impacts resulting from Delta II launches at SLC-2 and excluding 2004 and 2006 due to anomalous warm ocean temperatures which resulted in almost no nesting, the mean ± SD number of breeding LETE pairs per year at Purisima Point was 30.6± 18.0 SD, with a peak of 82 pairs in 2003 (Robinette et al. 2023). The mean ± SD fledglings per pair for this period was 0.81 ± 0.38 with a peak of 1.32 in both 2001 and 2015 (Robinette et al. 2023). Productivity appears to be tied to the occurrence of rockfish and anchovy in the diet (Robinette et al. 2015). However, despite high anchovies and rockfish occurrence in the 2022 diet, breeding productivity was below the average, indicating other factors may affect reproductive success, including oceanographic conditions and predation (Robinette et al. 2023).

4.1.2 Annual Population and Nest Surveys

Annual LETE population and nest surveys will be conducted in a similar fashion as the established protocols that have been employed on VSFB since the beginning of the LETE monitoring program on Base. Permitted biologists will survey the LETE colony at Purisima Point at least five days a week while LETE are present (typically April through August). Off-colony surveys will be conducted by making observations with binoculars and spotting scopes from six previously established observation points along the perimeters of the Purisima Point colony. Biologists will record numbers of adults on the ground and flying in the vicinity of the colony. Typically, 50 to 60 off-colony survey visits are conducted throughout each season. Biologists will not enter the colony until the first nests are observed. At that point, biologists will enter the colony on foot twice a week to record nest contents. Biologists will also enter the colony in order to retrieve dead chicks or investigate predator tracks. In addition, historical breeding sites on VSFB will continue to be monitored for potential LETE activity.

Once LETE begin to nest, the population will be estimated by documenting the number of active nests observed in the colony each day. All nests will be monitored in the colony throughout the breeding season to determine nest fate. This will allow the biologists to document second nesting attempts and overall colony site occupancy. As chicks begin to hatch and leave nest sites, biologists will record the numbers of chicks and fledglings observed during each survey. Visits to the colony will be conducted until all chicks have fledged and dispersed. Surveys will end after no adults or fledglings are seen at the colony for three consecutive visits.

On-colony surveys will be conducted by two biologists in the early morning when heat and wind are at a minimum. Each active nest site will be marked with a tongue depressor placed one meter from the nest. Tongue depressors will be placed facing the observation point that will best facilitate observations during off-colony surveys. The number of eggs and chicks found in each nest will be recorded, and any damaged or abandoned eggs and chick mortality will be documented.

4.1.3 Launch Monitoring

The DAF will deploy motion triggered video cameras during the breeding season (typically 15 April to 15 August) to determine LETE nest fates and potential impacts to nests due to launches and landings. The DAF will monitor at least 10 percent of active LETE nests at Purisima Point with motion triggered video cameras during the breeding season. The cameras will be placed in a manner to minimize disturbance to nesting LETE, as determined in the field based on the best judgement of a permitted biologist.

The DAF will also utilize landscape level camera monitoring in conjunction with individual nest cameras to document LETE response to launch and sonic boom noise and overpressures. The landscape level camera(s) will be capable of long-term recording, time marking the moment of disturbance events, and deployed adjacent to areas of highest density nesting to best capture population level reaction. The camera installation and placement will be conducted by a USFWS approved biologist to ensure no additional effects would occur (i.e., perching for raptors).

The DAF will review LETE nest camera recordings as soon as possible.

4.1.4 Acoustic Monitoring

The DAF will utilize two approaches for acoustic monitoring. The first approach will characterize the acoustic environment at LETE colony at Purisima Point. The DAF will conduct acoustic monitoring throughout the SNPL breeding season (typically 15 April to 15 August) by placing an SLM immediately inland of the colony to characterize the noise environment and any related launch and landing associated disturbance. The SLM station consists of a pelican case, external mic w/windscreen on a ground plate, and solar panel (Figure 3.1-1). The SLM stations will enable the DAF to quantify baseline peak and cumulative noise parameters and analyze how those parameters change as launch cadence increases.

The second approach will be used to quantify the overpressure and engine noise levels generated during each launch and return flight of the Falcon 9. A SLM recording unit will be deployed adjacent to the LETE colony at Purísima Point with a high-fidelity broad range microphone and pre-amplifier. The system allows for accurate measurements of rocket engine noise and sonic boom in a variety of parameters that will be used in analyses of both short-term and long-term effects of rocket noise.

4.1.5 Geospatial Analysis

The DAF will augment the current LETE monitoring program on VSFB by performing geospatial analysis of nesting activity at Purisima Point to assess potential adverse effects from Falcon 9 noise events. The current basewide LETE monitoring program estimates breeding effort, nest fates, and fledging success while recording patterns of habitat use throughout the season. The DAF will perform geospatial analysis to identify spatial relationships between the LETE population, nesting activity, and reproductive success and the cumulative effects of multiple launches and landings from SLC-4.

The DAF will leverage the existence of the long-term LETE dataset at VSFB to examine whether there are any relationships between launch activities over the past two decades and the nesting ecology of the LETE. Based on the cadence of launches since the early 2000s compared to prior decades, the last 20 years have been a quiet period for launches. This relatively quiet period will provide a baseline for shorebird nesting ecology. A baseline to which we can compare the expected increase in launch cadence over the next several years. During the baseline period of 2001-2020, nest density, hatch success, spatial distribution of nests [i.e., heatmap]) over time in response to rocket launches, as well as potential yearly lag effects, will be modeled. This effort will use the results of the data-validated sound environment modeling as inputs. Other covariates important to shorebird nesting (e.g., temperature, precipitation, nest depredation, habitat restoration, etc.) will be input to these models to help differentiate the potential effects of noise versus other factors. A variety of generalized linear regression (Hall et al. 2018; Nix et al. 2018; Hall et al. 2021; Ochoa et al. 2021) and machine learning approaches will be used in this effort.

4.2 California Least Tern Mitigation

4.2.1 California Least Tern Mitigation Threshold Criteria

The threshold for the DAF to perform mitigation for negative impacts to LETE are:

1) Geospatial analysis shows a statistically significant decline (defined as a decline greater than the baseline annual variation in these variables between 1995-2020 (as depicted in 4.1.1) at Purisima Point) in population or reproductive success, and
2) the decline from baseline maintains over two consecutive years within the areas impacted by noise from the Falcon 9.

If these threshold criteria are met and cannot confidently be attributed to other natural- or human-caused catastrophic factors, not related to the Proposed Action, that may eliminate or significantly degrade suitable habitat (see potential scenarios described below), the DAF will mitigate for these impacts as discussed below. Examples of potential catastrophic scenarios include the following:

1) Significantly higher levels of predation, lower prey availability, etc. as compared with the existing baseline and demonstrable across remainder of base population.
2) Significant avian disease demonstrable across the species range.
3) Separate work activities (i.e., restoration efforts) not related to project.

The DAF will review the supported cause of decline with the USFWS and reach agreement. If cause of declines is determined to be inconclusive, the DAF will implement the proposed mitigation.

4.2.2 California Least Tern Mitigation Actions

Mitigation for potential impacts to the LETE would involve increasing predator control efforts in the non-breeding season. These activities would include trapping, shooting, and tracking known predators of LETE with particular focus on raven and perhaps gull removal at and adjacent to VSFB beaches. The DAF would report predator removal efforts and success within an annual report.

4.2.3 California Least Tern Mitigation Success Criteria

Within 5 years or less from initiation of LETE mitigation actions described above, the threshold variables (adult population or nesting success at the Purisima Point colony) are expected to rebound to the baseline levels (see Section 4.1.1). These variables would be evaluated using the same statistical tests discussed in Section 4.2.1, above. The mitigation would meet the success criteria if these variables were not statistically significantly less than the baseline levels at the alpha 0.05 level for two consecutive years. In the event declines are still observed across 3 years of LETE mitigation consecutively, the USSF will coordinate with the USFWS in Year 3 on what additional actions would be planned after Year 5 to supplement predator control efforts.

5 Literature Cited

Christopher, S.V. 2002. Sensitive amphibian inventory at Vandenberg Space Force Base, Santa Barbara County, California, summary of preliminary results and site maps Appendix A Field Survey Data. Prepared for 30 CES/CEI.

[DATF] Declining Amphibian Task Force. 2019. Fieldwork Code of Practice. Available online: https://www.fws.gov/ventura/docs/species/protocols/DAFTA.pdf.

Department of the Air Force. 2011. Monitoring Protocol for Western Snowy Plover on Vandenberg Air Force Base.

Hall, L.K., R.T. Larsen, R.N. Knight, and B.R. McMillan. 2018. Feral horses influence both spatial and temporal patterns of water use by native ungulates in a semi-arid environment. Ecosphere 9: e02096.

Hall, L.K., R.T. Larsen, R.N. Knight, and B.R. McMillan. 2021. The influence of predators, competitors, and habitat on the use of water sources by a small desert carnivore. Ecosphere 12: e03509.

Higham, V., N.D.S. Deal, Y.K. Chan, C. Chanin, E. Davine, G. Gibbings, R. Keating, M. Kennedy, N Reilly, T. Symons, K. Vran, and D.G. Chapple. 2021. Traffic noise drives an immediate increase in call pitch in an urban frog. Journal of Zoology 313: 307–315.

Kruger, D.J.D., and L.H. Du Preez. 2016. The effect of airplane noise on frogs: a case study on the Critically Endangered Pickersgill's reed frog (*Hyperolius pickersgilli*). Ecological Research 31(3): 393-405.

ManTech SRS Technologies, Inc. 2009. Occurrence of the Amphibian Pathogen, Batrachochytrium dendrobatidis, in Ranids of Vandenberg Air Force Base, California. Prepared for 30 CEV/CEVNN.

ManTech SRS Technologies, Inc. 2014. Assessment of California Red-Legged Frog Habitat, Population Status, and Chytrid Fungus Infection on Vandenberg Air Force Base, California. ManTech SRS Technologies, Lompoc, California. 83 pp.

ManTech SRS Technologies, Inc. 2016. California Red-Legged Frog Habitat Assessment, Population Status, and Chytrid Fungus Infection in Cañada Honda Creek and San Antonio West Bridge Area on Vandenberg Space Force Base, California. Unpublished report. 51 pp.

ManTech SRS Technologies, Inc. 2018a. California red-legged frog habitat assessment, population status, and chytrid fungus infection in Cañada Honda Creek, Cañada del Jolloru, and seasonal pools on Vandenberg Air Force Base, California. Submitted to 30th Civil Engineer Squadron, Environmental Flight, Natural Resources Section (30 CES/CEIEA), Vandenberg Air Force Base, California.

ManTech SRS Technologies, Inc. 2018b. Post-Construction Biological Monitoring for 13th Street Bridge Replacement at Vandenberg Air Force Base, California. Prepared for 30 CES/CEIEA. 26 November 2018. 43 pp.

ManTech SRS Technologies, Inc. 2023. Biological Monitoring Report for the Honda Culverts Repair on Vandenberg Space Force Base, California.

Nix, J.H., R.G. Howell, L.K. Hall, and B.R. McMillan. 2018. The influence of periodic increases of human activity on crepuscular and nocturnal mammals: testing the weekend effect. Behavioural Processes 146: 16-21.

Ochoa, G.V., P.P. Chou, L.K. Hall, R.N. Knight, R.T. Larsen, and B.R. McMillan. 2021. Spatial and temporal interactions between top carnivores at water sources in two deserts of western North America. Journal of Arid Environments 184: 104303.

Robinette, D., J. Miller, and J. Howar. 2015. Monitoring and Management of the Endangered California Least Tern and the Threatened Western Snowy Plover at Vandenberg Air Force Base, 2015. Unpublished Report, Point Blue Conservation Science, Petaluma, CA.

Robinette, D., E. Rice, J. Miller, A. Fortuna, L. Hargett, and J. Howar. 2023. Monitoring and management of the endangered California least tern and the threatened western snowy plover at Vandenberg Space Force Base, 2022. Unpublished Report, Point Blue Conservation Science, Petaluma, CA.

U.S. Fish and Wildlife Service. 2023. Reinitiation of the Biological Opinion on the Launch, Boost-Back, and Landing of the Falcon 9 First Stage at Space Launch Complex 4 (SLC-4) at Vandenberg Space Force Base, Santa Barbara County, California (2017-F-0480). Ventura Field Office, Ventura California. 21 March 2023.

United States Department of the Interior
U.S. FISH AND WILDLIFE SERVICE
Ecological Services
Ventura Fish and Wildlife Office
2493 Portola Road, Suite B
Ventura, California 93003

IN REPLY REFER TO:
2022-0013990-S7-001-R001

August 28, 2024

Beatrice L. Kephart
30 CES/CEI
1028 Iceland Avenue
Vandenberg Space Force Base, California 93437

Subject: Biological Opinion on the Launch, Boost-Back, and Landing of the Falcon 9 First Stage at Space Launch Complex 4 (SLC-4) with project modification to include up to 16 additional launches between October 1 and December 31, 2024, Vandenberg Space Force Base, Santa Barbara County, California.

Dear Beatrice Kephart:

This document transmits the U.S. Fish and Wildlife Service's (Service) biological and conference opinion based on our review of the U.S. Space Force's (Space Force) proposed authorization of the Space Exploration Technologies Corporation (SpaceX or project proponent) to conduct up to 16 Falcon-9 launches from SLC-4 between October 1 and December 31, 2024 on Vandenberg Space Force Base (VSFB), and its effects on the federally threatened California red-legged frog (*Rana draytonii*) and western snowy plover (*Charadrius nivosus nivosus*), and the proposed threatened southwestern pond turtle (*Actinemys pallida*) (88 Federal Register [FR] 68370 68399), in accordance with section 7 of the Endangered Species Act of 1973, as amended (Act) (16 U.S.C. 1531 et seq.). We received your June 27, 2024, amended biological assessment and communicated request to initiate formal consultation on June 28th, 2024.

We have based this biological and conference opinion on information that followed your June 27, 2024 revised biological assessment (MSRS 2024a), previous relevant information included or coordinated following your 2022 biological assessment (MSRS 2022a) on related operations, as well as subsequent information coordinated in 2024 between Space Force and Service staff. Electronic documents of information related to the consultation are stored at the Ventura Fish and Wildlife Office.

Definitions Related to Launch Noise and Overpressure Disturbance

We include brief descriptions on launch noise and overpressure disturbance that will be referenced in the following 'Not Likely to Adversely Affect Determination' sections. More specific detail on this modeling can be located under 'Project Description' found later in this document.

Launch and Static Test Fire Noise

The highest sound pressure level measure during a single event is the SPL_{max}. Although it provides some measure of the event, SPL_{max} does not fully describe the noise disturbance because it does not account for how long the sound occurs. Sound exposure level (SEL) takes into account the length of time a noise occurs and provides a measure of the net impact of the entire acoustic event.

Each of the 16 proposed full launches would generate noise disturbance from the ignition of the rocket fuel with a maximum sound level of 150 decibels (dB) SPL_{max} on SLC-4. Noise level would attenuate outward in all directions reaching 100 dB approximately 17 miles away (Appendix A, Figure 1A–F, Launch Noise Effect Area).

Two associated terrestrial landings would occur and produce similar levels which are expected to attenuate more quickly. Consequently, launch landing noise has a slightly smaller footprint entirely encompassed within the Launch Noise Effect Area, reaching 100 dB SPL approximately between 5.8 and 10.5 miles away. The terrestrial landings would occur approximately 6 to 10 minutes following a launch ascent.

Similarly, a total of two static test fires could occur one day before a full launch and is also considered a separate form of launch disturbance. Static test fires would impact a smaller portion of a full launch's disturbance footprint over a substantially shorter duration (7 seconds) and are consequently a separate distinct disturbance event that is not comparable or substitutable for a full launch. Associated static test fires would also produce noise levels of up to 145 dB SPL_{max} with levels attenuating outward in all directions reaching 100 dB SPL approximately 9.8 miles away (USSF, unpublished project data, 2024a).

Launch descent Sonic Boom

Each proposed launch ascent and descent (landing at SLC-4) would generate a separate sonic boom. Each sonic boom would produce disturbance in the form of overpressure, which is high energy impulsive sound that would last a fraction of a second (BRRC 2020, p. 32). Overpressure disturbance from launch ascent and landing would impact separate areas (Appendix A, Figure 2A–P, Sonic Boom Overpressure Effect Area). Static test fires would not create a sonic boom.

During the two Falcon-9 descents, overpressure levels would be up to 9.5 pounds per square foot (psf) at SLC-4 itself. Based on the visuals provided, these levels would attenuate quickly to 5.0 psf within the immediate vicinity of the launch pad (USSF, unpublished project data, 2024a; Appendix A Figure 2B).

Overpressure can be expressed as instantaneous noise disturbance (SPL_{max}) by using a mathematical conversion from psf to decibel levels. The biological assessment did not include conversions of overpressure into instantaneous noise disturbance (SPL_{max}). The Service used past

Falcon 9 monitoring reports to reference these conversions for purposes of facilitating comparison (Robinette and Rice 2019, p. 14, 2022, p. 13; MSRS 2022b, p. 4).

Launch Ascent Sonic Boom modeling (Mainland California)

The Space Force has included specific sonic boom modeling for the proposed project's launch ascent easterly trajectories that will be referenced in the following 'Not Likely to Adversely Affect Determination' sections. More specific detail on this modeling can be located under 'Project Description; Launch Sonic Boom (Overpressure Disturbance); Mainland California (Southeastern Santa Barbara, Ventura, and Los Angeles Counties) – Launch Ascent'.

To briefly summarize, the Space Force includes that 75 percent of the 16 launches are expected to contain easterly trajectories. The Service consequently understands that there would be 12 associated sonic booms over the 3-month project period (each separated by an anticipated average of 5 days). The Space Force's provided modeling indicates that the sonic booms that would impact these areas would be reasonably certain to be less than 1.0 psf (MSRS 2024a, p. 112). The Service consequently understands that the proposed project's associated mainland sonic boom disturbance would be relatively infrequent and that none of these 12 launches would reasonably result in sonic booms of over 1.0 psf to mainland California. To help provide a clear project description, the Service uses this understanding to define parameters considered within analysis. Appendix A, Figures 2I-P, are included to provide visual depiction of sonic boom modeling impacts within mainland California.

Not Likely to Adversely Affect Determination

The Space Force's request for consultation also included the determination that the proposed action may affect but is not likely to adversely affect the federally threatened marbled murrelet (*Brachyramphus marmoratus*), California gnatcatcher (*Polioptila californica californica*), and southern sea otter (*Enhydra lutris nereis*), and the federally endangered California tiger salamander (*Ambystoma californiense*), California condor (*Gymnogyps californianus*), unarmored threespine stickleback (*Gasterosteus aculeatus williamsoni*), tidewater goby (*Eucyclogobius newberryi*), arroyo toad (*Anaxyrus californicus*), and light-footed Ridgway's rail (*Rallus obsoletus levipes*). The Space Force also requested informal conference on the proposed western spadefoot (*Spea hammondii*), which is under review for potential listing under the Act.

Marbled Murrelet

<u>Marbled Murrelet Occurrence</u>

There are 25 total observations of marbled murrelets offshore from VSFB between 1995 and 2023 (eBird 2024). In 2023, one observation recorded two marbled murrelets near Brown's Beach south of Lion's Head on VSFB. In 2011, one observation recorded approximately 0.5 mile west of SLC-4 indicated presence of a marbled murrelet at an unreported distance offshore. Two additional 1995 observations (each of one individual) taken from approximately 7.5 miles north of SLC-4 indicated presence offshore from Purisima Point. The remaining observations occurred north of Minuteman Beach. Marbled murrelets do not breed on VSFB due to lack of breeding habitat; project activities would only impact foraging adults which observers document infrequently. Marbled murrelet observations in this area have occurred as close as 984 to 6,561 feet from the shore (Strachan et al. 1995, p. 247).

Effects to Marbled Murrelet

Sound pressure and overpressure produced by the proposed project activities (launch, landing, and static test fire events) have the potential to affect marbled murrelets in the vicinity of SLC-4 during up to 16 launches, 2 boost-backs, and 2 static test fires between October 1, 2024 and December 31, 2024. Immediately off the coast, maximum anticipated noise levels during proposed activities at SLC-4 would be up to 130 dB SPL_{max} during Falcon 9 launches at SLC-4 (Appendix A, Figure 1D). This area would also experience sonic booms with overpressure levels up to 4.0 psf during each vehicle landing at SLC-4 (Appendix A, Figure 2E). However, marbled murrelets typically inhabit areas further off the coast (984 to 6,561 feet from shore) that would experience much lower noise levels. It is unknown how various noise and overpressure levels would affect marbled murrelet, but we expect any nearby individuals to exhibit a temporary startle response (i.e., dive and resurface) during launch, landing, or static test fire events and quickly return to normal behavior post-event (Bellefleur et al. 2009, p. 535). It is unlikely marbled murrelets would be present at the exact moment of a launch, landing, or static test fire event because of their transitory nature and overall scarcity within the action area. Therefore, the probability of noise-related impacts to marbled murrelets from project activities would be extremely low if they occur.

The Space Force has determined that there would be no effect to marbled murrelet populations located off-base from launch ascents with easterly trajectories that are likely to create low level (less than 1.0 psf) sonic booms (MSRS 2024a, p. 126).

Avoidance and Minimization Measures

1. The Space Force will ensure that annual marbled murrelet population surveys will continue to be conducted at the current levels to monitor the frequency and distribution of marbled murrelet within the action area.

After reviewing the information provided, we concur with your determination that the proposed action may affect but is not likely to adversely affect the marbled murrelet based on discountable effects. Our concurrence is based on the following:

1. Within the project vicinity, marbled murrelets occur irregularly and only as adults foraging offshore; they do not breed at VSFB.
2. Available monitoring data suggest that maximum noise levels produced from launch

operations are unlikely to have a significant effect on marbled murrelets. In the unlikely event any effects occur, we expect only minor temporary behavioral reactions to infrequent noise disturbance.

California Condor

California Condor Occurrence on VSFB

There have been two separate occurrences of California condor on VSFB based on GPS transmitter data: one individual in 2017 (studbook number 760) and another in 2022 (studbook number 1031). In both instances, it was a single condor that spent a short period of time (one to three days) at VSFB. These data indicate that while condors can occur on VSFB, the current frequency of occurrence is very low.

California Condor Occurrence Outside of VSFB

California condors occupy many of the foothills and mountains of Santa Barbara, Ventura, and Los Angeles Counties. These areas are occupied by both the Southern California Flock managed by Hopper Mountain National Wildlife Refuge Complex staff and Central California Flock managed by Ventana Wildlife Society and Pinnacles National Park. Both flocks overlap in distribution within the mainland California sonic boom overpressure effect area. The majority of California condor activity relative to VSFB is east of Interstate 101 in Santa Barbara County, more than 20 miles from SLC-4.

Effects to California Condor on VSFB

Sound pressure and overpressure produced by the proposed project activities (launch, landing, and static test fire events) have the potential to affect California condors in the vicinity of SLC-4 during up to 16 launches, 2 boost-backs, and 2 static test fires between October 1, 2024 and December 31, 2024. The maximum anticipated noise levels during proposed activities at SLC-4 would be up to 150 dB SPL_{max} during Falcon 9 launches at SLC-4 (MSRS 2024a, p. 104). This area would also experience sonic booms with overpressure levels up to 9.5 psf during each vehicle landing at SLC-4 (USSF 2024b). Launch noise would attenuate outward for approximately 17 miles. If California condors were present in the on-base portions of the proposed project area, they would likely be foraging or roosting. The Service anticipates that in the unlikely event that a California condor was within the immediate area of SLC-4 during the time of the launch, the potential magnitude of noise from launch, landing, or static test fire events, sonic booms, physical flame and steam, and visual disturbances could result in physical harm and other behavioral shifts to the species. However, GPS transmitter data indicate that California condor occurrences on VSFB are very rare or infrequent and it is unlikely that California condors would be on-base during project activities. Therefore, the probability of project-related impacts to California condors are very low.

Effects to California Condor Outside of VSFB

California condors occur within the region potentially impacted by sonic booms during missions with easterly trajectories. 12 launches (75 percent of the 16) that would occur between October 1 and December 31, 2024, would include easterly trajectories that would generate sonic booms with the potential to impact California condors within the mainland California sonic boom overpressure effect area. Sonic boom overpressure levels are dependent on atmospheric conditions. The Service considers for the purposes of this analysis that these sonic boom levels are reasonably expected to be under 1.0 psf (MSRS 2024a, p. 145), are not coupled with any visual stimuli, would occur relatively infrequently, and each last only a fraction of a second.

It is unknown how various noise and overpressure levels can affect California condors, but we expect individuals within this region to exhibit a temporary startle response or other minor and temporary behavioral shifts in response to noise from sonic booms. California condors are remarkably tolerant of human disturbance as indicated by the variety of hands-on management (J. Brandt, USFWS, pers. comm. 2024). Therefore, the probability of noise-related impacts to California condors from project activities off-base would be low if they occur.

Avoidance and Minimization Measures

1. Prior to any launch, the Space Force will determine if any California condors are present by coordinating with Service and Ventana Wildlife Society personnel (Note: VSFB computers are unable to review the Service's 'Daily Snapshot – California Condor Population' Google Earth imagery). The Space Force will contact the Service if California condors appear to be near or within the area affected by a launch from SLC-4. In the unlikely event that a California condor is nearby, Qualified Biologists will monitor California condor movements in the vicinity of VSFB and coordinate with the Service to analyze data before, during, and after launch events to determine whether any changes in movement occur.
2. The Space Force will coordinate with current Service personnel, including Arianna Punzalan, Supervisory Wildlife Biologist, USFWS California Condor Recovery Program, at arianna_punzalan@fws.gov or (805) 377-5471; or Steve Kirkland, California Condor Field Coordinator, USFWS California Condor Recovery Program, at steve_kirkland@fws.gov or 805-766-4630. The Space Force will also coordinate with current Ventana Wildlife Society personnel, including Joe Burnett, Senior Wildlife Biologist, at joeburnett@ventanaws.org or 831-800-7424.

After reviewing the information provided, we concur with your determination that the proposed action may affect but is not likely to adversely affect the California condor on the basis of both discountable and insignificant effects. Our concurrence is based on the following:

1. The probability of a California condor being present on-base during project activities is extremely low, making associated effects discountable. In the unlikely event a California

condor is determined to be present at the time of launch activities (Measure 1), this scenario would be outside the parameters of this analysis.

2. We anticipate that effects that would occur off-base would be insignificant. If any effects occur from overpressure of less than 1.0 psf, we expect only minor temporary behavioral reactions to infrequent noise disturbance.

Southern Sea Otter

Southern Sea Otter Occurrence

Southern sea otters irregularly inhabit (i.e., transit, forage) the coast of VSFB between Purisima Point and Point Arguello. There is a small breeding colony approximately 5.5 miles south of SLC-4 at the boat harbor near Sudden Flats (MSRS 2022a, p. 46). Consequently, noise and overpressure produced from the proposed project's launch operations has the potential to affect southern sea otters in the vicinity of SLC-4.

Effects to Southern Sea Otter

Sound pressure and overpressure produced by the proposed project activities (i.e., launch, landing, and static fire events) have the potential to affect southern sea otters if present offshore at the time of launch within the vicinity of SLC-4. Immediately off the coast, maximum anticipated noise levels during proposed activities would be up to 130 dB SPL_{max} during Falcon 9 launches at SLC-4. Potentially occupied southern sea otter areas would also experience sonic booms with overpressure levels up to 5.0 psf during each boost-back landing at SLC-4. No psf to dB SPL comparison was provided and the Service assumes this level is comparable to instantaneous exposure of 140 to 150 dB SPL. The location of the southern sea otter breeding colony south of SLC-4 would experience slightly lower noise levels with maximum anticipated levels of up to 110 dB SPL_{max} during launches, and sonic boom overpressure levels up to 4.0 psf. Project-related activities could also impact southern sea otters via visual disturbance during launch and landing events.

The Space Force has conducted previous launch monitoring for southern sea otter that focuses on before and after counts of the population. This monitoring data during low levels (generally less than 10 launches a year) of space launch activities since 1998 indicate that launch noise and visual disturbances do not substantially affect the number of southern sea otters in the nearshore marine environments of VSFB (MSRS 2022a, p. 71). Southern sea otters adjacent to LF-05 on north base have historically experienced launch noise of 136.6 dB SPL associated with Peacekeeper launches and continue to experience 127.8 dB SPL associated with Minuteman III launches with no obvious observed effects on populations before or after launching (SRS 1999a as cited in MSRS 2021a, p. 55). Previous monitoring conducted during the SpaceX Sentinel 6A launch mission that contained a boost-back and landing actions with similar noise and overpressure levels on November 21, 2020 documented similar before and after launch counts of southern sea otter (MSRS 2021b, p. 3). Biologists did not detect any discernible impact to southern sea otter populations from the launch activity.

The previous monitoring efforts have not reviewed behavioral reactions to southern sea otter during launch activities. The Service uses pinnipeds as appropriate surrogates to understand potential effects to southern sea otter from launch noise and overpressure. A 2023 annual report included pinniped launch monitoring that occurred during SLC-4 launches (USSF 2024c, p. 14-21 (Section 4.3)). Monitoring results included that different species of pinnipeds have had differing behavioral responses to launch disturbance including the following: elephant seals will raise their heads and flail during launchings, rarely fleeing into water; Pacific harbor seals would flee into water during launch events; reduction in number of California sea lion pups observed on VSFB; and several Pacific harbor seal pup mortality events (potentially as a result of trampling associated with adult's flee movements in response to launch events). However, the southern sea otter are generally less sensitive to noise when compared with Pacific harbor seals and California sea lions (Carswell, L., pers. comm., 2024). The Space Force will implement both camera and in person biological monitoring during launch events as described below (Avoidance and Minimization 1) to ensure no unanticipated behavioral effects of southern sea otter in response to launch disturbance occur.

Previous research indicates that sea otters may acclimatize to frequent noise disturbance. Davis et al. (1988, pp. 7, 14) conducted a study of northern sea otter's (*Enhydra lutris kenyoni*) response to underwater and in-air noise stimuli utilizing a variety of sounds, including air horns and an underwater acoustic harassment device capable of producing 190 dB SPL for longer period playbacks, pulsing sound every 15 seconds over a maximum of 3 hours. The louder underwater acoustic harassment device did not disturb northern sea otters (Davis et al. 1988, p. 22), but noise exposure to air horn noise resulted in a startle, fleeing response with individuals moving between 300 to 600 feet before resuming normal activity and exhibiting habituation to the variety of noise stimuli over a short amount of time (Davis et al. 1988, pp. 31, 35). The Service consequently anticipates that southern sea otters located off the coast of VSFB may already exhibit a degree of habituation due to the existing launch environment, and we do not currently expect the proposed project to result in novel effects. The Service will review the future proposed southern sea otter monitoring during launch operations to help confirm this expectation.

Permanent and temporary threshold shifts in hearing sensitivity have yet to be determined for the southern sea otter. The Service reviewed surrogate thresholds for otariid pinnipeds, closely related marine mammals, developed by the U.S. Navy and the National Marine Fisheries Service (Finneran and Jenkins 2012, pp. 5, 19–21; Navy 2017, p. 164). The lower limit for temporary threshold in-air shifts for otariids is 170 dB SPL, and the lower limit permanent threshold in-air shift is 176 dB SPL (Navy 2017, p. 164). The Service anticipates that these levels are above the likely predicted exposure levels between 110 dB SPL_{max} during launches and up to 150 dB SPL_{max} during boost-back events. The Service understands that the proposed project and that individual noise occurrences will be of short duration (less than one minute). The Service consequently does not anticipate associated temporary or permanent hearing loss for southern sea otters.

In the unlikely event that a launch anomaly component or associated debris struck a southern sea otter on the water surface, it could result in disturbance, injury, or death to the individual. The Service assumes there is an extremely low probability of strike potential, as southern sea otters are not known to regularly occur and congregate under the proposed Falcon 9 launch azimuths (MSRS 2022a, pp. 6, 46).

Following vehicle landings that occur downrange on a droneship in the Pacific Ocean, SpaceX would transport the reclaimed vehicle first to the Port of Long Beach and then back to the VSFB Harbor via a 'roll-on-roll-off' barge. A tug would pull the barge from the Port of Long Beach into the VSFB Harbor. SpaceX personnel would then drive the first stage off the barge, transport it from the VSFB Harbor to SLC-4E and unload vehicle in the hangar. The proposed action would include up to 14 tugboat events between October 1, 2024 and December 31, 2024, utilizing roll-on-roll-off operations to the VSFB Harbor. Adverse effects to southern sea otter from VSFB activities in the VSFB harbor during these operations are unlikely. Boats that utilize the harbor during hours of darkness operate under a lighting management plan to reduce potential impacts to rafting otters from visual disturbance (SLD 30 2024, p. 39). The project proponent would also be required to maintain reduced wake speeds to avoid direct injury to southern sea otter individuals (Refer to SSO-4 in Tab A4, 30 CES 2023). Existing similar harbor operations have not demonstrated quantifiable effects to southern sea otter population levels in the past.

<u>Avoidance and Minimization Measures</u>

1. The Space Force biologist(s) will utilize at least two video cameras positioned at a high location, and trained on an area where sea otters typically rest/raft (e.g., known rafting sites immediately south of Purisima Point and off of Sudden Flats). Cameras will be repositioned as necessary and turned on immediately prior to a scheduled launch to help document sea otter behavior during launch/boost-back events. The Space Force will complete in person monitoring and record behavior response for at least three Falcon 9 launches and boost-backs that measure at least 2.5 psf during the proposed project. Considering fog and wave conditions may obscure visibility during individual launches, the Service understands that the Space Force will make meaningful attempts to capture southern sea otter behavioral reactions during adequate visibility conditions throughout the proposed project until this objective is met. Other technology such as infra-red cameras could be used if initial attempts to complete in person/video recording are not successful. The Space Force will save the video footage, share it with the Service within seven days following a launch in tandem with the associated received dB SPL and psf levels, and provide a summary of the observed behavior from the field biologists.
2. The Space Force will ensure that a Service Approved Biologist monitors southern sea otters from a monitoring location within occupied habitat on VSFB where landing events

at SLC-4W generate boost-back sonic booms of 2.5 psf or greater (i.e., Sudden Flats). Upon establishment of any new southern sea otter populations within areas of potential impact from project-related activities, the Space Force will consider additional monitoring locations (MSRS 2024a, p. 39).

    a. The Service Approved Biologist will conduct daily counts of southern sea otters from the monitoring location when otters are most likely rafting (between 9:00AM and 12:00PM) beginning three days before and continuing three days after boost-back and landing events, noting any mortality, injury, or abnormal behavior. Personnel will use both binoculars (10X) and a high-resolution (50–80X) telescope for monitoring.

3. The Space Force will deploy recording equipment at or near the monitoring location to document and quantify sonic boom levels.
4. The Space Force will require that project-related boats that utilize the harbor during hours of darkness operate under a lighting management plan to reduce potential impacts to rafting otters and other marine mammals from visual disturbance (SLD 30 2024, p. 39).(SLD 30 2024, p. 39).
5. As depicted in the 2022 Programmatic Biological Assessment, the Space Force will require the project proponent to adhere to the following measures in regard to watercraft speed within and adjacent to the VSFB Harbor (Refer to SSO-4 in Tab A4, 30 CES 2023):
    a. Within the harbor during hours of daylight, personnel will maintain a speed of less than 11.5 miles per hour (10 knots) if southern sea otters are present and maintain a minimum of 80 feet of separation from rafting southern sea otters;
    b. Within the harbor during hours of darkness, personnel will maintain a speed of less than 11.5 miles per hour (10 knots) at all times;
    c. Outside the harbor, personnel will maintain speeds of less than 17 miles per hour (15 knots) within depths of less than approximately 80 feet which correlates to approximately 5.5 miles from shore; and,
    d. Outside the harbor during hours of daylight, personnel will maintain a minimum of 325 feet of separation from rafting southern sea otters and 30 feet of separation from kelp. If this separation distance is determined to be infeasible in coordination with the Qualified Biologist, personnel will maintain a ‘no wake’ speed (5 miles per hour/4.3 knots) when within 30 feet of kelp.

After reviewing the information provided, we concur with your determination that the proposed action may affect but is not likely to adversely affect the southern sea otter on the basis of insignificant effects. Our concurrence is based on the following:

1. Currently available information indicates that maximum noise and overpressure levels produced from launch operations are unlikely to have an observable effect on southern sea otters. Past population-level monitoring has not shown an effect.
2. The probability of launch anomaly debris striking a southern sea otter individual is anticipated to be extremely low.

3. Harbor operations would include avoidance and minimization that should be effective at reducing any potential for adverse effects to southern sea otter and effects would be considered insignificant should they occur.

Tidewater Goby

Tidewater Goby Occurrence on VSFB

Tidewater gobies have been documented in all major drainages of VSFB up to 7.5 miles upstream from the Pacific Ocean (Swift 1999). The project area consists of suitable habitat for the species within Honda Creek, San Antonio Creek, Shuman Creek, Jalama Creek, and the Santa Ynez River. The tidewater goby has not occurred in Honda Creek since 2008, potentially as a result of changing habitat suitability conditions precluding the occupancy of and persistence of fish. Tidewater gobies occur in the Santa Ynez River from the estuary to the 13^{th} Street bridge and San Antonio Creek. In San Antonio Creek, tidewater gobies primarily inhabit the lagoon.

Effects to Tidewater Goby on VSFB

Sound pressure and overpressure produced by the proposed project activities (launch, landing, and static test fire events) have the potential to affect tidewater gobies that occur on-base. Project-related engine noise and vibrations could cause a temporary disruption to individuals within San Antonio Creek and the Santa Ynez River where they would experience variable noise levels not exceeding 115 dB SPL_{max} and variable overpressure levels not exceeding 2.0 psf (MSRS 2024a, p. 99) during up to 16 launches, 2 boost-backs, and 2 static test fires between October 1, 2024 and December 31, 2024. It is unknown how various noise and overpressure levels could affect tidewater gobies, but we currently expect individuals to only exhibit minor and temporary behavioral shifts, if any.

Within potential habitat for the species in Honda Creek, maximum anticipated in-air noise levels would be up to 123 dB SPL_{max} during launches at SLC-4 and maximum anticipated overpressure levels would be up to 3.0 psf during landings (MSRS 2024a, p. 99). However, using the best available information, the Service anticipates that disturbance would be overall unlikely given that the species has not occupied Honda Creek since 2008, potentially as a result of changing habitat suitability conditions. We currently anticipate that disturbance to other known to be occupied features located a further distance away from SLC-4 would likely be temporary and minor, if any, as a result of understood noise attenuation in water.

For the majority of the 91 days of the proposed project, the Space Force would source water from an existing connection between State Water and the VSFB water supply system. However, during annual maintenance that lasts approximately two weeks and may occur during this timeframe, VSFB utilizes four water wells in the San Antonio Creek Basin. The Service consequently conservatively assumes that across this 14-day period, up to 184,615 gallons (0.57 acre-feet) could be extracted from these wells in San Antonio Creek basin. Increasing water extraction could reduce flow rates, hydration periods, or water levels in San Antonio Creek and negatively impact tidewater gobies. However, referencing previous analysis (USGS 2019, p. 5) and associated discussion with hydrologists involved with the associated hydrological modeling (C. Faunt and G. Cromwell, USGS, pers. comm. 2021), the proposed project's 0.57 acre-feet extraction amount would not be anticipated to result in measurable decline of streamflow or associated aquatic habitat.

The Space Force has determined tidewater goby populations would not be affected in off-base locations from launch ascents with easterly trajectories creating low level (less than 1.0 psf) sonic booms (MSRS 2024a, p. 99).

After reviewing the information provided, we concur with your determination that the proposed action may affect but is not likely to adversely affect the tidewater goby on the basis of insignificant effects. Our concurrence is based on the following:

1. Any effects that would occur would be insignificant as a result of anticipated noise attenuation. If any effects occur, we expect only temporary and minor behavioral reactions to infrequent noise disturbance.
2. Tidewater goby does not currently occur in Honda Creek, and we understand there is currently low likelihood for recolonization.
3. Increased water extraction from the San Antonio Creek basin due to proposed project activities would be negligible.

Unarmored Threespine Stickleback

<u>Unarmored Threespine Stickleback Occurrence on VSFB</u>

Unarmored threespine stickleback occupy San Antonio Creek from Barka Slough to the lagoon (Swift 1999). The project area consists of unoccupied suitable habitat for the species within Honda Creek, Shuman Creek, Jalama Creek, and the Santa Ynez River. Historically in 1984, attempts to introduce unarmored threespine stickleback to Honda Creek were made but determined unsuccessful, potentially as a result of changing habitat suitability conditions precluding the occupancy of and persistence of fish. The presence of the species in Honda Creek is consequently unlikely.

<u>Effects to Unarmored Threespine Stickleback on VSFB</u>

Sound pressure and overpressure produced by the proposed project activities (launch, landing, and static fire events) have the potential to affect unarmored threespine stickleback that occur on-base. Project-related engine noise and vibrations could cause a temporary disruption to individuals within San Antonio Creek where they would experience variable noise levels not exceeding 105 dB SPL_{max} and variable overpressure levels not exceeding 2.0 psf (MSRS 2024a, p. 100) during up to 16 launches, 2 boost-backs, and 2 static test fires between October 1, 2024 and December 31, 2024. It is unknown how various noise and overpressure levels can affect unarmored threespine stickleback, but we expect individuals to only exhibit minor and temporary behavioral shifts, if any, as a result of understood noise attenuation in water.

Within potential habitat for the species in Honda Creek, maximum anticipated noise levels would be up to 123 dB SPL_{max} during launches at SLC-4 and maximum anticipated overpressure levels would be up to 3.0 psf during landings (MSRS 2024a, p. 99). However, using the best available information, the Service anticipates that any disturbance would be overall unlikely given that the species does not occupy Honda Creek and we do not anticipate the species to recolonize in the future due to the changing habitat conditions described above.

For the majority of the 91 days of the proposed project, the Space Force would source water from an existing connection between State Water and the VSFB water supply system. However, during annual maintenance that lasts approximately two weeks and may occur during this timeframe, VSFB utilizes four water wells in the San Antonio Creek Basin. The Service consequently conservatively assumes that across this 16-day period, up to 184,615 gallons (0.57 acre-feet) could be extracted from these wells in San Antonio Creek basin. Increasing water extraction could reduce flow rates, hydration periods, or water levels in San Antonio Creek and negatively impact unarmored threespine stickleback. However, referencing previous analysis (USGS 2019, p. 5) and associated discussion with hydrologists involved with the associated hydrological modeling (C. Faunt and G. Cromwell, USGS, pers. comm. 2021), the Service understands the proposed project's 0.57 acre-feet extraction amount would not be anticipated to result in measurable decline of streamflow or associated aquatic habitat.

The Space Force has determined unarmored threespine stickleback populations would not be affected in off-base locations from launch ascents with easterly trajectories creating low level (less than 1.0 psf) sonic booms (MSRS 2024a, p. 101).

After reviewing the information provided, we concur with your determination that the proposed action may affect but is not likely to adversely affect the unarmored threespine stickleback on the basis of insignificant effects. Our concurrence is based on the following:

1. Any effects that would occur are anticipated to be insignificant, if any, as a result of expected noise attenuation. If any effects occur, we expect only temporary and minor behavioral reactions to infrequent noise disturbance.
2. Unarmored threespine stickleback do not currently occur in Honda Creek, and there is low likelihood for recolonization.
3. We understand that increased water extraction from the San Antonio Creek basin due to proposed project activities would be negligible.

Arroyo Toad, Coastal California Gnatcatcher, and Light-Footed Ridgway's Rail

Arroyo Toad, Coastal California Gnatcatcher, and Light-Footed Ridgway's Rail Occurrence

Arroyo toad, coastal California gnatcatcher, and light-footed Ridgway's rail are not known to occur on VSFB. Arroyo toad, coastal California gnatcatcher, and light-footed Ridgway's rail occur throughout Santa Barbara, Ventura, and Los Angeles Counties, within the region potentially impacted by sonic booms during missions with easterly trajectories. Only select launches with easterly trajectories would create sonic booms that have the potential to reach these species. We do not expect sonic booms to reach these species from the other launch trajectories.

Arroyo Toad
Arroyo toads occur within the region potentially impacted by sonic booms during missions with easterly trajectories. Specifically, these areas include the upper Santa Ynez River, Sespe Creek, Piru Creek, Castaic Creek, and the upper Santa Clara River.

Coastal California Gnatcatcher
Within the region potentially impacted by sonic booms during missions with easterly trajectories, coastal California gnatcatchers occur across southern Ventura and western Los Angeles Counties (MSRS 2024a, p. 91).

Light-Footed Ridgway's Rail
Within the region potentially impacted by sonic booms during missions with easterly trajectories, light-footed Ridgway's rails occur at the Carpinteria Salt Marsh and the marshes at Naval Base Ventura County Point Mugu (MSRS 2024a, p. 93).

Effects to Arroyo Toad, Coastal California Gnatcatcher, and Light-Footed Ridgway's Rail

Arroyo toad, coastal California gnatcatcher, and light-footed Ridgway's rail are not expected to occur on VSFB; therefore, we do not anticipate any effects to arroyo toad, coastal California gnatcatcher, and light-footed Ridgway's rail from project activities on-base. Potential project effects would be limited to the proposed project's off-base sonic boom effects area for missions with easterly trajectories. For the purpose of this analysis, these sonic boom levels are reasonably expected to be under 1.0 psf (MSRS 2024a, p. 145). More specific detail on this modeling can be located under 'Project Description; Launch Sonic Boom (Overpressure Disturbance); Mainland California (Southeastern Santa Barbara, Ventura, and Los Angeles Counties) – Launch Ascent'.

Arroyo Toad
Of the 16 launches that would occur between October 1 and December 31, 2024, 12 would have easterly trajectories that would generate sonic booms with the potential to impact arroyo toads. For the purpose of this analysis, these sonic boom levels are reasonably expected to be under 1.0

psf (MSRS 2024a, p. 113). Each of the 12 sonic booms would last only a fraction of a second and would not be coupled with any visual stimuli in the areas we expect arroyo toads would occur. It is unknown how various noise and overpressure levels can affect arroyo toads, but we expect any potential effects are unlikely to manifest and would be overall negligible considering the sonic boom level would reasonably be very low, of very short duration, and likely comparable to ambient existing noise levels. Additionally, the Service anticipates arroyo toads would likely be aestivating between October 1 and December 31, 2024, when project activities would occur, and it is unlikely that arroyo toads would be above ground at the exact moment of a sonic boom. Therefore, referencing the available information, we do not anticipate any associated effects at this time.

After reviewing the information provided, we concur with your determination that the proposed project may affect but is not likely to adversely affect the arroyo toad based on insignificant effects. Our concurrence is based on the following:

1. Arroyo toads are likely to be aestivating underground during the time of project activities.
2. We anticipate that any effects that would occur from less than 1.0 psf sonic booms are unlikely to manifest and would be overall be insignificant.

Coastal California Gnatcatcher

Of the 16 launches that would occur between October 1 and December 31, 2024, 12 would have easterly trajectories that would generate sonic booms with the potential to impact coastal California gnatcatchers. Sonic boom overpressure levels are dependent on atmospheric conditions. For the purpose of this analysis, the Service understands these sonic boom levels are reasonably expected to be under 1.0 psf (MSRS 2024a, p. 147). Each of the 12 sonic booms would last only a fraction of a second and would not be coupled with any visual stimuli in the areas we expect coastal California gnatcatchers would occur. It is unknown how various noise and overpressure levels can affect coastal California gnatcatchers, but we expect any potential effects are unlikely to manifest and would be overall negligible considering the sonic boom level would reasonably be very low, of very short duration, and likely comparable to ambient existing noise levels. Coastal California gnatcatchers exhibit strong site tenacity (Atwood 1993, p. 152) and would be expected to return quickly in the unlikely event they flee if startled by a less than 1.0 psf sonic boom. Therefore, referencing the available information, we do not anticipate any associated effects at this time.

After reviewing the information provided, we concur with your determination that the proposed project may affect but is not likely to adversely affect the coastal California gnatcatcher based on insignificant effects. Our concurrence is based on the following:

1. We anticipate that any effects that would occur from less than 1.0 psf sonic booms are unlikely to manifest and would be overall be insignificant.

2. Coastal California gnatcatchers exhibit strong site tenacity and would be expected to return quickly in the unlikely event they are startled by low-level sonic boom noise during project operations.

Light-Footed Ridgway's Rail
Of the 16 launches that would occur between October 1 and December 31, 2024, 12 would have easterly trajectories that would generate sonic booms with the potential to impact light-footed Ridgway's rails. These sonic boom levels are reasonably expected to be under 1.0 psf (MSRS 2024a, p. 148). Each of the 12 sonic booms would last only a fraction of a second and would not be coupled with any visual stimuli in the areas we expect light-footed Ridgway's rail would occur. It is unknown how various noise and overpressure levels can affect light-footed Ridgway's rail, but we expect any potential effects are unlikely to manifest and would be overall negligible considering the sonic boom level would reasonably be very low, of very short duration, and likely comparable to ambient existing noise levels. Light-footed Ridgway's rails have exhibited successful territory establishment at Naval Base Ventura County Point Mugu (Zembal et al. 2016, p. 4), another military base where the species is subject to routine aircraft noise disturbance that is likely louder than noise from project-related sonic booms. Therefore, the probability of noise-related impacts to light-footed Ridgway's rails from project activities would be low if they occur.

After reviewing the information provided, we concur with your determination that the proposed project may affect but is not likely to adversely affect the light-footed Ridgway's rail based on insignificant effects. Our concurrence is based on the following:

1. We anticipate that any effects that would occur from less than 1.0 psf sonic booms are unlikely to manifest and would be overall be insignificant.
2. Light-footed Ridgway's rails are known to occur in other areas with routine noise disturbance from military aircraft operations.

Western Spadefoot

The western spadefoot is not listed under the Act; however, it is currently proposed threatened and under federal review for listing under the Act (88 FR 84252 84278).

Western Spadefoot Occurrence on VSFB

The western spadefoot has been documented in seasonal pools formed by heavy winter rains on north VSFB, most notably in vernal pools along New Mexico Avenue between 15th and 26th Streets. Several dozen western spadefoot were also documented in the VSFB cantonment area in 2010 in "Pond 82" incidentally while conducting California tiger salamander studies (U.S. Air Force 2014, p. 39). Additionally, historically occupied vernal pools exist within the southern portion of the cantonment area on north VSFB (Occurrence 1101; CNDDB 2024), approximately 6 miles from SLC-4. The species has not been recently observed in these areas but conservatively assumes that due to existing suitable habitat and the proximity of extant records, these features still have the potential to support the species.

Western Spadefoot Occurrence Outside of VSFB

Off-base within the proposed Launch Noise effects area, western spadefoot are found in the Santa Rita Hills east of Lompoc (MSRS 2024a, p. 59). Western spadefoots occur in eastern Ventura and northwestern Los Angeles Counties within the region potentially impacted by sonic booms during missions with easterly trajectories. Numerous records exist near Simi Valley, Santa Clarita, and Los Angeles (Appendix A, Figure 2L).

Effects to Western Spadefoot on VSFB

Sound pressure and overpressure produced by the proposed project activities (launch, landing, and static test fire events) have the potential to affect western spadefoot individuals that occur on-base where they would experience variable noise levels up to 110 dB SPL_{max} and variable overpressure levels up to 2.0 psf during up to 16 launches, 2 boost-backs, and 2 static test fires from SLC-4 between October 1, 2024 and December 31, 2024. Suitable but unoccupied habitat could experience variable noise levels up to 115 dB SPL_{max} and potentially occupied pools could experience variable noise levels up to 118 dB SPL_{max} (MSRS 2024a, p. 114).

Based on environmental conditions, during the month of October, western spadefoots may be underground and aestivating. Potential effects to aestivating western spadefoots could include early emergence stimulated by vibration and associated injury or mortality from desiccation if this is improperly timed. Existing studies of Couch's spadefoot toads have documented the species emerge from aestivation due to ground vibrations from rainfall (Márquez et al. 2016) as well as motorcycle noise (Dimmitt and Ruibal 1980). However, in the experiments, Couch's spadefoot toad burrows were shallower than the burrows western spadefoot is anticipated to use during overwintering. The potential launch-related vibration may be of low frequency which attenuates less readily than high frequency (Norton et al. 2011, p. 658) and may travel further. However, the biological assessment has indicated that project-related terrestrial vibration should attenuate based on distance and depth of extant populations of western spadefoots from SLC-4 (MSRS 2024a, p. 119). Given that approximately 30 percent of sound energy attenuates for every centimeter of depth (Oelze et al. 2002) and western spadefoots typically burrow up to 3 feet deep (Stebbins 1972), it is unlikely that aestivating western spadefoots would be impacted by launch vibration or associated noise.

Western spadefoots are active above ground from November through June. Individuals that are above ground may startle from launch noise and overpressure that happens during project activities between October 1, 2024 and December 31, 2024. It is unknown how various noise and overpressure levels can affect western spadefoot, but we expect individuals may exhibit a minor and temporary startle response and resume normal behavior shortly thereafter. Therefore, based on the available information, we currently anticipate that the probability of noise-related impacts to western spadefoot on-base from project activities would be insignificant.

Breeding and egg laying for western spadefoots normally occurs on VSFB from late winter to the end of March (U.S. Air Force 2014, p. 39), and the timing of breeding is determined by rainfall. Breeding may occur if there is heavy rainfall during the time of the proposed action, between October 1 and December 31, 2024. Western spadefoot tadpoles are fully aquatic until fully metamorphosized. The biological assessment indicates that launch noise would attenuate entirely between the air-water interface (Godin 2008), and consequently there would be no potential for impact to western spadefoot tadpoles. The Service also currently understands that any project-related terrestrial vibration should attenuate when it reaches the closest suitable aestivating or aquatic breeding habitat (approximately 5.25 miles from SLC-4) (MSRS 2024a, p. 115-116). The Space Force has indicated that only adult individuals, which are expected to be above ground for a short period of time, could be exposed to infrequent minor vibrations associated with launch activity (MSRS 2024a, p. 116). We understand that although western spadefoots may exhibit a temporary startle response, we expect any associated effects would be insignificant and that species would resume normal behavior shortly thereafter.

Effects to Western Spadefoot Outside of VSFB

The Santa Rita Hills locality of western spadefoot would be exposed to launch noise levels between 100 to 110 dB SPL_{max}. The Service anticipates that any temporary effects from launch noise on the Santa Rita Hills would be similar, if not less than, those discussed for western spadefoot on VSFB.

Western Spadefoot occur within the region potentially impacted by sonic booms during missions with easterly trajectories. Twelve launches (75 percent of the 16) that would occur between October 1 and December 31, 2024, would include easterly trajectories that would generate sonic booms with the potential to impact western spadefoot within the mainland California sonic boom action area. For the purpose of this analysis, the Service understands these sonic boom levels are reasonably expected to be under 1.0 psf (MSRS 2024a, p. 116). Each of the 12 sonic booms would last only a fraction of a second and is not coupled with any visual stimuli in the areas we expect western spadefoot toads would occur. Western spadefoots are active above ground from November through June. It is unknown how various noise and overpressure levels can affect western spadefoot, we currently expect any potential effects are unlikely to manifest and would be overall negligible considering the sonic boom level would reasonably be very low, of very short duration, and likely comparable to ambient existing noise levels.

After reviewing the information provided, we concur with your determination that the proposed action may affect but is not likely to adversely affect the western spadefoot toad on the basis of insignificant effects. Our concurrence is based on the following:

1. We currently anticipate that any potential effects to above-ground western spadefoot would be limited to minor temporary behavioral reactions and that species would return to normal behavior shortly thereafter.
2. We understand that aestivating western spadefoots and tadpoles would not be disturbed by the proposed project being that project-related noise and terrestrial vibration should attenuate based on distance and depth of extant populations of western spadefoots from SLC-4.

California Tiger Salamander

California Tiger Salamander Occurrence on VSFB

Santa Barbara County Distinct Population Segment (DPS) of California tiger salamanders have not been detected on VSFB during regular protocol surveys of suitable habitat since 2006 (MSRS 2024a, p. 45).

California Tiger Salamander Occurrence Outside of VSFB

The closest occurrences of California tiger salamander to the proposed project are approximately 14 miles east of SLC-4 within the Santa Rita Hills.

Effects to California Tiger Salamander on VSFB

California tiger salamanders are not expected to occur on-base due to a lack of recorded observations during regular protocol surveys of suitable habitat since 2006. Therefore, we do not anticipate any effects to California tiger salamander on-base from the proposed project activities.

Effects to California Tiger Salamander Outside of VSFB

Sound pressure and overpressure produced by the proposed project activities (launch, landing, and static test fire events) have the potential to affect California tiger salamander that occur off-base within the Santa Rita Hills where they would experience variable noise levels not exceeding 105 dB SPL_{max} and variable overpressure levels up to 1.5 psf during up to 16 launches, 2 boost-backs, and 2 static test fires from SLC-4 between October 1, 2024 and December 31, 2024 (MSRS 2024a, p. 101-102). Sonic boom overpressure levels are dependent on atmospheric conditions. For the purposes of this analysis, we expect that the maximum potential level that California tiger salamander could experience would be 1.5 psf.

Between October 1 and December 31, California tiger salamanders will likely be underground and aestivating. California tiger salamanders live in burrows for majority of their lives and temporarily emerge from burrows following rainfall to migrate to breeding pools. Potential effects to California tiger salamanders could include launch related vibration of burrows. If vibration mimics characteristics of rainfall, this could induce early emergence and associated injury or mortality from desiccation if this is improperly timed. Potential launch related vibration may be of low frequency which attenuates less readily than high frequency (Norton et al. 2011, p. 658) and may travel further. However, the biological assessment has indicated that project-related terrestrial vibration should attenuate based on distance and depth of extant populations of California tiger salamander from SLC-4 (MSRS 2024a, p. 102). Given that approximately 30 percent of sound energy attenuates for every centimeter of depth (Oelze et al. 2002) and that California tiger salamanders typically burrow deeper underground than surface noise is anticipated to reach (Barry and Shaffer 1994), it is unlikely that aestivating California tiger salamander would be impacted by launch vibration or associated noise. If California tiger salamanders are above ground during a launch ascent or landing, the species may have a temporary behavioral reaction (e.g. startle) in response and would return to normal behavior shortly thereafter. However, the Service anticipates that because California tiger salamanders are aboveground infrequently and for a short period (i.e., only a few rainy nights a year), sonic boom exposure and associated effects are overall unlikely to occur.

The Space Force has determined that there would be no effect to California tiger salamander populations located off-base within mainland California from launch ascents with easterly trajectories that are likely to create low level (less than 1.0 psf) sonic booms (MSRS 2024a, p. 102).

After reviewing the information provided, we concur with your determination that the proposed action may affect but is not likely to adversely affect the California tiger salamander on the basis of discountable effects. Our concurrence is based on the following:

1. We anticipate that aestivating California tiger salamander would not be disturbed by routine launch disturbance. We understand that associated launch noise and vibration would attenuate entirely based on distance and depth of extant populations of California tiger salamander precluding any potential effects.
2. Any effects to above ground California tiger salamander would likely occur very infrequently and are expected to be overall discountable. We expect any potential effects to only include temporary minor behavioral reactions and that species would return to normal behavior shortly thereafter.

In reference to the above ‘Not Likely to Adversely Affect’ analysis, further consultation pursuant to section 7(a)(2) of the Act is not required. If new information becomes available or the proposed action changes in any manner that may affect a listed species or critical habitat in a manner not previously considered, you must contact us immediately to determine whether additional consultation is required. In reference to western spadefoot, regulations allow for an opinion issued at the conclusion of a conference to be adopted as a biological opinion when the species is listed or critical habitat is designated, but only if no significant new information is developed (including that developed during the rulemaking process on the proposed listing or critical habitat designation) and no significant changes to the Federal action are made that would alter the content of the opinion (50 CFR 402.10(d)).

Consultation History

On June 27, 2024, the Space Force provided an updated biological assessment for 50 launches from SLC-4 and the development of SLC-6. However, through conversation with the Ventura Fish and Wildlife office and Region 8 Office, the project description was revised to include only 14 launches, 2 static tests and 1 boost-back from SLC-4 between October 1 to December 31, 2024 (SpaceX, meeting communication, July 2, 2024a). The Space Force requested expedited formal consultation (by August 15, 2024) for this stand-alone consultation. However, through conversation with the Ventura Fish and Wildlife office and Region 8 Office, the project description was revised to include only 14 launches, 2 static tests and 1 boost-back from SLC-4 between October 1 to December 31, 2024 (SpaceX, meeting communication, July 2, 2024a). The Space Force requested expedited formal consultation (by August 15, 2024) for this stand-alone consultation. In a subsequent meeting, the Space Force and project proponent revised their project description on July 25, 2025 to include 16 launches, 2 static tests, and 2 boost-backs from SLC-4 between October 1 to December 31, 2024 (SpaceX, meeting communication, July 25, 2024b). The Service provided the Space Force sections of the draft biological opinion for review between July 15 and August 15, 2024. The Space Force provided comments between this period. The Service reviewed and incorporated changes to the project description where necessary. Following a phone call and then subsequent Space Force's comments on the draft biological opinion's effects analysis and relevant terms and conditions provided on August 13, 2024, the Service and Space Force agreed to revise the biological opinion's due date to August 28, 2024, to provide necessary time to address comments. The Service and Space Force continued to coordinate on comment resolution until August 20, 2024.

BIOLOGICAL OPINION

DESCRIPTION OF THE PROPOSED ACTION

Project Overview

The proposed project includes up to 16 launches of the Falcon 9 first stage vehicle from Space Launch Complex (SLC)-4 and Vandenberg Space Force Base, Santa Barbara County, California between October 1 to December 31, 2024. Collectively, SpaceX would not exceed 50 launches on VSFB within 2024.

A total of two separate associated static test fires and two return to launch site events (landing descent or 'boost-back') would also occur during this period. All other boost-back events will occur offshore.

Launch Operations

SLC-4

SpaceX would launch the Falcon 9 vehicle up to 16 times from SLC-4E between October 1 and December 31, 2024. A static test fire of engines may precede two launches. Following each launch ascent, SpaceX would perform a boost-back and landing descent of the first stage either downrange on a droneship in the Pacific Ocean (14 times) or at SLC-4W at VSFB (2 times).

The proposed action includes launch azimuths between 140 and 325 degrees.

Launch Schedule and Frequency
The base provided the Service a launch schedule between this period for the purposes of analysis. Each of the 16 launches would be separated by a calculated average of nominally 5 days. Launches could occur as frequently as three days apart but this would not occur regularly as depicted in the provided estimated launch schedule that the Service considered for purposes of this analysis (USSF 2024b).

Launch operations would occur day or night under all but extreme weather conditions (i.e., would not occur during gale force winds, high wind shear, or extreme thunder and lightning conditions). Individual launch ascent noise disturbance would last up to 1 minute and occur 16 times. Launch ascent may infrequently result in a separate instantaneous sonic boom that impacts portions of the Channel Islands and mainland California discussed below. Individual launch landing disturbance (boost-back) would occur 2 times during this 3-month period at SLC-4 and would last up to 17 seconds. Launch landing would also create a separate instantaneous sonic boom that impacts the vicinity of VSFB. The total time from launch to landing would be 6 to 10 minutes (Kaisersatt 2024).

A static test fire could occur one day before a full launch and is considered a separate form of launch disturbance. Static test fires would impact a smaller portion of a full launch's disturbance footprint over a substantially shorter duration (7 seconds) and are consequently a separate distinct disturbance event that is not comparable or substitutable for a full launch. The Space Force has included that two separate static test fires could occur between October 1 to December 31, 2024.

Table 1. Summary of proposed launch disturbance type details

Launch Disturbance Type	Duration/Frequency	Frequency	Number Proposed between Oct 1 to Dec 31, 2024
Static Test Fire	7 seconds	Up to one day before full launch	2
Launch (Ascent)	1 minute ascent	Once every 5 days on average (up to 3 days very infrequently)	16
Terrestrial landing (boost-back)	17 seconds landing coupled with instantaneous sonic boom	6 to 10 minutes following launch ascent, up to once every 5 days	2

Vehicle Terrestrial Landing at VSFB (Boost-back) and offshore landings

SpaceX would perform up to two terrestrial landings known as a 'boost-back' on SLC-4W at VSFB between October 1 and December 31, 2024. Terrestrial landings would involve the landing noise disturbance which produces an associated instantaneous sonic boom immediately following the landing disturbance. Terrestrial landing noise disturbance is depicted in Appendix A, Figures 2A-G. Landing noise would be of reduced duration and extent when compared to launch ascent. Associated noise and sonic boom levels are discussed in further detail below. Terrestrial landings would occur nominally no closer than five days apart.

Appendix A, Figure 3 depicts the offshore Vehicle Landing Effects Area where 12 landings would occur on a droneship. This area encompasses approximately 500 to 1,100 miles of the western coast between Baja California, Mexico and San Francisco, California. Sonic booms associated with droneship landings would be directed entirely at the ocean surface without impacting any land. No associated terrestrial noise or sonic boom would occur during droneship landing events.

Launch Noise

The Space Force provided modeling of individual launches and associated static test fire events for the purposes of this analysis using the SPL_{max} noise metric. SPL_{max} is the unweighted maximum instantaneous sound level, the highest sound pressure level measure during a single launch event. Although it provides some measure of the event, SPL_{max} does not fully describe the noise disturbance because it does not account for the duration of the sound. Sound exposure level (SEL) considers the length of time a noise occurs and provides a measure of the net impact of the entire acoustic event. In previous analyses, the Service has considered the SEL metric; however, for the purposes of this analysis, the biological assessment did not include SEL information and consequently the Service will use the SPL_{max} metric.

The project proposes to use the existing Falcon 9 vehicle. The biological assessment indicates that engine noise would reach up to 150 dB SPL_{max} on SLC-4. During Falcon 9 launches, provided noise modeling indicates that noise levels would attenuate outward in all directions reaching 100 dB approximately 17 miles away from SLC-4.

As previously discussed in Table 1, noise produced by launch operations to terrestrial areas would last approximately 1 minute (60 seconds) during a full launch ascent, 17 seconds during terrestrial landings, and approximately 7 seconds during static fire events. Each event has a distinct noise disturbance area and temporal footprint and are not interchangeable.

Appendix A, Figures 1A–F depict the Launch Noise Effect Area, which is the modeled SPL_{max} footprint of the proposed project generated by noise modeling software RNoise. The Space Force indicates that the produced model incorporates numerous components, including the acoustic power of the rocket engine source, forward flight effects, the angle from the source to the receiver (directivity), Doppler effect, propagation between the source and receiver (ray path), atmospheric absorption, and ground interference to estimate received noise levels. RNoise assumes the surface of the earth is flat and therefore does not account for attenuation due to landforms. The Space Force has included that the produced model is conservative for areas shielded by hills, bluffs, or other features, such as buildings or dense vegetation. The Space Force has indicated in their biological assessment that atmospheric conditions have the potential to impact updated model output and associated accuracy. The Service will use the provided modeling and levels of the purposes of this analysis. More frequent or higher magnitude realized disturbance levels would be considered outside the scope of this analysis.

Launch Sonic Boom (Overpressure Disturbance)

Each proposed launch ascent and landing descent would generate a sonic boom resulting in overpressures of high energy impulsive sound. Sonic booms are low frequency, impulsive noise events with durations lasting a fraction of a second (BRRC 2020, p. 32). Sonic boom impact areas will depend on the launch trajectory. The Space Force used PCBoom to model sonic booms produced by the proposed project.

Northern Channel Islands – Launch Ascent

During launch ascent, a sonic boom with overpressure up to 5.0 psf could impact various linear pathways across the northern Channel Islands (Santa Rosa and Santa Cruz Islands) (Appendix A, Figure 2H). The Space Force has previously indicated that 30 percent of launches could impact the northern Channel Islands, with the vast majority constituting overpressure of under 2 psf (Kaisersatt, pers. comm, 2023a, p. 1). For this analysis, the Service consequently understands that of the 16 launches, reasonably 5 launches could impact the northern Channel Islands with any sonic booms under 2.0 psf.

During launch descent, it would be very unlikely for any sonic booms to impact the northern Channel Islands during landing events at SLC-4 or on droneships in offshore areas. No additional modeling was provided to address this potential. Consequently, we will not consider this as a part of the proposed action as we understand it is not reasonably likely to occur. During downrange droneship landings in the proposed landing areas, sonic booms would be directed entirely at the ocean surface without impacting any land.

Mainland California (*Southeastern Santa Barbara, Ventura, and Los Angeles Counties*) – *Launch Ascent*

For easterly trajectories, the Space Force has included that Falcon 9 launch ascents from SLC-4 may produce sonic booms with the potential to impact southeastern Santa Barbara County, Ventura County, and Los Angeles County on the mainland of California. The Space Force includes that 75 percent of the 16 launches are expected to contain easterly trajectories. There would be 12 associated sonic booms over the 3- month project period (each separated by an anticipated average of 5 days).

This biological assessment includes the following modeling predictions: 15 percent of model runs predicted any impacts in eastern Santa Barbara County; 50 percent of these sonic boom levels were less than 0.25 psf, 87 percent were less than 1.0 psf, and 0.3 percent were greater than 2.0 psf. The highest level predicted for eastern Santa Barbara County was 2.13 psf in two small areas near Carpinteria, which the Service understands is not reasonably likely to occur (MSRS 2024, p. 25). 97 percent of the model runs predicted sonic boom impacts within Ventura County; 65 percent were less than 0.25 psf, 86 percent were less than 1.0 psf, and 0.04 percent were greater than 2.0 psf. The highest predicted boom level predicted for Ventura County is 2.03 psf which is again not reasonably likely to occur. 94 percent of model runs predicted impacts in western Los Angeles County; 95 percent were less than 0.25 psf, and 100 percent were less than 0.75 psf.

In summary, the Space Force's provided modeling indicates that the sonic booms that would impact these areas would be reasonably certain to be less than 1.0 psf (MSRS 2024, p. 112). The Service consequently understands that the proposed project's associated mainland sonic boom disturbance would be relatively infrequent and that none of these 12 launches would reasonably result in sonic boom of over 1.0 psf to mainland California. To help provide a clear project description, the Service states this understanding to define parameters considered within analysis.

Appendix A, Figures 2I-P are included to provide visual depiction of sonic boom modeling impacts within mainland California.

Vicinity of VSFB, Lompoc and Jalama Beach (*Launch Descent*)

For the purposes of this proposed project, the Space Force indicates that the Falcon 9 vehicle landings that occur at SLC-4, will create a sonic boom with overpressure of up to 9.5 psf (USSF 2024b). However, the Space Force's biological assessment only included sonic boom contour extent mapping for maximum level of 5.0 psf. Consequently, based on the information provided, the two proposed boost-backs could contain levels between 6.1 to 9.5 psf but that they would be entirely confined to the SLC-4 pad. The provided modeling encompasses the cantonment area of VSFB to the north, extending eastward to Lompoc, southward to encompass Jalama Beach, and westward across the Pacific Ocean. The extent of sonic boom impacts within the immediate vicinity of VSFB considered within this analysis is depicted both in this text summary as well as in Appendix A, Figure 2B, Sonic Boom Overpressure Effect Area.

Overpressure to decibel conversion

Overpressure can be expressed as instantaneous noise disturbance (SPL_{max}) by using a mathematical conversion from psf to decibel levels. The biological assessment did not include conversions of overpressure into instantaneous noise disturbance (SPL_{max}).

The Service reviewed past Falcon 9 monitoring reports to reference these conversions for purposes of facilitating comparison. Previous realized monitoring, prior to observed changes in past provided overpressure modeling for the same vehicle, indicates that the realized sonic boom at south Surf Beach was 3.6 psf which produced experienced noise levels of 138 dB SPL_{max}; 1.1 psf produced experienced noise of 129 dB SPL_{max} at Purisima Point; and 2.4 psf produced experienced noise of 135 dB SPL_{max} at Honda Creek (Robinette and Rice 2019, p. 14, 2022, p. 13; MSRS 2022b, p. 4). Consequently, considering the current consultation's proposed modeling, the proposed project overpressure levels in natural habitat outside of SLC-4 (e.g. 5.0 psf) would reasonably equate to maximum received noise levels between 140 to 150 dB produced from sonic booms.

<u>Vehicle Recovery</u>

Following vehicle landings that occur downrange on a droneship in the Pacific Ocean, SpaceX would transport the reclaimed vehicle first to the Port of Long Beach and then back to the VSFB Harbor via a 'roll-on-roll-off' barge. A tug would pull the barge from the Port of Long Beach into the VSFB Harbor. SpaceX personnel would then drive the first stage off the barge, transport it from the VSFB Harbor to SLC-4E and unload vehicle in the hangar.

The proposed action would include 12 events between October 1 and December 31, 2024, utilizing roll-on-roll-off operations to the VSFB harbor.

Roll-on-roll-off operations occur during daytime hours. However, boats can hotel in the harbor overnight. If a boat must hotel in the harbor overnight, its lights are turned on before dusk and then kept on until morning. When at the dock, boats generally operate under auxiliary power thus do not move much. Within the harbor, boats operate at low speeds (generally 1 to 3 knots). Outside the harbor, boats do not exceed 10 knots (USSF 2024b).

Launch Fueling and Combustion

During launch operations, mobile fuel trailers would supply fuel (rocket propellant-1 (RP-1) and liquid oxygen (LOX) rocket propellant) to on-site ground support equipment. Black carbon (soot) can be a byproduct of rocket launches and is largely a factor of running a fuel-rich mixture, such as a fuel-rich gas generator rocket engine. The Space Force has included that the proposed project uses oxidizer-rich staged combustion engines that produce a diminutive amount of terrestrial soot. The primary emission products from the Falcon liquid engines are carbon dioxide (CO2), carbon monoxide (CO), water vapor, oxides of nitrogen, and carbon particulates. Although the exhaust is fuel-rich and contains high concentrations of CO, subsequent entrainment of ambient air results in complete conversion of the CO into CO2 and oxidation of the soot from the gas generator exhaust. Referencing previously produced environmental assessments for other Falcon 9 launch operations, the Space Force has specified that the proposed project's exhaust process results in the complete conversion of produced carbon monoxide into carbon dioxide as well as the oxidation of soot from the gas generation exhaust. The Space Force consequently expects that the produced soot would subsequently burn up in the exhaust plume (Kaisersatt, pers. comm., 2023a, p. 7).

No additional information detailing amounts of atmospheric emissions or an associated effects analysis from the proposed rocket launching were provided within the biological assessment.

Flame Duct, Deluge Water System, and Water Usage

At SLC-4, SpaceX would utilize an existing water-filled flame duct to reduce vibration impacts from noise on payloads. During Falcon 9 launches, approximately 70,000 gallons of water would be utilized per launch with approximately 40,000 gallons per landing. Using these estimates, for 16 launches and 2 terrestrial landing this would amount to roughly 1.2 million gallons (3.68 ac-ft) between October 1 and December 31, 2024, to support personnel and operational activities at SLC-4.

The Space Force has recently clarified that the current water source for VSFB, including SLC-4, is via an existing connection between State Water and the VSFB water supply system. For the majority of the 91 days of the proposed project, the Space Force would source water from this connection. However, during annual maintenance that lasts approximately two weeks and may occur during this timeframe, VSFB utilizes four water wells in the San Antonio Creek Basin. The Service consequently conservatively assumes that across this period (14 days), up to 184,615 gallons (0.57 ac-ft) could be extracted from these wells in San Antonio Creek Basin in support of the proposed project.

Launches would eject flame duct water. Based on prior Falcon 9 missions, approximately half of the volume of water remains in the flame duct and half is expelled as water and water vapor. Of the expelled water, approximately half is in the form of hot steam (17,500 gallons) with the remaining half being liquid (17,500 gallons). The proposed project would not create any overland flow of water into Spring Canyon as v-ditches divert and collect the water before it leaves the SLC-4 fence line. The containment features (e.g. v-ditch, etc.) within SLC-4 holds all water for a short duration until it dissipates. A minimal quantity of water reaches Spring Canyon in the form of steam and water droplets and is expected to dissipate quickly.

Vegetation Maintenance

The Space Force maintains vegetation within the v-ditch feature at SLC-4 on a periodic basis (Kaisersatt, pers. comm. 2023e). The Service assumes these activities could occur at any time of year.

SpaceX would continue to maintain all vegetation to just above ground level within a 3.3-acre area of Spring Canyon adjacent to SLC-4 (hereafter referred to as the Vegetation Management Area) that launches impact by the ejection of hot steam.

The Service also understands that the Space Force would continue to maintain firebreaks surrounding SLC-4 and that these activities could occur at any time of year.

AVOIDANCE AND MINIMIZATION MEASURES

For this analysis, all avoidance and minimization measures identified in previous consultations (Service 2017; 2017-F-0480) (Service 2023a; 2022-0013990-S7-001) are incorporated by reference for brevity due to operational similarity. The following is a list of additional avoidance and minimization measures applicable to this analysis. The measures provided below are either new for this analysis or sourced from the 2017 and/or 2023 consultations and reiterated for clarity.

Biologist Definitions

Avoidance and minimization measures included in this biological opinion require various levels of biological competency from personnel completing specific tasks, as defined below:

- Permitted Biologist: Biologist with a valid and current Section 10(a)(1)(A) Recovery Permit issued by the Service or specifically named as a Service Approved Biologist in a project-specific biological opinion. The Space Force will coordinate with the Service prior to assigning Permitted Biologists to a specific project.
- Service Approved Biologist: Biologist with the expertise to identify listed species and species with similar appearance. The Space Force will review and approve the resumes for each individual, and then submit them to the Service for review and approval no less

than 30 days prior to the start of the project. A Service Approved Biologist could train other biologists and personnel during surveys and project work; in some cases, a Service Approved Biologist could also provide on-site supervision of other biologists.

- Qualified Biologist: Biologist trained to accurately identify specific federally listed species and their habitats by either a Permitted or Service Approved Biologist. This person could perform basic project monitoring but would need to have oversight from a Permitted or Service Approved Biologist. Oversight will require a Permitted or Service Approved Biologist to be available for phone/electronic mail consultation during the surveys and to have the ability to visit during monitoring/survey activities if needed.

General Project Avoidance and Minimization Measures

As part of the proposed action, the Space Force proposes to implement the following measures. These protection and monitoring measures would apply to all aspects of the proposed action to protect and minimize effects on biological resources. The Space Force will ensure SpaceX takes all identified applicable actions as listed below.

GM-1 The Space Force will ensure that SpaceX continue to implement measures described in the 2017 biological assessment (MSRS 2017) which include: (1) SpaceX will follow the site-specific Stormwater Pollution Prevention Plan already implemented for SLC-4; (2) SpaceX will implement the Best Management Practices within the latest California Stormwater Quality Association's Stormwater Best Management Practices Handbook; (3) SpaceX will collect any rocket propellant seen floating in the retention basin using absorbent pads prior to discharge to the spray field; and (4) SpaceX will fully implement the procedures in VSFB's Hazardous Materials Emergency Response Plan in the event of a hazardous materials spill.

a. The Space Force will continue to sample water quality in lower Spring Canyon once annually whenever ponded water is present to ensure no project-related byproducts (i.e., launch combustion residue, operations-related run-off, etc.) have entered the waterway in a manner not previously considered in this analysis. The Space Force will continue to perform sampling a minimum of once a year until 2026, as required under BO 2022-0013990-S7-001 (USFWS 2023a). The Space Force will design water quality sampling to detect potential project related byproducts and any resulting associated changes in aquatic habitat (i.e., salinity, pH, etc.). Sampling will consider and utilize the most recent applicable advances in water quality sampling technology. The Space Force will include maps depicting sampling locations during annual reporting. The Space Force will collect and clearly present data including any associated chemical and nutrient presence, dissolved oxygen, water temperature, turbidity, and any other pertinent observations regarding ecosystem condition for purposes of annual comparison. If project-related water contamination occurs, the Space Force will coordinate with the Service, address sources of input, and begin remediation within the month.

GM-2 The Space Force will require 30 CES/CEIEA and Service approval of all Service Approved Biologists, which will be personnel who are familiar with and possess necessary qualifications to be approved for capture, handle, and release species as stated above. These biologists will be responsible for monitoring, surveying, and other biological field activities. They will also be responsible for relocating species at risk of being directly killed or injured by project related activities (such as California red-legged frog and southwestern pond turtle).

GM-3 The Space Force will require Qualified Biologists brief all project personnel prior to participating in project implementation activities. At a minimum, the training will include a description of the listed species and sensitive biological resources occurring in the area, the general and specific measures, and restrictions to protect these resources during project implementation, the provisions of the Act and the necessity of adhering to the provisions of and the penalties associated with violations of the Act.

GM-4 The Space Force will ensure that disturbances be kept to the minimum extent necessary to accomplish project objectives.

GM-5 The Space Force will ensure that all human-generated trash at the project site will be disposed of in proper containers and removed from the work site and properly secured in a suitable trash container at the end of each workday, all food waste will be properly contained, and trash will be removed from the work area weekly throughout the course of the proposed project.

GM-6 The Space Force will ensure that a Qualified Biologist will inspect any equipment left overnight prior to the start of work the following day. The Qualified Biologist will check equipment for presence of special-status species in the vicinity and for fluid leaks and immediately let 30 CES/CEIEA know to coordinate subsequent actions prior to the start of work.

GM-7 The Space Force will continue to remove nonnative, invasive predators encountered during survey efforts (i.e., bullfrogs [*Lithobates catesbeianus*]).

GM-8 The Space Force will ensure that any vegetation clearance (within Spring Canyon) or firebreak maintenance conducted between October 1 and December 31, 2024, in the vicinity of SLC-4 will require biological clearance surveys and the presence of a biological monitor during these work activities. As stated in GM-2, in the event listed species are encountered and are at risk of being directly killed or injured, or nests destroyed, by work activities, a Service Approved Biologist will be responsible for species relocation. To avoid transferring disease or pathogens between aquatic habitats during surveys and handling of amphibians, the Space Force will ensure that Service Approved Biologists will follow decontamination procedures described in the Declining Amphibian Population Task Force’s Code of Practice (DAPTF) (USFWS 2002a).

GM-9 The Space Force will establish a pre-project baseline for hydrodynamic data within San Antonio Creek. During project operations the Space Force will collect hydrodynamic data annually using consistent data collection methodologies for purposes of comparison against the established baseline. The Space Force will use this data to ensure that the proposed project's water extraction, when viewed in addition to the unknown total water extraction amount of permitted launch projects, is not measurably affecting flow rate or water level within San Antonio Creek.

GM-10 The Space Force will ensure that SpaceX prepare a lighting management plan for SLC-4 to retrofit the existing facility's lighting to be completed by January 2025. This plan will incorporate best management practices in lighting retrofit design to reduce current and future lighting impacts into natural, undeveloped areas, to the maximum degree possible while still meeting operational requirements. This requirement will be accomplished through strategic placement of lights, and the use of shields, timers, and motion sensors wherever possible to minimize potential effects associated with novel persistent artificial light at night. The SLC-4 lighting management plan will be submitted to the Space Force for approval and USFWS for reference prior to the end of 2024.

Species-specific Avoidance and Minimization Measures

California Red-Legged Frog

Measures GM-6 to GM-8 above address California red-legged frog avoidance. In addition, the following California red-legged frog specific measures are included:

CRLF-1 The Space Force will maintain exhaust ducts and associated v-ditch at SLC-4 be free of standing water to the maximum extent possible between launches to help minimize the potential to attract California red-legged frog to the area.

CRLF-2 The Space Force will require that a Qualified Biologist survey the SLC-4 features for California red-legged frog prior to any vegetation maintenance activities and relocate any encountered individuals.

CRLF-3 Vegetation removal clearance surveys and monitoring: refer to GM-8.

CRLF-4 Pre/Post Launch Surveys: At SLC-4, the Space Force will require a Qualified Biologist to perform one California red-legged frog survey annually during peak breeding season (typically November through April, depending on rainfall) in Spring Canyon when individuals are most likely to be present and detectable. If the Qualified Biologist does not encounter California red-legged frog at the time of this survey, the Space Force will not require any other subsequent pre-/post-launch surveys. If California red-legged frogs are present during the annual survey, the Space Force will require pre- and post-launch surveys and relocation of any California red-legged frogs encountered for each subsequent launch event.

CRLF-5 California red-legged frog baseline and launch monitoring:

a. The Space Force will implement long-term monitoring of annual population and distribution trends associated with California red-legged frog populations within Jalama Creek, Honda Creek, Bear Creek, and the Santa Ynez River. The Space

Force will develop a monitoring plan that adequately addresses potential short- and long-term project effects that may result from sensory pollutants.

i. The monitoring plan will clearly establish a pre-project baseline of the California red-legged frog average population level within each impacted breeding feature (Jalama Creek, lower Honda Creek, Bear Creek, and Santa Ynez River) and clearly define the survey area and methodology. Following project implementation, the Space Force will conduct quarterly surveys utilizing the same methodology within each impacted breeding feature during the breeding season when California red-legged frogs are most likely to be encountered.

ii. The monitoring plan will include passive bioacoustics monitoring (Wildlife Acoustics Song-Meter 4 or similar technology) and will establish California red-legged frog calling behavior baseline within each impacted breeding feature (Jalama Creek, Honda Creek, Bear Creek, and Santa Ynez River). In the event the baseline is unable to be established prior to an increase in historic average launch rate, the plan will include identified appropriate control sites outside of impacted areas for purposes of signal characteristic comparison for additional necessary reference. California red-legged frog calling behavior baseline will include applicable call characteristics (e.g., any changes in signal rate, call frequency, amplitude, call timing, call duration, etc.). The Space Force will ensure that bioacoustics monitoring conducted is designed to best address confounding factors in order to appropriately characterize impacts of launch, static fire, and landing events on calling behavior. Statistical analysis of results will incorporate long term annual population data whenever possible to ensure any observed changes in signal characteristics are not resulting in observable declines in population.

CRLF-6 The Space Force will conduct quarterly night surveys for California red-legged frog and spring tadpole surveys of lower Honda Creek, Jalama Creek, Bear Creek, and the Santa Ynez River to compare baseline California red-legged frog occupancy data collected over the past 10 years and assess if there are any changes in California red-legged frog habitat occupancy, breeding behavior (calling), and breeding success (egg mass and tadpole densities). The Space Force will record and measure the following during the surveys:

a. California red-legged frog detection density (number of individuals per survey hour) following the same survey methods conducted previously at these sites and throughout VSFB;
b. California red-legged frog locations and breeding evidence (e.g., calling, egg masses);
c. environmental data during surveys (temperature, wind speed, humidity, and dewpoint) to determine if environmental factors are affecting California red-legged frog detection or calling rates;

d. annual habitat assessments to measure flow rates, stream morphology, depths, and sediment to determine if any changes in California red-legged frog metrics are associated with other environmental factors, such as drought;
e. and, locations and densities of co-occurring anurans, including bullfrogs (*Lithobates catesbeianus*) and Baja California tree frogs (*Pseudacris hypochondriaca*).

CRLF-7 The Space Force will conduct bioacoustic monitoring annually during California red-legged frog breeding season (typically November through April, depending on rainfall) to characterize the noise environment and determine if there are changes in calling behaviors as the proposed project commences. The Space Force will place passive noise recorders and environmental data loggers (temperature, relative humidity, dew point) at two suitable breeding locations each within lower Honda Creek, Jalama Creek, Bear Creek, and the Santa Ynez River. Passive bioacoustic recording will occur throughout the entirety of the breeding season using the Wildlife Acoustics Song-Meter 4 (or similar technology) with software that enables autodetection of California red-legged frog calling. The Space Force will use bioacoustic monitoring to characterize and analyze impacts of launch, static fire, and landing events on calling behavior during the breeding season to assess whether Falcon 9 noise events affect California red-legged frog calling frequency or other characteristics.

CRLF-8 To address potential declining population trends that may be a result of the proposed project, the specified threshold criteria is described below.

a. California red-legged frog occupancy, or tadpole densities decline (or bioacoustics signal characteristics change) from baseline by 15 percent or more and,
b. the 15 percent decline (or signal characteristic change) from baseline maintains for two consecutive years.

CRLF-9 If any of these threshold criteria are met and cannot confidently be attributed to other natural- or human-caused catastrophic factors unrelated to the proposed action (see potential scenarios defined below), the Space Force will mitigate these impacts as discussed under the *Habitat Mitigation and Monitoring Plan* section below. Potential catastrophic scenarios include the following:

a. Fire, unrelated to project activities or launch operations, that directly impacts Jalama Creek, lower Honda Creek, Bear Creek, or the Santa Ynez River and is demonstrated to degrade or destroy breeding habitat.
b. Landslides or significant erosion events, unrelated to project activities or launch operations, in Jalama Creek, Honda Creek, Bear Creek, or the Santa Ynez River that result in the elimination or degradation of California red-legged frog breeding habitat.
c. Drought or climate impacts (clearly unrelated to launch activities) that quantifiably reduce available aquatic habitat further than what was available during existing baseline.

d. Flash flood events during the breeding season that are more significant than those experienced during the existing baseline.

The Space Force will review the purported cause of decline with the Service and reach agreement. If cause of declines is determined to be inconclusive (e.g. if the Space Force and Service disagree), the Space Force will implement or require the project proponent to implement proposed mitigation.

CRLF-10 In the event the aforementioned California red-legged frog mitigation threshold criteria are met, the Space Force will implement the following California red-legged frog mitigation actions:

a. The Space Force will create new California red-legged frog breeding habitat at a 2:1 ratio (habitat enhanced: habitat affected with acreage calculated using National Wetlands Inventory data) for adverse effects to occupied California red-legged frog habitat, as determined above, at the San Antonio Creek Oxbow Restoration Area, an established wetland mitigation site on VSFB. Historically occupied by riparian vegetation, restoration efforts will focus on enhancing this abandoned tract of agricultural land to improve sensitive species habitat in San Antonio Creek and expand breeding habitat for California red-legged frog.
b. The Space Force will conduct additional restoration in the "expansion area" adjacent to the existing restoration area (where restoration has already been conducted in support of other projects). Restoration will involve digging a channel that reaches ground water. Spoils generated during excavation will be used to create a berm bordering the channel that will be planted with willows. This method is already being used at this site and has been proven to successfully create deep water aquatic habitat, that supports California red-legged frog reproduction, bordered by riparian woodland. The restored habitat mirrors naturally occurring high-flow channels in San Antonio Creek.
c. Action taken within this area will include site preparation via herbicide application, plowing, container plant installation, seeding, willow pole planting (via water jet, hand-held power auger, or manually driving a steel rod into the ground), and watering via water truck. The mitigation actions for California red-legged frog are included in the existing Service PBO (8-8-12-F-49R) and all applicable avoidance, minimization, and monitoring measures required under the PBO would be implemented.

<u>Southwestern Pond Turtle</u>

Measures GM-6 to GM-8 above address southwestern pond turtle avoidance. In addition, the following southwestern pond turtle specific measures are included:

SWPT-1 Southwestern pond turtle Baseline Monitoring: The Space Force will implement long-term monitoring of annual population and distribution trends associated with southwestern pond turtle populations within Jalama Creek, Honda Creek, Bear Creek, and the Santa Ynez River. The Space Force will develop a monitoring plan that adequately addresses potential short- and long-term project effects that may result from sensory pollutants. The plan will provide best practices in land for the conservation and recovery of the species.

SWPT-2 The monitoring plan will clearly establish methods to estimate average population levels to be used as a baseline within each impacted breeding feature (Jalama Creek, Honda Creek, Bear Creek, and the Santa Ynez River) and clearly define the survey area and methodology. The baseline of southwestern pond turtle populations by each feature and base-wide will be established prior to increased launching or an appropriate off-site control will be used.

a. The Space Force will identify overwintering, breeding, basking, and nesting habitat within the vicinity of SLC-4 and within identified major riparian features. Mark-recapture techniques will be used to monitor population sizes and movements of individuals.
b. The Space Force will implement annual habitat assessments to measure flow rates, stream morphology, depths, and sediment to determine if any changes in southwestern pond turtle metrics are associated with other environmental factors, such as drought.

SWPT-3 To address potential declining trends that may be a result of the proposed project, the specified threshold criteria are described below:

a. Southwestern pond turtle population estimates (baseline) decline by 15 percent or more and,
b. The 15 percent decline from baseline is maintained for two consecutive years.

SWPT-4 If any of these threshold criteria are met and cannot confidently be attributed to other natural- or human-caused catastrophic factors unrelated to the proposed action (see potential scenarios defined below), the Space Force will mitigate these impacts as discussed under the *Habitat Mitigation and Monitoring Plan* section below. Potential catastrophic scenarios include the following:

a. Fire, unrelated to project activities or launch operations, that directly impacts Jalama Creek, Honda Creek, Bear Creek, or the Santa Ynez River and is demonstrated to degrade or eliminate breeding habitat.
b. Landslides or significant erosion events, unrelated to project activities or launch operations, that result in the elimination or degradation of southwestern pond turtle habitat.
c. Drought or climate impacts (clearly unrelated to launch activities) that quantifiably reduce available aquatic habitat further than what was available during existing baseline.
d. Flash flood events during the breeding season that are more significant than that experienced during the existing baseline.

The Space Force will review the purported cause of decline with the Service and reach agreement. If cause of declines is determined to be inconclusive (e.g. if the Space Force and Service disagree), the Space Force will implement or require their project proponent to implement proposed mitigation.

SWPT-5 In the event the aforementioned southwestern pond turtle mitigation threshold criteria are met, the Space Force will implement the following southwestern pond turtle mitigation actions:

a. The Space Force will create new southwestern pond turtle habitat at a 2:1 ratio (habitat enhanced: habitat affected, with acreage calculated using National Wetlands Inventory data) for adverse effects to occupied southwestern pond turtle habitat, as determined above, at the San Antonio Creek Oxbow Restoration Area, an established wetland mitigation site on VSFB. Historically occupied by riparian vegetation, restoration efforts will focus on enhancing this abandoned tract of agricultural land to improve San Antonio Creek and provide habitat for southwestern pond turtle.
b. The Space Force will conduct additional restoration in the "expansion area" adjacent to the existing restoration area (where restoration has already been conducted in support of other projects). Restoration will involve digging a channel that reaches ground water. Spoils generated during excavation will be used to create a berm bordering the channel that will be planted with willows. This method is already being used at the site and has proven successful at creating deep water aquatic habitat, suitable for southwestern pond turtle, with adjacent riparian woodland that simulates naturally occurring high-flow channels.
c. The Space Force will ensure that actions taken within this area will include site preparation via herbicide application, plowing, container plant installation, seeding, willow pole planting (via water jet, hand-held power auger, or manually driving a steel rod into the ground), and watering via water truck.

SWPT-6 Vegetation removal clearance surveys and monitoring: refer to GM-8

<u>Western Snowy Plover</u>

WSPL-1 The Space Force will implement long-term monitoring of annual population and distribution trends associated with western snowy plover along Surf Beach. The Space Force will develop a monitoring plan that adequately addresses potential short- and long-term project effects that may result from sensory pollutants. The western snowy plover monitoring plan will include a clear, established baseline annual variation and decline threshold that would trigger proposed mitigation discussed below.

a. The Space Force will implement the current western snowy plover monitoring program on VSFB and continue to perform acoustic monitoring and geospatial analysis of nesting activity on South Surf Beach to assess potential adverse effects from Falcon-9 associated noise events.

b. The current Base-wide western snowy plover monitoring program estimates breeding effort, nest fates, and fledging success while recording patterns of habitat use through the season. The Space Force will continue to place sound level meters (SLMs) immediately inland of South Surf Beach to characterize the noise environment and any related launch and landing associated disturbance. The Space Force will perform annual geospatial analysis to identify declines in the western snowy plover population (both breeding and overwintering), nesting activity, and reproductive success that may result from collective effects of multiple Falcon launches and landings from SLC-4.

WSPL-2 To address potential declining trends that may be a result of the proposed project, the specified threshold criteria is described below.

a. Geospatial analysis shows a statistically significant decline (defined as a decline greater than the baseline annual variation in these variables over the past 10 years at South Surf Beach) in population or reproductive success, and

b. the decline from baseline maintains over two consecutive years within the areas impacted by noise from the Falcon 9.

WSPL-3 If any of these threshold criteria are met and cannot confidently be attributed to other natural- or human-caused catastrophic factors unrelated to the proposed action (see potential scenarios defined below), the Space Force will mitigate these impacts as discussed under the *Habitat Mitigation and Monitoring Plan* section below. Potential catastrophic scenarios include the following:

a. Significantly higher levels of tidal activity as compared with the existing baseline and demonstrable across remainder of base population.
b. Significant avian disease demonstrable across the recovery unit.
c. Separate work activities (i.e., restoration efforts) not related to the project.

The Space Force will review the purported cause of decline with the Service and reach agreement. If cause of declines is determined to be inconclusive (e.g. if the Space Force and Service disagree), the Space Force will implement or require the project proponent to implement proposed mitigation.

WSPL-4 In the event the aforementioned western snowy plover mitigation threshold criteria are met, the Space Force will implement the following western snowy plover mitigation actions:

a. The Space Force will increase predator removal efforts to include the non-breeding season, particularly focusing on raven removal at and adjacent to VSFB beaches. Raven population increases are a substantial threat to western snowy plover populations on VSFB. The Space Force anticipates that off-season raven control efforts will help reduce the raven population on VSFB prior to the breeding season which should increase nest success and overall breeding adult numbers (See Appendix A; Figure 4B)
b. Predator control actions will include trapping, shooting, and tracking western snowy plover predators from VSFB beaches and surrounding areas on Base.

> The mitigation actions for SNPL are permitted under the existing Service Beach Management BO (8-8-12-F-11R; Service 2015) and all applicable avoidance, minimization, and monitoring measures required under BO 8-8-12-F-11R will be implemented. CEIEA also maintains a USFWS depredation permit.

Habitat Mitigation and Monitoring Plan

As discussed in the avoidance and minimization measures above, the Space Force proposes habitat mitigation in the event the proposed project's monitoring detects a change in the established baselines of species populations (CRLF 8-10, SWPT 3-5, WSPL 2-4). In the event the Space Force detects declines and declines meet threshold trigger criteria, the Space Force will implement mitigation activities as detailed below.

The potential mitigation actions for California red-legged frog and southwestern pond turtle include the creation of new breeding habitat at a 2:1 ratio (habitat enhanced: habitat affected with acreage calculated using National Wetlands inventory data for riparian features) within the San Antonio Creek Oxbow Restoration "expansion area", which comprises approximately 7.5 acres (Appendix A, Figure 4A). The original Oxbow Restoration site approximately 3.25 acres of abandoned agricultural land that borders San Antonio Creek where riparian vegetation historically occupied. The Space Force initiated compensatory mitigation restoration work at this site associated with a separate previous project (2016-F-0103; Service 2018) in the fall of 2019 to improve California red-legged frog habitat within San Antonio Creek (MSRS 2020, p. 2). The proposed expansion area as well as the original Oxbow Restoration site are both located within the proposed action's launch noise effect area (Appendix A). Potential mitigation actions associated with the proposed project within the Oxbow Restoration area include expansion of the original site with preparation via herbicide application, plowing, container plant installation, seeding, willow pole planting, and watering via water truck. The existing biological opinion (2016-F-0103; Service 2018) includes potential mitigation actions for California red-legged frog and the Space Force will implement all required avoidance, minimization, and monitoring measures. Southwestern pond turtle is not currently covered under this document and is consequently addressed below. The Space Force will track and report on restoration efforts and success within an annual report. No additional off-site areas have yet been identified where proposed mitigation may occur. Although the Space Force has not yet identified specific additional recovery projects for California red-legged frog or southwestern pond turtle, their potential restoration activities will align with the objectives of the California red-legged frog Conservation Strategy (Service, *in prep*) with the commitment to achieve no net loss to the species (Kephart, in litt., 2022, p. 3; MSRS 2024a, p. 113).

The potential mitigation actions for western snowy plover include increasing predator control in the non-breeding season, including trapping, shooting, and tracking known predators of western snowy plover with particular focus on raven removal at and adjacent to VSFB beaches. The Service refers to areas targeted for predator control as the Predator Management Area which includes the majority of VSFB (Appendix A, Figure 4B). The Predator Management Area is located on-base and falls within the proposed project's Noise and Overpressure Effect Area (Appendix A). An existing biological opinion (8-8-12-F-11R; Service 2015) permits these actions, and the Space Force will implement all required avoidance, minimization, and monitoring measures. The Space Force also maintains a depredation permit issued by the Service. The Space Force will report on predator removal efforts and success within an annual report. The Space Force has not yet identified specific alternative recovery projects for western snowy plover that may serve as an appropriate offset. However, the Space Force has communicated that they will pursue other beneficial actions including recovery opportunities outlined in the western snowy plover recovery plan (Service 1970, Service 2007a) and 5-year reviews (Service 2006a, 2019, 2020)following mutual agreement by the Service and the Space Force annually, supporting the Space Force's commitment to ensure no net loss (Kephart, in litt., 2022, p. 3; MSRS 2024a, p. 141).

ANALYTICAL FRAMEWORK FOR THE JEOPARDY AND ADVERSE MODIFICATION DETERMINATIONS

Jeopardy Determination

Section 7(a)(2) of the Act requires that Federal agencies ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of listed species. "Jeopardize the continued existence of" means "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR 402.02).

The jeopardy analysis in this biological opinion relies on four components: (1) the Status of the Species, which describes the current rangewide condition of the California red-legged frog, western snowy plover, California least tern, and southwestern pond turtle the factors responsible for that condition, and its survival and recovery needs; (2) the Environmental Baseline, which analyzes the condition of the California red-legged frog, western snowy plover, California least tern, and southwestern pond turtle in the action area, the factors responsible for that condition, and the relationship of the action area to the survival and recovery of the California red-legged frog, western snowy plover, California least tern, and southwestern pond turtle; (3) the Effects of the Action, which determines all consequences to the California red-legged frog, western snowy plover, California least tern, southwestern pond turtle caused by the proposed action that are reasonably certain to occur in the action area; and (4) the Cumulative Effects, which evaluates the effects of future, non-Federal activities, that are reasonably certain to occur in the action area, on the California red-legged frog, western snowy plover, California least tern, and southwestern pond turtle.

In accordance with policy and regulation, the jeopardy determination is made by evaluating the effects of the proposed Federal action in the context of the current status of the California red-legged frog, western snowy plover, California least tern, and southwestern pond turtle by taking into account any cumulative effects, to determine if implementation of the proposed action is likely to reduce appreciably the likelihood of both the survival and recovery of the California red-legged frog, western snowy plover, California least tern, and southwestern pond turtle in the wild by reducing the reproduction, numbers, and distribution of that species.

STATUS OF THE SPECIES AND ITS CRITICAL HABITAT

Southwestern Pond Turtle

Legal Status

The southwestern pond turtle is not listed under the Act; however, it is currently proposed threatened and under federal review for listing under the Act (88 FR 68370).

The Service was petitioned to list 53 species of reptiles and amphibians, including the western pond turtle (*Actinemys marmorata*), as threatened or endangered under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531–1543), in July 2012. On April 10, 2015, we published a 90-day finding that the petition presented substantial scientific or commercial information indicating that listing may be warranted for the western pond turtle (80 FR 19262–19263). Since then, the western pond turtle was split into two separate species, the northwestern pond turtle (*Actinemys marmorata*) and southwestern pond turtle (*Actinemys pallida*). The species status assessment was issued in April 2023 (Service 2023b), compiling biological information and condition on both species.

Natural history and Species Description

The southwestern pond turtle is a medium-sized turtle, with adults ranging from 110 to 179 mm long (maximum carapace (shell) length) and weighing between 194 to 828 grams (Germano and Riedle 2015, p. 104). Females tend to have a smaller head, less angled snout, taller and rounder carapace, flat (rather than concave) plastron (underside of shell) , and thinner tail as compared to males (Holland 1994, pp. 2-4; Rosenberg et al. 2009, p. 10). Colors and markings vary geographically and by age with most appearing olive to dark brown, or blackish, occasionally without pattern but usually with a network of spots, lines, or dashes of brown or black that often radiate from growth centers of shields (Bury et al. 2012, p. 4; Stebbins and McGinnis 2018, pp. 204–205). Hatchlings are generally a brown-olive color with visible mottling on the head and neck (Hays et al. 1999, p. 2) that darken with age. Hatchlings are 25 to 31 mm long carapace length (CL) (approximately the size of an American quarter) and weigh 3 to 7 grams at the time of emergence (Bury et al. 2012, pp. 4, 17). The shell of hatchlings is soft and pliable, and the tail is nearly as long as the shell (Ashton et al. 1997, p. 3; Stebbins and McGinnis 2018, p. 205). The shell becomes fairly hard around three to four years of age (Bury et al. 2012, p. 4). Eggs are off-white, elliptical-oval shaped, and range from 32 to 42 mm long and from 18 to 25 mm in diameter (Bury et al. 2012, p. 15).

Seeliger (1945, entire) first proposed geographic differentiation of western pond turtles into northern and southern subspecies based on differences in coloration and the presence and shape of the inguinal scute, the plate where the carapace joins the plastron at the groin. Since then, the western pond turtle was split into two separate species, the northwestern pond turtle (*Actinemys marmorata*) and southwestern pond turtle (*Actinemys pallida*). Recent genetic results corroborate the morphologic distinctiveness (presence/absence of inguinal scutes) as one of the components differentiating northwestern and southwestern pond turtles (Shaffer and Scott 2022, p. 9).

Southwestern pond turtles are semi-aquatic, having both terrestrial and aquatic life history phases. Eggs are laid in upland terrestrial habitat, and hatchings, juveniles, and adults use both terrestrial and aquatic habitat. Terrestrial environments are required for nesting, overwintering, and aestivation (warm season dormancy), basking, and movement/dispersal. Aquatic environments are required for breeding, feeding, overwintering and sheltering, basking, and movement/dispersal. Perennial (i.e., year-round) and intermittent (i.e., not year-round) bodies of water occur throughout the range. Some are flowing/lotic (e.g., streams, rivers, irrigation ditches), while others are not flowing/lentic (e.g., ponds, lakes, and reservoirs).
Preferred aquatic conditions are those with abundant basking sites, underwater shelter sites (undercut banks, submerged vegetation, mud, rocks, and logs), and standing or slow-moving water (Holland 1991, pp. 13–14; Reese and Welsh Jr. 1998a, p. 852; Hays et al. 1999, p. 10; Bury and Germano 2008, p. 001.4; Ernst and Lovich 2009, p. 175). Western pond turtles inhabiting lentic aquatic habitat, such as ponds, lakes, and slack water habitats, often overwinter within the aquatic environment, burying themselves within the bottom substrate, such as mud. Various depths of water provide western pond turtles with habitat necessary for overwintering and hatchling growth. Primary habitat for hatchlings and young juveniles is shallow water with dense submerged vegetation and logs, which most likely provides shelter, prey, and thermoregulatory requirements or other functions for survival (Holland 1994, pp. 1-14, 2-12; Rosenberg and Swift 2013, p. 119). Western pond turtles are extremely wary and will rapidly flee from basking sites into the water when disturbed by the sight or sound of people at distances of greater than 100 m (328 ft) (Bury and Germano 2008, p. 001.5).

Nesting habitat is in close proximity to aquatic habitat and is typically characterized as having sparse vegetation with short grasses and forbs and little or no canopy cover to allow for exposure to direct sunlight (Holland 1994, p. 2-10; Rathbun et al. 2002, p. 232; Rosenberg et al. 2009, pp. 16–17; Riensche et al. 2019, p. 97). Females excavate nests in compact, dry soils that are 3 to 400 m from water (Holland 1994, p. 2-10; Holte 1998, p. 54). Soils need to be loose enough to allow nest excavation, and typically have a high clay or silt component. Disturbance needs to be infrequent enough or of sufficiently low intensity that nesting females are not disturbed. Nests are shallow and generally occur between 9 to 12 cm below the surface (Service 2023b, p. 22). Additional features of nesting habitat/sites that may be important include aspect, slope, and vegetation.

Overwintering is a state of little to no activity (e.g., brumation) that occurs during the cooler months of the year and can occur in either upland or aquatic environment (Holland 1994, p. 2-7;

Ultsch 2006, pp. 341, 356). During overwintering, southwestern pond turtle can utilize the duff and leaf litter layers leaving part of their carapace exposed. Southwestern pond turtles also use upland habitat for migration (intra-population (within local populations) movements occurring between aquatic and upland environments), dispersal (movement between populations/watersheds), and aestivation. Aestivation is a period of inactivity, usually in response to the hottest time of year or dry conditions (Hays et al. 1999, p. 7) that occurs in terrestrial habitat. Along the central California coast, western pond turtles that occupied pond habitat overwintered on-site, whereas most turtles from an adjacent stream left with the first heavy rains and overwintered in the upland or moved to the pond (Service 2023b, p. 26).

In Central California, southwestern pond turtle egg-laying takes place May to July. Additionally, from southwestern pond turtles will move from seasonal ponds and permanent streams and rivers to overwinter at least 500 meters away in September or October and finish overwintering between March and April (Bury et al. 2012). On VSFB, available information indicates that egg laying occurs between April and August (U.S. Air Force 2014, p. 38). Hatchlings could stay in the nest and overwinter as well.

The southwestern pond turtle is omnivorous and considered a dietary generalist (Holland 1994, p. 2-5), consuming a wide variety of food items. Prey resources are primarily found within water but can be captured or scavenged on land. Food captured or scavenged on land must be brought back to water for consumption, as they appear to be unable to swallow in the air (Holland 1994, p. 2-6). Animal matter appears to constitute a larger portion of the diet than plant material (Bury 1986, pp. 518–520; Holland 1994, pp. 2-5–2-6). Stomach contents reveal the diet consists of small aquatic invertebrates, with small vertebrates (fish, tadpoles, and frogs), carrion, and plant material (Bury 1986, p. 516; Holland 1994, pp. 2-5–2-6). Nonnative predators include American bullfrogs (*Lithobates catesbeianus*; hereafter bullfrogs) and invasive fish, such as large and smallmouth bass (*Micropterus* sp.; hereafter bass). Native predators of western pond turtles include raccoons, skunks, foxes, coyotes. mink, herons, river otters, burrowing small mammals, and giant water bugs.

Southwestern pond turtles mature slowly and have low fecundity but are potentially long-lived. In southern California, the smallest known reproductive female was approximately 111 mm carapace length and at least 6 to 7 years old (Holland 1994, p. 5-2). Courtship behaviors have been observed from April through November, with mating observed in May through September (Holland 1991, p. 23). Oviposition usually occurs from May through July (Bury et al. 2012, p. 15). Clutch size for western pond turtles varies from 1 to 13 eggs, and is positively correlated with body size (Holland 1994, p. 5-2; Holte 1998, p. 5). Incubation time is approximately 80 to 126 days (Holland 1994, pp. 2-10, 5-7). Western pond turtles exhibit temperature-dependent sex determination (TSD) during incubation (Ewert et al. 1994, p. 7). In California, female hatchlings were more likely when 30 percent of the sex-determining period occurred above 29° Celsius (C) (84° Fahrenheit (F)) (Christie and Geist 2017:49). In addition, lower fluctuations in temperature resulted in development of males, whereas females developed in nests with high and low temperature fluctuations. In southern and central California, some hatchlings may emerge from the nest chamber in late-summer to early-fall, whereas others overwinter in the nest chamber and emerge in spring (Holland 1994, p. 2-10). The maximum lifespan of western pond turtles is unknown. However, they are long-lived species after reaching adulthood, with some northwestern pond turtles living to at least 55 years of age (Bury et al. 2012, p. 17).

Home range size and configuration varies between age class, sex, and location. Measured home ranges of western pond turtles average 1 hectare (2.5 acres) for males, 0.3 hectare (0.7 acre) for females, and 0.4 hectare (1 acre) for juveniles (Bury 1972). Female pond turtles in two southern California streams had home ranges that were longer and smaller (Goodman and Stewart 2000) than those observed by Bury (1972, entire), likely because the streams in southern California tend to be narrower so pond turtles have to move further distances to obtain sufficient resources. Western pond turtles are capable of dispersing substantial distances, although large overland movements are uncommon. Available information on radio-tagged western pond turtles in central California demonstrated that individuals spent over half of the year in terrestrial habitat, typically with movements no farther than 0.21 mile from seasonal ponds (Service 2023b, p. 27). However, dispersal of southwestern pond turtle between populations and watersheds is generally not well understood. Genetic analyses suggest that most movements occur within drainages, but few accounts of larger dispersal movements exist. Dispersal distance of 4.35 miles within aquatic habitat and 3.1 miles by a single individual of terrestrial upland habitat have been documented (D.C. Holland 1994, p. 7-28). However, in the same study, no movements between drainages were detected from three other sites with over 1,100 hundred captures and recaptures over a 7-year period indicating large movements are likely atypical and may be related to resource availability.

<u>Rangewide status</u>

The historical range of western pond turtles extends along the Pacific coast from British Columbia, Canada to the northern part of Baja California, Mexico, primarily west of the Sierra Nevada and Cascade ranges (Ernst and Lovich 2009, p. 173; Stebbins and McGinnis 2018, p. 205). Western pond turtles have been found at sites from brackish estuarine waters at sea level up to 2,048 meters (m) (6,719 feet (ft) (Ernst and Lovich 2009, p. 176) but mostly occur below 1,371 m (4,980 ft.) (Stebbins and McGinnis 2018, p. 205). The range of the southwestern pond turtle is restricted to those populations inhabiting the central Coast Range south from the middle of Monterey Bay to the species' southern range boundary in Baja California**.** A new population found south of the nearest reported population represents a range extension of 95.5 kilometers (and the only oasis population within the Central Desert ecoregion in Baja California) (Valdez-Villavicencio et al. 2016:265).

Shaffer and Scott (2022, entire) clarified areas of previous uncertainty immediately south, east, and west of the San Francisco Bay, where there were no specimens used in Spinks et al. (2014:2233) when describing northwestern and southwestern pond turtles, and the range around the San Francisco Bay presented in Thomson et al. (2016:297). Based on these genomic data, Shaffer and Scott recommended that the border along the coast between the two species was in the middle of Monterey Bay (Shaffer and Scott 2022, p. 5). It also clarified the contact zone between the two species at the edge of the South Coast Ranges where they meet the floor of the Central Valley; although there are individuals with genetics from both species along the area where the species come into contact in this area, it appears that the boundaries are adjacent but do not overlap (Shaffer and Scott 2022, pp. 4–5).

Threats and Conservation Needs

Habitat destruction and alternation are primary threats to the southwestern pond turtle. Extensive land conversion due to urbanization and agriculture has resulted in substantial losses to both upland and aquatic habitats across the range (Holland 1994, p. 1-23; Hays et al. 1999, pp. ix, 31; Spinks et al. 2003, p. 258; Bury and Germano 2008, p. 001.6; Rosenberg et al. 2009, p. 40; Thomson et al. 2016, pp. 300–301). As a result, a large fraction of the remaining habitat in southern California existing only as patches with little suitable upland habitat available for nesting (Thomson et al. 2016, p. 301). Overall, the range of the southwestern pond turtle is fragmented to varying degrees by human activities, with some sites extirpated, and in many cases, only small, isolated groups or individuals remaining (Holland 1991, p. 13).

Aquatic resources used by the western pond turtle have experienced high levels of loss, alteration, and degradation throughout the range of the two species (Reese and Welsh Jr. 1998b, p. 505; Germano 2010, p. 89). A substantial portion of the losses of aquatic habitat are due to anthropogenic water use (e.g., dams and diversions for the purposes of providing water for human use). Moreover, within the historical range of the western pond turtle, an extensive system of hydrologic infrastructure, including dams, reservoirs, diversions, and aqueducts, supports extensive agricultural and municipal water uses, and provides domestic water to many densely populated areas (Lund et al. 2007, p. 43; Hanak et al. 2011, pp. 19–69). These alterations include stream channelization, altered flow regimes, groundwater pumping, water diversions, damming, and water regulation for flood risk management (flood control), which affect hydrology, thermal conditions, and structure of western pond turtle aquatic and upland habitat.

Loss of upland habitat adjacent to southwestern pond turtle aquatic habitat can isolate pond turtles from surrounding populations and eliminate nesting sites, thus limiting the ability to successfully reproduce (Holland 1994, entire; Spinks et al. 2003). Agricultural areas and grazing pastures provide suitable habitat for nesting southwestern pond turtles, but certain practices, such as plowing and irrigation, could destroy nests (Crump 2001, entire). Western pond turtle eggs have permeable shells that have been observed to rupture after absorbing excess moisture, killing the pond turtle embryo (Feldman 1982:10). For example, this could be a problem in urban areas that are irrigated (Spinks et al. 2003:263).Roads can affect western pond turtle viability because of vehicles killing or injuring individuals or disturbing basking behavior, and by reducing connectivity between populations, which reduces migration between upland and aquatic habitat (Rosenberg et al. 2009:41; Nyhof 2013, p. 43; Thomson et al. 2016:301; Nicholson et al. 2020:entire; Manzo et al. 2021:494, S1 text supplement).

Development can also indirectly lead to habitat degradation and/or mortality as a result of down cutting and erosion, introduction of non-native plants and animals, water pollution, and recreational activities (Holland 1991). Increased runoff from irrigation results in down cutting and erosion which can eliminate pools, basking sites, and refugia used by pond turtles and isolates the aquatic environment from the surrounding upland environment. Invasion by nonnative aquatic plant species, such as *Arundo* spp. can alter the stream hydrology and displace emergent aquatic vegetation that provides refuge for juvenile turtles. Introduced non-native and urban-related animals include predators (e.g., non-native fish, bullfrogs, crayfish, dogs, and corvids) and competitors (e.g., non-native turtles, such as the red-eared slider).
Recreational activities such as hiking, biking, fishing, boating, and off-highway vehicles, and the associated disturbance within or adjacent to aquatic and nest habitats, can affect western pond turtles in a variety of ways, depending on the region and type of recreation. Some forms of recreation may cause mortality of individuals through trampling, while others degrade habitat, disturb pond turtle behavior, and/or contribute to other threats. For example, recreational activities may interact with the threat of collection because humans may encounter the species while engaging in other activities. Western pond turtles are extremely wary and will rapidly flee from basking sites into the water when disturbed by the sight or sound of people at distances of greater than 100 m (328 ft) (Bury and Germano 2008, p. 001.5).

Desiccation of waterways from drought has led to declines and extirpations of western pond turtle populations by negatively affecting the quality and/or quantity of its aquatic habitat, impacting survival, recruitment, and connectivity, and exacerbating the effects of other threats. Western pond turtle mortality during drought is well documented, and appears to occur as a result of drought-induced starvation (Lovich et al. 2017, p. 7) and/or drought-induced predation (Purcell et al. 2017, p. 21). Extended drought occurring during 1986–1987 through at least 1991 caused major population declines and extirpations in many areas, but most significantly in southern and central California (Holland 1991, p. 65). During this time, turtles in small to moderate sized watercourses were abundant until 1988–1989, but as water continued to dry, resulting in major increases in distance to the next water source, turtles concentrated in the few remaining pools exhausted available prey, and were exposed to increased predation.
During normal drought conditions, when water levels are low, western pond turtles can aestivate in upland habitat or move to another water body if one is within migration and/or dispersal distance. Aestivating southwestern pond turtles remained in upland habitat for approximately 7 months (mean 201 days, range 154 to 231 days) during the 2011–2012 drought (Belli 2016, p. 57), suggesting that even in a severe drought, individuals could remain alive to repopulate the water body once conditions become suitable again (see Purcell et al. 2017). However, extended drought conditions and/or increased frequency of droughts, could have substantive effects on populations, and other synergistic effects could also make repopulation by aestivating individuals unlikely. In addition, because females often forego nesting when conditions are unfavorable, extended drought can result in reduced reproduction and recruitment opportunities.

The conservation needs for pond turtles include conserving large blocks of suitable aquatic and associated upland habitat and maintaining connectivity by providing suitable habitat linkages for dispersal. Management activities that address threats to this species include controlling nonnative plants such as *Arundo donax*, controlling non-native aquatic predators and competitors such as fish, bullfrogs, crayfish, and red-eared sliders, and limiting predation by urban predators, such as dogs, ravens, and mammalian mesopredators such as coyote and raccoon (Service 2023b, pp. 48, 50-51, 61). Bullfrogs have been introduced into western pond turtle habitat and influence viability of the species by increasing predation pressure on hatchlings and small juveniles, and thus are considered to have the largest impact on western pond turtle demography (Service 2023b, pp. 87-88, 89-90, 95). Due to the potential threat posed by road mortality, measures such as the installation of low-lying fine-mesh fence or barrier fencing in areas likely to be used by pond turtles may help minimize this source of mortality. In addition, because pond turtles may be collected as pets or non-native red-eared sliders purchased from the pet store could be released into the wild, public education regarding these effects would benefit this species.

California Red-Legged Frog

Legal Status

The California red-legged frog was federally listed as threatened on May 23, 1996 (61 Federal Register (FR) 25813). Revised critical habitat for the California red-legged frog was designated on March 17, 2010 (75 FR 12816, Service 2010). The Service issued a recovery plan for the species on May 28, 2002 (Service 2002, entire).

Natural History

The California red-legged frog uses a variety of habitat types, including various aquatic systems, riparian, and upland habitats. They have been found at elevations ranging from sea level to approximately 5,000 feet. California red-legged frogs use the environment in a variety of ways, and in many cases, they may complete their entire life cycle in a particular area without using other components (i.e., a pond is suitable for each life stage and use of upland habitat, or a riparian corridor is not necessary). Populations appear to persist where a mosaic of habitat elements exists, embedded within a matrix of dispersal habitat. Adults are often associated with dense, shrubby riparian or emergent vegetation and areas with deep (greater than 1.6 feet) still or slow-moving water; the largest summer densities of California red-legged frogs are associated with deep-water pools with dense stands of overhanging willows (*Salix* spp.) and an intermixed fringe of cattails (*Typha latifolia*) (Hayes and Jennings 1988, p. 147). Hayes and Tennant found juveniles to seek prey diurnally and nocturnally, whereas adults were largely nocturnal (Hayes and Tennant 1985, p. 604).

California red-legged frogs breed in aquatic habitats; larvae, juveniles, and adult frogs have been collected from streams, creeks, ponds, marshes, deep pools and backwaters within streams and creeks, dune ponds, lagoons, and estuaries. They frequently breed in artificial impoundments such as stock ponds, given the proper management of hydro-period, pond structure, vegetative cover, and control of exotic predators. While frogs successfully breed in streams and riparian systems, high spring flows and cold temperatures in streams often make these sites risky egg and tadpole environments. An important factor influencing the suitability of aquatic breeding sites is the general lack of introduced aquatic predators. Accessibility to sheltering habitat is essential for the survival of California red-legged frogs within a watershed and can be a factor limiting population numbers and distribution.

California red-legged frogs are “irruptive” breeders where their breeding capacity is highly dependent on local environmental conditions, specifically the availability of cool water for egg deposition and larval maturation (Jennings and Hayes 1994, p. 62). California red-legged frogs breed from November to May and breeding activity typically begins earlier at southern coastal than northern coastal localities (Storer 1925, p. 2; Alvarez et al. 2013, pp. 547-548). Breeding may start as late as March or April in Sierra Nevada localities, due to low temperatures at these sites in January and February (Tatarian 2008, p. 16). Breeding in southern California localities may start as late as April, as exemplified in Matilija Canyon following the 2017 Thomas Fire (P. Lieske, pers. comm., 2021). High water flows in the winter and spring also can delay breeding in streams and rivers (Fellers et al. 2001, p. 157). Female California red-legged frogs lay only one egg mass in a breeding year and each egg mass contains between 300 to 4,000 eggs (Storer 1925, p. 240). Frogs typically deposit egg masses in relatively shallow water (approximately 1.6 to 2 feet deep) on emergent vegetation within 4 feet of shore (Storer 1925, p. 239; Jennings and Hayes 1994, p. 64). However, the species can deposit eggs on a wide variety of substrates including boulders and cobbled substrate and submerged tips of overhanging branches, and egg masses have been documented 39 feet from shore and in water up to 10.5 feet deep (Alvarez et al. 2013, pp. 544-545; Wilcox et al. 2017, p. 68). California red-legged frog tadpoles hatch from egg masses after 6 to 14 (Storer 1925, p. 241). Tadpole development and growth rates are variable and likely temperature dependent (Fellers 2005, pp. 552-554). Occasionally, tadpoles may overwinter and then metamorphose the following spring, a phenomenon so far observed in Santa Clara, Marin, Contra Costa, and San Luis Obispo Counties (Fellers et al. 2001, entire).

The juvenile California red-legged frog life stage is defined as the time after an individual undergoes metamorphosis (when they lose their tails and become small froglets) which typically occurs four to five months after hatching and it spans to when an individual is able to breed (Storer 1925, p. 241; Wright and Wright 1949, p. 422). On average, the juvenile life stage is from about five months of age to three years in California red-legged frogs. Immediately after metamorphosis, juveniles shelter near their natal pond. However, some juveniles may disperse in the fall to nearby moist uplands or different aquatic habitat to avoid predation by larger, older frogs. Hayes and Tennant (1985, p. 604) found juveniles to seek prey diurnally and nocturnally, whereas adults were largely nocturnal. During periods of wet weather, starting with the first rains of fall, some individual California red-legged frogs may make long-distance overland excursions through upland habitats to reach breeding sites. In Santa Cruz County, Bulger et al. (2003, p. 90) found marked California red-legged frogs moving up to 1.74 miles through upland habitats, via point-to-point, straight-line migrations without regard to topography, rather than following riparian corridors. Most of these overland movements occurred at night and took up to 2 months.

Similarly, in San Luis Obispo County, Rathbun and Schneider (2001, p. 1302) documented the movement of a male California red-legged frog between two ponds that were 1.78 miles apart in less than 32 days; however, most California red-legged frogs in the Bulger et al. (2003, p. 93) study were non-migrating frogs and always remained within 426 feet of their aquatic site of residence (half of the frogs always stayed within 82 feet of water). Rathbun et al. (1993, p. 15) radio-tracked three California red-legged frogs near the coast in San Luis Obispo County at various times between July and January; these frogs also stayed close to water and never strayed more than 85 feet into upland vegetation. Scott (2002, p. 2) radio-tracked nine California red-legged frogs in East Las Virgenes Creek in Ventura County from January to June 2001, which remained relatively sedentary as well; the longest within-channel movement was 280 feet and the farthest movement away from the stream was 30 feet.

After breeding, California red-legged frogs often disperse from their breeding habitat to forage and seek suitable dry-season habitat. Cover within dry-season aquatic habitat could include boulders, downed trees, and logs; agricultural features such as drains, watering troughs, spring boxes, abandoned sheds, or hayricks, and industrial debris. California red-legged frogs use small mammal burrows and moist leaf litter (Jennings and Hayes 1994, p. 64; Rathbun and Schneider 2001, p. 15); incised stream channels with portions narrower and deeper than 18 inches may also provide habitat (Service 2002, p.14). This type of dispersal and habitat use, however, is not observed in all California red-legged frogs and is most likely dependent on the year-to-year variations in climate and habitat suitability and varying requisites per life stage.

Although the presence of California red-legged frogs is correlated with still water deeper than approximately 1.6 feet, riparian shrubbery, and emergent vegetation (Jennings and Hayes 1994, p. 64), California red-legged frogs appear to be absent from numerous locations in its historical range where these elements are well represented. The cause of local extirpations does not appear to be restricted solely to loss of aquatic habitat. The most likely causes of local extirpation are thought to be changes in faunal composition of aquatic ecosystems (i.e., the introduction of invasive predators and competitors) and landscape-scale disturbances that disrupt California red-legged frog population processes, such as dispersal and colonization. The introduction of contaminants or changes in water temperature may also play a role in local extirpations. These changes may also promote the spread of predators, competitors, invasive plants, parasites, and diseases.

Rangewide Status

The historical range of the California red-legged frog extended coastally from southern Mendocino County and inland from the vicinity of Redding, California, southward to northwestern Baja California, Mexico (Storer 1925, p. 235; Jennings and Hayes 1985, p. 95; Shaffer et al. 2004, p. 2673). The California red-legged frog has sustained a 70 percent reduction in its geographic range because of several factors acting singly or in combination (Davidson et al. 2001, p. 465).

Over-harvesting, habitat loss, non-native species introduction, and urban encroachment are the primary factors that have negatively affected the California red-legged frog throughout its range (Jennings and Hayes 1985, pp. 99-100; Hayes and Jennings 1988, p. 152). Habitat loss and degradation, combined with over-exploitation and introduction of exotic predators, were important factors in the decline of the California red-legged frog in the early to mid-1900s. Continuing threats to the California red-legged frog include direct habitat loss due to stream alteration and loss of aquatic habitat, indirect effects of expanding urbanization, competition or predation from non-native species including the bullfrog, catfish (*Ictalurus* spp.), bass (*Micropterus* spp.), mosquito fish (*Gambusia affinis*), red swamp crayfish (*Procambarus clarkii*), and signal crayfish (*Pacifastacus leniusculus*). Chytrid fungus (*Batrachochytrium dendrobatidis*) is a waterborne fungus that can decimate amphibian populations and is considered a threat to California red-legged frog populations.

A 5-year review of the status of the California red-legged frog was initiated in May 2011, but has not yet been completed.

Recovery

The 2002 final recovery plan for the California red-legged frog (Service 2002, entire) states that the goal of recovery efforts is to reduce threats and improve the population status of the California red-legged frog sufficiently to warrant delisting. The recovery plan describes a strategy for delisting, which includes: (1) protecting known populations and reestablishing historical populations; (2) protecting suitable habitat, corridors, and core areas; (3) developing and implementing management plans for preserved habitat, occupied watersheds, and core areas; (4) developing land use guidelines; (5) gathering biological and ecological data necessary for conservation of the species; (6) monitoring existing populations and conducting surveys for new populations; and (7) establishing an outreach program. The California red-legged frog will be considered for delisting when:

1. Suitable habitats within all core areas are protected and/or managed for California red-legged frogs in perpetuity, and the ecological integrity of these areas is not threatened by adverse anthropogenic habitat modification (including indirect effects of upstream/downstream land uses).
2. Existing populations throughout the range are stable (i.e., reproductive rates allow for long-term viability without human intervention). Population status will be documented through establishment and implementation of a scientifically acceptable population monitoring program for at least a 15-year period, which is approximately 4 to 5 generations of the California red-legged frog. This 15-year period should coincide with an average precipitation cycle.
3. Populations are geographically distributed in a manner that allows for the continued existence of viable metapopulations despite fluctuations in the status of individual populations (i.e., when populations are stable or increasing at each core area).

4. The species is successfully reestablished in portions of its historical range such that at least one reestablished population is stable/increasing at each core area where California red-legged frog are currently absent.
5. The amount of additional habitat needed for population connectivity, recolonization, and dispersal has been determined, protected, and managed for California red-legged frogs.

The recovery plan identifies eight recovery units based on the assumption that various regional areas of the species' range are essential to its survival and recovery. The recovery status of the California red-legged frog is considered within the smaller scale of recovery units as opposed to the overall range. These recovery units correspond to major watershed boundaries as defined by U.S. Geological Survey hydrologic units and the limits of the range of the California red-legged frog. The goal of the recovery plan is to protect the long-term viability of all extant populations within each recovery unit.

Within each recovery unit, core areas have been delineated and represent contiguous areas of moderate to high California red-legged frog densities that are relatively free of exotic species such as bullfrogs. The goal of designating core areas is to protect metapopulations that combined with suitable dispersal habitat, will support long-term viability within existing populations. This management strategy allows for the recolonization of habitat within and adjacent to core areas that are naturally subjected to periodic localized extinctions, thus assuring the long-term survival and recovery of the California red-legged frog.

Western Snowy Plover

Legal Status

The Service listed the Pacific Coast population of the western snowy plover as threatened on March 5, 1993 (Service 1993). We designated critical habitat in 1999 (Service 1999) and redesignated it in 2005 (Service 2005). In 2012, we issued a revised critical habitat designation which included a change in taxonomic nomenclature (Service 2012). We issued a recovery plan in August 2007 (Service 2007b) and completed 5-year status reviews in 2006 and 2019 (Service 2006b, 2019).

Natural History

The western snowy plover is a small shorebird in the family Charadriidae, a subspecies of the snowy plover (*Charadrius nivosus*). It is pale gray/brown above and white below, with a white collar on the hind neck and dark patches on the lateral breast, forehead, and behind the eyes. The bill and legs are black.

Foraging Behavior

Western snowy plovers are primarily visual foragers, using the run-stop-peck method of feeding typical of most plover species. They forage on invertebrates in the wet sand and amongst surf-cast kelp within the intertidal zone, in dry sand areas above the high tide, on saltpans, on spoil sites, and along the edges of salt marshes, salt ponds, and lagoons. They sometimes probe for prey in the sand and pick insects from low-growing plants (Service 2007b, pp. 17–18).

Breeding

The Pacific Coast population of the western snowy plover breeds primarily on coastal beaches from southern Washington to southern Baja California, Mexico. The main coastal habitats for nesting include sand spits, dune-backed beaches, beaches at creek and river mouths, and saltpans at lagoons and estuaries (Wilson 1980, p. 23; Page and Stenzel 1981, p. 12). Western snowy plovers nest less commonly on bluff-backed beaches, dredged material disposal sites, salt pond levees, dry salt ponds, and gravel river bars (Wilson 1980, p. 9; Page and Stenzel 1981, pp. 12, 26; Tuttle et al. 1997, pp. 1–3; Powell et al. 2002, pp. 156, 158, 164).

Their nests consist of a shallow scrape or depression, sometimes lined with beach debris (e.g., small pebbles, shell fragments, plant debris, and mud chips). As incubation progresses, western snowy plovers may add to and increase the nest lining. Driftwood, kelp, and dune plants provide cover for chicks that crouch near objects to hide from predators. Because invertebrates often occur near debris, driftwood and kelp are also important for harboring western snowy plover food sources (Page et al. 2009, Breeding).

Along the west coast of the United States, the nesting season of the western snowy plover extends from early March through late September. Generally, the breeding season may be 2 to 4 weeks earlier in southern California than in Oregon and Washington. Fledging (reaching flying age) of late-season broods may extend into the third week of September throughout the breeding range (Service 2007b, p. 11).

The approximate periods required for western snowy plover nesting events are: 3 days to more than a month for scrape construction (in conjunction with courtship and mating), usually 4 to 5 days for egg laying, and incubation averaging 28.4 days in the early season (before May 8) to 26.9 days in the late season (Warriner et al. 1986, pp. 23–24). The usual clutch size is three eggs with a range from two to six (Page et al. 2009, Breeding). Both sexes incubate the eggs with the female tending to incubate during the day and the male at night (Warriner et al. 1986, pp. 24–25). Adult western snowy plovers frequently will attempt to lure people and predators from hatching eggs and chicks with alarm calls and distraction displays.

Western snowy plover chicks are precocial, leaving the nest with their parents within hours after hatching (Service 2007b, p. 14). They are not able to fly for approximately 1 month after hatching; fledging requires 29 to 33 days (Warriner et al. 1986, p. 26). Broods rarely remain in the nesting area until fledging (Warriner et al. 1986, p. 28; Lauten et al. 2010, p. 10). Casler et al. (1993, pp. 6, 11–12) reported broods would generally remain within a 1-mile radius of their nesting area; however, in some cases would travel as far as 4 miles.

Wintering

In winter, western snowy plovers use many of the beaches used for nesting, as well as beaches where they do not nest. They also occur in man-made salt ponds and on estuarine sand and mud flats. In California, most wintering western snowy plovers concentrate on sand spits and dune-backed beaches. Some also occur on urban and bluff-backed beaches, which they rarely use for nesting (Page and Stenzel 1981, p. 12; Page et al. 1986, p. 148). South of San Mateo County, California, wintering western snowy plovers also use pocket beaches at the mouths of creeks and rivers on otherwise rocky points (Page et al. 1986, p. 148). Western snowy plovers forage in loose flocks. Roosting western snowy plovers will sit in depressions in the sand made by footprints and vehicle tracks, or in the lee of kelp, driftwood, or low dunes in wide areas of beaches (Page et al. 2009, Behavior). Sitting behind debris or in depressions provides some shelter from the wind and may reduce their detectability by predators.

Rangewide Status

Historical records indicate that nesting western snowy plovers were once more widely distributed and abundant in coastal Washington, Oregon, and California (Service 2007b, p. 21). In Washington, western snowy plovers formerly nested at five coastal locations (WDFW 1995, p. 14) and at over 20 sites on the coast of Oregon (Service 2007b, p. 24). In California, by the late 1970s, nesting western snowy plovers were absent from 33 of 53 locations with breeding records prior to 1970 (Page and Stenzel 1981, p. 27).

The first quantitative data on the abundance of western snowy plovers along the California coast came from window surveys conducted during the 1977 to 1980 breeding seasons by Point Reyes Bird Observatory (Page and Stenzel 1981, p. 1). Observers recorded an estimated 1,593 adult western snowy plovers during these pioneering surveys. The results of the surveys suggested that the western snowy plover had disappeared from significant parts of its coastal California breeding range by 1980 (Service 2007b, p. 27).

Breeding and winter window survey data from 2005 to 2022 includes approximately 250 sites in Washington, Oregon, and California, with most sites located in California (Table 2). In California, biological monitors counted 1,830 western snowy plovers during the 2022 breeding window survey, and 4,196* western snowy plovers during the 2021 to 2022 winter window survey (Service 2022a, entire). Across the Pacific Coast range, the 2022 breeding window survey estimated 2,371 western snowy plovers, and the 2021 to 2022 winter window survey estimated

*This number likely includes wintering inland birds that are not part of the listed Pacific Coast population.

4,803 western snowy plovers in Washington, Oregon, and California (Service 2022a, entire). These numbers demonstrate that monitors counted a large percentage of all western snowy plovers in the Pacific Coast range in California during both winter and breeding window surveys.

Table 2. Pacific Coast western snowy plover breeding window survey results, in descending order from 2022 to 2005, for each recovery unit (RUl through RU6) and the U.S. Pacific Coast (excludes the Baja California peninsula). All counts are breeding age adults and are uncorrected (raw). Recovery Units are RU1: Washington and Oregon; RU2: Northern California (Del Norte to Mendocino Counties); RU3: San Francisco Bay; RU4: Monterey Bay area (Sonoma to Monterey Counties); RU5: San Luis Obispo area (San Luis Obispo to Ventura Counties); RU6: San Diego area (Los Angeles to San Diego Counties) (Service 2019, p. 3).

Year	*RU1*	*RU2*	*RU3*	*RU4*	*RU5*	*RU6*	*TOTAL (U.S. Pacific Coast)*
2023	487	64	368	308	676	433	2336
2022	541	71	281	281	804	393	2,371
2021	624	84	263	292	737	358	2,358
2020	469	46	147	308	855	484	2,309
2019	479	41	190	303	807	397	2,217
2018	402	52	235	361	874	451	2,375
2017	342	56	246	369	856	464	2,333
2016	477	46	202	366	820	373	2,284
2015	340	38	195	348	963	376	2,260
2014	269	27	178	374	822	346	2,016
2013	260	23	202	261	754	326	1,826
2012	234	21	147	324	771	358	1,855
2011	202	28	249	311	796	331	1,917
2010	196	19	275	298	686	311	1,785
2009	182	15	147	279	707	257	1,587
2008	147	18	133	257	717	269	1,541
2007	175	26	207	270	676	183	1,537
2006	158	45	102	357	917	298	1,877
2005	137	41	124	337	969	209	1,817

Recovery and Threats

The primary objective of the recovery plan (Service 2007b, p. vi) is to remove the Pacific Coast population of the western snowy plover from the list of endangered and threatened wildlife and plants by:

1. Increasing population numbers distributed across the range of the Pacific Coast population of the western snowy plover;
2. Conducting intensive ongoing management for the species and its habitat and developing mechanisms to ensure management in perpetuity; and
3. Monitoring western snowy plover populations and threats to determine success of recovery actions and refine management actions.

Outlined below are the delisting criteria for the Pacific Coast population of the western snowy plover (Service 2007b, p. vii):

1. An average of 3,000 breeding adults has been maintained for 10 years, distributed among 6 recovery units as follows: Washington and Oregon, 250 breeding adults; Del Norte to Mendocino Counties, California, 150 breeding adults; San Francisco Bay, California, 500 breeding adults; Sonoma to Monterey Counties, California, 400 breeding adults; San Luis Obispo to Ventura Counties, California, 1,200 breeding adults; and Los Angeles to San Diego Counties, California, 500 breeding adults. This criterion also includes implementing monitoring of site-specific threats, incorporation of management activities into management plans to ameliorate or eliminate those threats, completion of research necessary to modify management and monitoring actions, and development of a post-delisting monitoring plan.
2. A yearly average productivity of at least one (1.0) fledged chick per male has been maintained in each recovery unit in the last 5 years prior to delisting.
3. Mechanisms have been developed and implemented to assure long-term protection and management of breeding, wintering, and migration areas to maintain the subpopulation sizes and average productivity specified in Criteria 1 and 2. These mechanisms include establishment of recovery unit working groups, development and implementation of participation plans, development and implementation of management plans for Federal and State lands, protection and management of private lands, and public outreach and education.

Our current estimate (2,371 breeding adults) remains below the population size of 3,000 birds listed as a recovery objective in the recovery plan (Service 2007b), although some local population sizes have surpassed recovery objectives for some areas (e.g., Monterey Bay, Oregon, Washington). Yearly average productivity (Criterion 2; number of fledglings per male) are not compiled annually for the entire U.S. Pacific Coast; however, the best available information indicates that the yearly average productivity has not been met (Service 2019, p. 6).

Threats have not changed significantly since the 2006 5-year review. Evidence of habitat loss and degradation remains widespread; while the degree of this threat varies by geographic location, habitat loss and degradation attributed to human disturbance, urban development, introduced beachgrass, and expanding predator populations remain the management focus in all six recovery units. Efforts to improve habitat at current and historic breeding beaches, and efforts to reduce the impacts of human recreation and predation on nesting plovers, have improved western snowy plover numbers. Active vegetation and predator management and habitat restoration should be continued. Because of active management efforts, including increased monitoring, use of predator exclosures at some sites, predator management, and expanded beach closures, western snowy plover population numbers have increased at some locations. However, despite active vegetation and predator management, we expect ongoing and projected changes in sea level and climate to affect coastal habitat suitability, nest survival, overwinter survivorship, and quality of nesting and roosting habitats (Service 2019, p. 7).

ENVIRONMENTAL BASELINE

The implementing regulations for section 7(a)(2) (50 CFR 402.02) define the environmental baseline as "the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline."

Action Area

The implementing regulations for section 7(a)(2) of the Act (50 CFR 402.02) define the "action area" as all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action. The action area for this biological opinion includes all areas subject to noise generated from individual launches; areas subject to overpressure as a result of sonic booms generated from launches breaking the sound barrier; areas subject to launch vehicle disposal; four water extraction wells located within the San Antonio Creek Basin and the 9.5 miles of San Antonio Creek downstream habitat; and areas subject to potential mitigation/restoration efforts that may occur as a result of the proposed project.

Appendix A, Figures 1A-F depict the Launch Noise Effect Area of potential disturbance, Appendix A, Figures 2A–P depict the Sonic Boom Overpressure Effect Area of potential disturbance associated with the sonic boom produced during vehicle SLC-4 landing. The Service includes the Space Force's updated 2024 modeling and understands that the Space Force indicates that mainland California (between eastern Santa Barbara and Northern Los Angeles counties) experience very low levels (understood to be insignificant) both in terms of frequency and magnitude. We also understand that the Overpressure Effect Area includes various sonic boom trajectories consisting of a narrow band across Santa Rosa Island and Santa Cruz Island (Appendix A, Figure 2H). The Space Force again anticipates this portion of the Overpressure Effect Area to receive irregular and infrequent disturbance. This would be like be up to 5 times between October 1 to December 31, 2024, with anticipated levels well below 2 psf. Further unanticipated changes to our understanding of the action area may warrant reinitiation as described at the end of this document.

Appendix A, Figures 4A-B depicts a portion of the described potential mitigation areas that may be associated with the proposed project. The Service considers all areas within the noise and overpressure effect areas, water extraction within the San Antonio Creek Basin, as well as potential mitigation/restoration areas to encompass the entirety of the action area.

Habitat Characteristics of the Action Area

The proposed action includes more frequent utilization of an existing launch site, SLC-4, located in south VSFB. SLC-4 currently contains predominantly ruderal and developed areas. SLC-4 is located immediately north of Spring Canyon, 0.75 mile southwest of Bear Creek, and approximately 0.5 mile east of Surf Beach. Primary vegetation types within the near vicinity of SLC-4 include Central Coast Scrub, Central Dune Scrub, Central Coastal Arroyo Willow Riparian Forest and Scrub, and Bishop Pine Forest (30 CES 2021, Appendix A, Figure 2). Spring Canyon also contains dense eucalyptus stands. SpaceX currently removes vegetation to just above ground level within a 3.327-acre impact area of Spring Canyon that is affected by liquid and water vapor expelled from the flame duct, an action previously consulted on in 2017 (Service 2017; 2017-F-0480). SpaceX also currently conducts additional mowing surrounding SLC-4 in previously disturbed portions.

The Launch Noise Effect and Overpressure Effect Areas include the vast majority of VSFB apart from a small northern portion of the installation. The Launch Noise Effect Area also includes a wide diversity of native and non-native habitat types including multiple riparian features, central dune scrub, maritime chapparal, live oak woodland, and pine forest (30 CES 2021, Appendix A, Figure 2). Riparian features located within the Launch Noise Effects area contains aquatic habitat with deep ponded features as well as Central Coast Arroyo Willow Riparian Forest and Scrub (30 CES 2021, Appendix A, Figure 2).

A limited portion of proposed project's water extraction and potential mitigation activities would occur within San Antonio Creek, a perennial feature that contains intact Central Coast Arroyo Willow Riparian Forest and Scrub (30 CES 2021, Appendix A, Figure 2).

Off base components include portions of mainland California between eastern Santa Barbara County to northern Los Angeles County as well as narrow linear pathways across Santa Rosa Island and Santa Cruz Island (Appendix A, Figure 2H). The mainland California portion includes a diverse array of native and non-native habitats including the Los Padres National Forest and large portions of urban development. Santa Rosa Island is one of California's Channel Islands and is managed by the National Park Service as part of the Channel Islands National Park. The topography of Santa Rosa Island in the overpressure effects area is generally mountainous, with elevations ranging between sea level and 1,000 feet above mean sea level and includes a variety of vegetation types including coastal sage scrub and chaparral.

Existing Conditions in the Action Area

SLC-4 is an active launch site occupying approximately 122 acres in the south base of VSFB. Prior to 2022, VSFB has generally supported an average of 6.2 rocket launches per year with very recent highs of 17 launches in 2022 and 29 in 2023. SpaceX constitutes the majority of all recent launches from VSFB (with 28 of the 29 in 2023) with a marked increase in launch frequency from SLC-4 in 2023 and an anticipated 36 launches in January to September 2024.

Other active or permitted launch programs that are not yet realized and may be cancelled also occur within the Launch Noise Effect Area making the true potential for collective launch numbers difficult to ascertain. However, the Space Force has confirmed that no more than 110 launches could occur annually in the future. However, SpaceX operations from SLC-4 currently constitute the majority of realized launches on VSFB with 28 of the 29 launches in 2023 being Falcon-9.

The Space Force has clarified that the water source for all base operations has transitioned to State Water. The only period in which well water from San Antonio Creek is utilized is during an annual maintenance period which typically occurs in late October to early November and lasts approximately 2 weeks (York, pers. comm., 2024).(York, pers. comm., 2024).

In February 2024, the Service reviewed available historic NASA Visible and Infrared Imaging Radiometer Suite (VIIRS) data and recognizes an increase in the lighting levels associated with SLC-4 occurred between 2020 and 2023. At present, the surrounding area of SLC-4 is exposed to similar artificial light at night levels as is observable within the city of Lompoc (NASA 2024a; b).

Mainland California encompasses a large area that is comprised of both natural areas and urban development that experience variable degree of both lighting and noise disturbance. Santa Rosa Island generally encompasses undisturbed natural areas.

Previous Consultations in the Action Area

On May 14, 2021, Vandenberg Air Force Base changed its name to Vandenberg Space Force Base. Consultations prior to this date refer to the Air Force. The Service includes recent consultations within the on-base portion of the Action Area below.

1. April 25, 2023: The Service issued a final biological opinion to the Space Force for the Phantom Launch Program at SLC-5 Project. We determined that the proposed action was not likely to jeopardize the continued existence of the western snowy plover and the California red-legged frog. This action has not yet occurred to date.
2. March 22, 2023: The Service issued a final reinitiation of the 2017 biological opinion of the SpaceX project at SLC-4 from the existing 12 launches to 36 launches annually (with launch rate not to exceed 3 times a month separated by every 8 days) (Service 2023; 2022-0013990-S7-001). We determined that the proposed action was not likely to jeopardize the continued existence of the western snowy plover, California least tern and the California red-legged frog. This action is currently in progress.
3. October 4, 2022: The Service issued a final biological opinion to the Space Force for the Terran 1 Launch Program (Relativity Space, Inc.) at SLC-11 Project. We determined that the proposed action was not likely to jeopardize the continued existence of the western snowy plover and the California red-legged frog. This action has not yet occurred to date.
4. September 26, 2022: The Service issued a final biological opinion to the Space Force for the Honda Bridge Replacement Project. We determined that the proposed action was not likely to jeopardize the continued existence of beach layia (*Layia carnosa*) or the California red-legged frog. This action is currently in progress.
5. November 18, 2020: The Service issued a biological opinion to the Air Force for the Blue Origin Orbital Launch Site at SLC-9 Project. We determined that the proposed action was not likely to jeopardize the continued existence of the California least tern, western snowy plover, and California red-legged frog. This action has not yet occurred to date.
6. November 21, 2018: The Service issued a reinitiation of a biological opinion to the Air Force on routine mission operations and maintenance activities at VAFB for changes to California red-legged frog-specific avoidance and minimization measures. We concluded the proposed action was not likely to jeopardize the continued existence of the California red-legged frog or alter effects of the proposed activities on the beach layia, Gaviota tarplant (*Deinandra increscens* ssp. *villosa*), Lompoc yerba santa (*Eriodictyon capitatum*), Vandenberg monkeyflower (*Diplacus vandenbergensis*), vernal pool fairy shrimp (*Branchinecta lynchi*), El Segundo blue butterfly (*Euphilotes battoides allyni*), tidewater goby, unarmored threespine stickleback, California least tern, and western snowy plover.
7. December 12, 2017: The Service issued a biological opinion to the Air Force for the proposed launch, boost-back, and landing of the Falcon 9 first stage at Space Launch Complex 4 (SLC-4). We concluded that the proposed action was not likely to jeopardize the continued existence of the El Segundo blue butterfly, California red-legged frog, California least tern, and western snowy plover. This project began in the spring of 2018 and is currently ongoing.
8. February 4, 2015: The Service issued a biological opinion to the Air Force for the proposed beach management plan for VAFB. We concluded that the proposed action was not likely to jeopardize the continued existence of the El Segundo blue butterfly, California red-legged frog, California least tern, and western snowy plover.

9. December 3, 2015: The Service issued a programmatic biological opinion to the Air Force for routine mission operations and maintenance activities at VAFB. We concluded that the proposed action was not likely to jeopardize the continued existence of the Vandenberg monkeyflower, beach layia, Gaviota tarplant, Lompoc yerba santa, vernal pool fairy shrimp, El Segundo blue butterfly, California red-legged frog, tidewater goby, unarmored threespine stickleback, California least tern, and western snowy plover.
10. September 9, 2014: The Service issued a biological opinion to the Air Force for the proposed replacement of the 13th Street Bridge on the Santa Ynez River. We concluded that the proposed action was not likely to jeopardize the continued existence of the tidewater goby and California red-legged frog. The National Marine Fisheries Service also issued a biological opinion (WCR-2014-1093) for effects on the federally endangered southern California Distinct Population Segment of the southern steelhead (*Oncorhynchus mykiss*).

Condition (Status) of the Species in the Action Area

Southwestern pond turtle

The southwestern pond turtles are anticipated to occupy wetland and riparian features across VSFB (U.S. Air Force 2014, p. 38) On north VSFB, southwestern pond turtles have been documented along San Antonio Creek, the Santa Ynez River, Shuman Creek, Lake Canyon, MOD Lake, and Punchbowl Pond. On south VSFB, southwestern pond turtles have been documented along Honda Creek and Jalama Creek (U.S. Air Force 2014, p. 38; MSRS 2024a, p. 64). The distribution surveys conducted as recently as 2013 confirmed southwestern pond turtle at all eight of these locations, but no population estimates were provided. In April 1995 and June 1996, southwestern pond turtles were sampled on Vandenberg Space Force Base, and 179 individuals total were sampled from Pine Canyon and Punchbowl Pond (Germano and Rathbun 2008). The Space Force has not yet conducted comprehensive southwestern pond turtle surveys across the base, but the survey effort is currently in progress.

Bear Creek has not been surveyed for turtles but is known to support California red-legged frog, and therefore may reasonably support southwestern pond turtle breeding. Biologists familiar with Bear Creek reported that the habitat may reasonably support the species during high rain years, and otherwise was identified as marginal habitat (USSF 2024d). Bear Creek is located approximately 0.75 mile to the northeast of SLC-4 and so is within the Launch Noise Effect and Overpressure Effect Areas. Noise modeling projects Bear Creek would receive noise levels between 125 to 130 dB SPL_{max} of engine noise during launches and understood overpressure levels of up to 5.0 psf during boost-backs (USSF, unpublished data, 2024b), which would equate to between 140 to 150 dB SPL, as previously discussed. Due to the adjacent of potential suitable southwestern pond turtle breeding habitat and their documented overwintering dispersal distance, the Service considers that the species has limited potential to occur within vegetation clearance and firebreak maintenance areas surrounding SLC-4 between October 1 and December 31, 2024.

Honda Creek, located 2 miles south of SLC-4, is known to support southwestern pond turtle (U.S. Air Force 2014, p. 38) with documented observations as recent as 2023 from the Honda Bridge Replacement project. Noise modeling projects Honda Creek would receive levels between 115 to 125 dB SPL_{max} of engine noise during launches and up to 5.0 psf (approximately 140-150 dB SPL) during boost-backs (USSF, unpublished data, 2024b). However, past realized monitoring results indicate Honda Creek has received an instantaneous sonic boom with overpressure level of 2.4 psf (comparable noise level of up to 135 dB SPL_{max}), which were the realized levels recorded during previous Falcon 9 launch monitoring (MSRS 2022b, p. 4).

The Santa Ynez River and San Antonio Creek are both large perennial features that are anticipated to support southwestern pond turtle. Large portions of each feature are included in the Launch Noise Effects and Overpressure Effect Areas. The Santa Ynez River is located approximately 4 miles north of SLC-4 while San Antonio Creek is located approximately 10 miles to the north. Available noise modeling projects that the Santa Ynez River would receive up to 118 dB SPL_{max} of engine noise during launches and overpressure of up to 4.0 psf during boost -backs. Modeling anticipates San Antonio Creek would receive engine noise levels between 100 to 110 dB SPL_{max} during launches and is located just outside of the area of overpressure effect (USSF, unpublished data, 2024b). San Antonio Creek contains the potential San Antonio Creek Oxbow Restoration expansion area that the Space Force may utilize for project mitigation purposes. Additionally, the proposed well water extraction area is in San Antonio Creek and includes 9.5 miles of downstream habitat between Barka Slough to the estuary.

Additionally, Shuman Creek and Canada del Jolloru may potentially support southwestern pond turtle breeding habitat considering they are known to support California red-legged frog breeding. Southwestern pond turtle have also been documented in isolated natural wetlands throughout VSFB (U.S. Air Force 2014, p. 38). Suitable upland dispersal habitat exists throughout VSFB between the various riparian zones and ponds. The vast majority of the Launch Noise Effect and Overpressure Effect Areas support areas of dense vegetation that could provide shelter for dispersing southwestern pond turtle.

Population outside VSFB

Jalama Creek is located just outside of VSFB and within the Launch Noise and Overpressure Effect area (Figure 1A and 2B). This feature likely supports suitable southwestern pond turtle breeding habitat considering it is known to support California red-legged frog breeding (MSRS 2024a, p. 48).

Within the mainland California portion of the Action Area potentially impacted by low level (less than 1.0 psf) sonic boom from missions with easterly trajectories, southwestern pond turtle are known from CNDDB records throughout Santa Barbara County, Ventura County, and Los Angeles County (MSRS 2024a, p. 66).

<u>California Red-legged Frog</u>

Population within VSFB

California red-legged frogs have been documented in nearly all permanent streams and ponds on VSFB as well as most seasonally inundated wetland and riparian sites (MSRS 2022c, p. 33). Spring Canyon is an ephemeral drainage located approximately 200 feet south of SLC-4. Throughout the majority of the drainage there is no definable channel and minimal evidence of potential pooling or surface water flow. Several small areas of Spring Canyon may constitute suitable habitat for California red-legged frog during wet periods when adequate surface water is present (MSRS 2022a, p. 27). A Permitted Biologist reassessed the drainage following an above-average rain year in July 2017 and found no suitable California red-legged frog breeding habitat within the Vegetation Removal Area or downstream. Between 2017 and 2022, the Space Force performed 11 survey efforts within the Spring Canyon Vegetation Removal Area and found no suitable breeding habitat or California red-legged frog individuals, likely a result of the protracted drought conditions in Santa Barbara County (MSRS 2022a, p. 28). It is therefore unlikely that California red-legged frog occupy the existing Vegetation Removal Area on a regular basis, other than as transitory habitat.

Bear Creek, located approximately 0.75 mile to the northeast of SLC-4, is within the Launch Noise Effect and Overpressure Effect Areas. A night survey of the Bear Creek Lagoon in late February 2024 documented 12 adult and 11 juvenile California red-legged frog (MSRS 2024a, p. 110). Noise modeling projects Bear Creek would receive noise levels between 125 to 130 dB SPL_{max} of engine noise during launches and understood overpressure levels of up to 5.0 psf during boost-backs (USSF, unpublished data, 2024b), which would equate to between 140 to 150 dB SPL as previously discussed.

Biologists have also consistently documented a moderately sized population and breeding habitat of California red-legged frogs over the last 10 years across variable survey efforts within Honda Creek. Honda Creek is located approximately 2 miles south of SLC-4 and is within the Launch Noise Effect and Overpressure Effect Areas. Noise modeling projects Honda Creek would receive levels between 115 to 125 dB SPL_{max} of engine noise during launches and up to 5.0 psf (approximately 140-150 dB SPL) during boost-backs (USSF, unpublished data, 2024b). However, past realized monitoring results indicate Honda Creek has received an instantaneous sonic boom with overpressure level of 2.4 psf (comparable noise level of up to 135 dB SPL_{max}), which were the realized levels recorded during previous Falcon 9 launch monitoring (MSRS 2022b, p. 4). Using protocol night California red-legged frog survey information between 2013 and 2022, adult frogs encountered ranged between 1 to 12 individuals with the current average annual high number being 7.2 adult individuals within the approximate anticipated Launch Noise Effect and Overpressure Effect Areas. Honda Creek includes multiple deep pond features that biologists have documented support breeding with 68 juveniles in 2017 and with 50 tadpoles and over 13 egg masses observed in 2022 (USSF, unpublished data, 2022). In April 2024, 8 adult and 7 juvenile California red-legged frog were documented during a night survey on the lower Honda

Creek stretch, exceeding the average number of adults (7.2) observed on this same stretch over the past 11 years (MSRS 2024a, p. 110).

The Santa Ynez River and San Antonio Creek are both large perennial features. Large portions of each feature are included in the Launch Noise Effects and Overpressure Effect Areas. The Santa Ynez River is located approximately 4 miles north of SLC-4 while San Antonio Creek is located approximately 10 miles to the north. Both features are thought to support large populations of California red-legged frog and breeding habitat (MSRS 2016, p. 37, MSRS 2022c, p. 34) although the presence of non-native predators (e.g. bullfrogs) is considered to be a current threat. Available noise modeling projects that the Santa Ynez River would receive up to 118 dB SPL_{max} of engine noise during launches and overpressure of up to 4.0 psf during boost-backs. Modeling anticipates San Antonio Creek would receive engine noise levels between 100 to 110 dB SPL_{max} during launches and is located just outside of the area of overpressure effect (USSF, unpublished data, 2024b). San Antonio Creek contains the potential San Antonio Creek Oxbow Restoration expansion area that the Space Force may utilize for project mitigation purposes. Additionally, the proposed well water extraction area is in San Antonio Creek and includes 9.5 miles of downstream habitat between Barka Slough to the estuary.

Additionally, Shuman Creek and Canada del Jolloru supports California red-legged frog population and breeding habitat. California red-legged frog have also been documented in isolated natural wetlands on south VSFB (MSRS 2024a, p. 48). Suitable upland dispersal habitat exists throughout VSFB between the various riparian zones and ponds. The vast majority of the Launch Noise Effect and Overpressure Effect Areas support areas of dense vegetation that could provide shelter for dispersing California red-legged frog, especially during periods of wet weather.

Population outside VSFB

Jalama Creek is located just outside of VSFB and within the Launch Noise and Overpressure Effect area (Figure 1B and 2C). This feature is known to support a California red-legged frog population and suitable breeding habitat (MSRS 2024a, p. 48).

Within the mainland California portion of the Action Area potentially impacted by low level (less than 1.0 psf) sonic boom from missions with easterly trajectories, California red-legged frogs are known to occupy the south coast of Santa Barbara County, including Gaviota Creek, Arroyo Honda, Arroyo Quemado, and other nearby creeks and tributaries. There are also observations of California red-legged frog from San Antonio Creek in Ojai, Las Virgenes Creek near Calabasas, and the Ventura River near Casitas Springs, from 2000 to 2016 (MSRS 2024a, p. 50).

<u>Western Snowy Plover</u>

Population within VSFB

VSFB provides critically important nesting and overwintering habitat for western snowy plovers, which includes all sandy beaches and adjacent coastal dunes from the rocky headlands at the north end of Wall Beach on north VSFB to the rock cliffs at the south end of Surf Beach on south VSFB (approximately 12.5 miles). VSFB averaged 225 breeding adults between 2014 to 2019 making it roughly 25 percent of Recovery Unit 5 and approximately 10 percent of the entire species range. Available historic data has shown that VSFB has consistently supported the largest populations of breeding western snowy plovers across the entire species range while simultaneously supporting high numbers of overwintering individuals. Being that this analysis focuses on a short period between September to December, the Service will include information on the condition of overwintering individuals for western snowy plover.

The nearest observation of anticipated overwintering western snowy plover to the action area's Launch Noise Effect Area is on the southern end of Surf Beach, approximately 0.8-mile northwest of SLC-4; The Launch Noise Effect Area now encompasses the entirety of beaches that western snowy plovers occupy on VSFB (Appendix A, Figure 1C). This is in contrast to the action area previously understood within the 2023 Biological Opinion. The noise and overpressure modeling has been updated to address identified inaccuracies in both disturbance magnitude and extent. The revised modeling indicates that the entire VSFB western snowy plover population (both breeding and overwintering) would fall within the Launch Noise Effect Area and would routinely experience short term (up to one minute) noise levels of over 100 dB SPL, with the Surf Beach population experiencing levels between 110 to 130 dB SPL. The vast majority of the VSFB western snowy plover population is also located within the Overpressure Effect Area, which encompasses all western snowy plover occupied beaches up to 0.75 mile north of Purisima Point (Appendix A, Figure 2D). A large portion of Surf Beach could experience instantaneous levels of up to 5.0 psf during terrestrial boost-back events. Although no conversion was provided, reviewing past available information, the magnitude of this overpressure levels would be roughly between 140 to 150 dB SPL during associated sonic booms (Robinette and Rice 2019, p. 14; reference to 3.63 psf which converts to an instantaneous noise disturbance of 138 dB SPLmax).

Vandenberg is an important overwintering location for western snowy plover, supporting 360 roosting plovers in total in 2024. More specifically, Vandenberg South Beaches (comprised of Surf Beach North and South, and Wall Beach) which would be subjected to both higher launch noise and overpressure levels supported 146 roosting plovers in 2024 (Service, unpublished data, 2024a). Table 3 below demonstrates that overwintering populations have been variable across the number of individuals observed on South Beaches (Service 2024b).

Table 3. VSFB Overwintering western snowy plover population counts

YEAR	Number of overwintering individuals Across VSFB	Number of overwintering individuals on South Beaches
2024	360	146
2023	214	62
2022	256	143
2021	289	152
2020	221	116
2019	290	199
2018	117	80

VSFB is also the largest breeding site for western snowy plover within the species range. South Beaches have also demonstrated capacity to support 327 breeding adults and up to 303 nests historically (SRS 2004, pp. 13 and 19), with 93 breeding adults and 179 nests in 2023 (MSRS 2024b, Appendix D, p. 57). This being said, the proposed project will take place between October 1 to December 31, 2024 which is outside of the known western snowy plover breeding season.

Recovery

<u>Southwestern pond turtle</u>

The southwestern pond turtle is not listed under the Act; however, it is currently proposed threatened and under federal review for listing under the Act (88 FR 68370). We consequently have not yet developed a recovery plan for southwestern pond turtle to assess its recovery status or how VSFB may factor into such status. However, a range-wide conservation strategy was developed with multi-stakeholder support from Washington, Oregon, Nevada, and California in the United States and from Baja California Norte, Mexico. The strategy was prepared by representatives from Federal and State entities, along with non-governmental organizations, scientists, and other experts on western pond turtles ([RCC] Western Pond Turtle Range-wide Conservation Coalition 2020).

The goal of the conservation strategy is to ensure long-term viability in the wild of the two species of western pond turtles (i.e., northwestern, and southwestern pond turtles). To achieve the goal, the following recovery efforts on VSFB should be implemented:

1. Coordinate Strategy implementation efforts through the Western Pond Turtle Range-wide Conservation Coalition and working groups.
2. Conduct distribution and abundance surveys of known, historical, and potential habitat to help determine priority conservation areas, and conduct more detailed surveys in targeted areas to determine long-term trends of populations.

3. Identify management regions, and priority conservation areas within those regions, and secure their long-term conservation.
4. Investigate the genetic variability of the western pond turtle throughout its range.
5. Scientific investigation of threats to facilitate and enhance recovery efforts.
6. Ameliorate and manage threats to western pond turtle populations and habitat, particularly in priority conservation areas.
7. Avoid and minimize direct and indirect adverse effects to western pond turtles and their habitat.
8. Consider population augmentation to enhance viability of severely depleted populations once causes for decline or extirpation have been addressed.
9. Develop and implement an effective outreach and education program about western pond turtles.

California Red-legged Frog

In the recovery plan for California red-legged frog, the Service revised recovery units and identified core areas that are watersheds, or portions thereof, that biologists determined essential to the recovery of the California red-legged frog. VSFB is located within the Northern Transverse Ranges and Tehachapi Mountains Recovery Unit and Core Area 24, Santa Maria River-Santa Ynez River. This core area is important because it is currently occupied, contains a source population, and provides connectivity between source populations (Service 2002, pp. 6, 146).

In this recovery unit, biologists consider the lower drainage basin of San Antonio Creek, the adjacent San Antonio Terrace, and San Antonio Lagoon to be among the most productive areas for California red-legged frogs in Santa Barbara County (Christopher 1996, as cited in Service 2002, p. 10). Most of this area occurs on VSFB.

Recovery task 1.24 identifies that the conservation needs in Core Area 24 are (1) to protect existing populations; (2) reduce contamination of habitat (e.g., clean contaminated ponds on VSFB); (3) control non-native predators; (4) implement management guidelines for recreation; (5) cease stocking dune ponds with non-native, warm water fish; (6) manage flows to decrease impacts of water diversions; (7) implement guidelines for channel maintenance activities; and (8) preserve buffers from agriculture such as in lower reaches of Santa Ynez River and San Antonio Creek (Service 2002, p. 75).

Western Snowy Plover

In the recovery plan for western snowy plover, the Service designated six recovery units across the range. VSFB is located within Recovery Unit (RU) 5, which includes San Luis Obispo, Santa Barbara, and Ventura Counties. RU5 supports the greatest number of western snowy plovers in the range (approximately half of the U.S. population) and has the greatest amount of available suitable habitat (Service 2007c, p. 142).

In 2019, the population trajectory of RU5 was considered stable, positive, with minimal annual fluctuation (Service 2019, p. 5). Annual monitoring reports from several of the larger sites, including VSFB, report fecundity results that exceed the recovery criterion in most years (Service 2019, p. 5). As of 2024, the draft 5-year review and communication with the Arcata USFWS indicate that RU4 and RU5 show non-growth trends while RU1, 2, 3, and 6 show statistically significant growth (Service 2024c, p. 8). Between 2018 and 2023, the most recent data indicates that RU5 is the only recovery unit experiencing notable downward population trajectory. RU5 population has not attained or exceeded the recovery target in any survey year (Service 2024c, p. 8; July 9th 2024, pers. comm. Arcata FWS Office).

In 2023, VSFB recorded 196 breeding adults. This is less than half of the identified 400 breeding adult site recovery goal. In 2022, VSFB comprised approximately 26 percent of breeding adults in RU5, 12 percent of California's breeding population, and 10 percent of breeding adults rangewide (Service 2022b, entire). Table 4 outlines average numbers of breeding adults counted during breeding window surveys from 2014 to 2022. Percentages illustrate the numbers of breeding western snowy plovers at VSFB relative to numbers rangewide, across California, and within RU5.

Table 4. 2014–2022 breeding adult averages from uncorrected (raw) breeding window survey numbers for the Pacific Coast range of western snowy plover, California, RU5, and VSFB with relative percentages (Service 2022b).

Area Surveyed	2014–2022 Averages	Percent of Range	Percent of CA	Percent of RU5
Rangewide	2,283	100	-	-
California Only	1,843	81	100	-
RU5	857	38	47	100
VSFB	226	10	12	26

EFFECTS OF THE ACTION

The implementing regulations for section 7(a)(2) define effects of the action as "all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action" (50 CFR 402.02).

In conducting this analysis, we have considered factors such as previous consultations, 5-year reviews, published scientific studies and literature, and the professional expertise of Service personnel and other academic researchers with aspects directly related to the sensitive species involved in determining whether effects are reasonably certain to occur. We have also determined that certain consequences are not caused by the proposed action, such as the increase or spread of disease, poaching, or collecting, because they are so remote in time, or geographically remote, or separated by a lengthy causal chain, so as to make those consequence not reasonably certain to occur.

Effects of the Proposed Action on the Southwestern Pond Turtle

<u>Firebreak Maintenance</u>

The Space Force will maintain existing SLC-4 firebreaks and these activities could occur at any time of year. No southwestern pond turtle survey data or habitat assessment exists in the vicinity of SLC-4. Bear Creek is located approximately 0.15 mile from the nearest firebreak that appears to be associated with SLC-4. Bear Creek contains California red-legged frog breeding habitat, and we therefore anticipate suitable southwestern pond turtle breeding and overwintering habitat could be located in near vicinity. Southwestern pond turtle individuals could appear on firebreaks during maintenance activities and could be killed or injured. However, we anticipate most individuals, if any, within these areas would likely be overwintering underground at the time of vegetation clearance due to the timing of the proposed project which would reduce the likelihood of direct injury. In the unlikely event that southwestern pond turtle chose to overwinter or nest within firebreak clearance areas and are not identified, these individuals or nests could be crushed and destroyed. The existing firebreak areas would be unlikely to support nesting or overwintering habitat due to compact soils but assume that they could occur on the periphery of the road edge where vegetation maintenance may occur. We understand that the Space Force has not yet surveyed these areas and expects that suitable southwestern pond turtle breeding habitat, of marginal quality, may exist nearby in Bear Creek. To attempt to minimize potential effects, the Space Force will ensure that during any SLC-4 firebreak maintenance work conducted between October 1 and December 31, 2024, that a biologist will conduct clearance surveys and monitor these work activities (GM-2 and GM-8). If southwestern pond turtles are found during firebreak maintenance, the Space Force will require a Service Approved Biologist to relocate the species, limiting the duration of handling, requiring proper transport of individuals, and identifying suitable relocation sites (GM-8). The Space Force will also reduce any associated risk of spreading disease during capture and relocation activities by requiring implementation of DAPTF (GM-8). Using the available information, the Service consequently anticipates associated likelihood of effects would be low.

<u>Launch Operations Effects on Base</u>

Lighting

An increase in artificial night lighting associated with the proposed project increased operations could have adverse physiological and behavioral effects on southwestern pond turtle. An increase in artificial night lighting may also increase southwestern pond turtle predation rates if predators are able to better detect dispersing individuals. However, the Service does not anticipate lighting effects to southwestern pond turtle, between October 1 and December 31, 2024, are likely to occur because the species should be overwintering underground or at the bottom of perennial ponds likely at a distance of over 1 mile from SLC-4. Therefore, for this consultation, the Service will not analyze effects of lighting from SLC-4 to southwestern pond turtles.

Flame Duct Use and associated vegetation maintenance

The proposed project includes up to 16 launches, 2 boost-backs, and 2 static test fires occurring from October 1 to December 31, 2024 from SLC-4. Each launch requires water release associated with the flame bucket with liquid water directed to the SLC-4 v-ditch feature and a minimum amount of water vapor directed towards Spring Creek. The maximum temperature of the water vapor would be 130 degrees Fahrenheit at the point it would reach Spring Canyon. Water vapor releases may cause injury or mortality of southwestern pond turtle through scalding individuals in the Spring Creek area if present within the vicinity. Associated Spring Canyon vegetation maintenance may also cause injury or mortality to southwestern pond turtles. Currently, the nearest known occupied feature with records of southwestern pond turtle is Honda Creek, 2 miles to the South of SLC-4. Marginally suitable but not known to be occupied habitat for southwestern pond turtles occurs in Bear Creek, located 0.75-mile northeast of SLC-4. As indicated in the Status of the Species above, southwestern pond turtle typically move no farther than 0.21 mile from seasonal ponds (Service 2023b, p. 27) with atypical dispersal distance 3.1 miles across terrestrial upland habitat (Holland 1994, p. 7-28). Consequently, although southwestern pond turtle has the capacity to disperse the distance required between currently known occupied habitat such as Honda Creek to Spring Canyon, dispersal movements of this distance are expected to be very uncommon. In addition, since 2017, the Space Force has performed 11 survey efforts within the Spring Canyon Vegetation Removal Area and found no suitable permanent aquatic habitat (MSRS 2022a p. 28). It is therefore unlikely that southwestern pond turtle currently occupy the existing Vegetation Removal Area or would move into these areas in the near future based on the characteristics of the drainage. The Space Force will further minimize potential effects by requiring biologists to conduct clearance surveys to ensure no unanticipated southwestern pond turtles are located in Spring Canyon (GM-8). If southwestern pond turtle is present during the clearance surveys, the Space Force will require relocation of any southwestern pond turtle encountered (GM-2). These avoidance measures should further reduce potential for unanticipated effects from flame duct use to southwestern pond turtle. Reviewing available information on dispersal movements in combination with minimization measures, associated effects are unlikely to occur.

Approximately 17,500 gallons of hot water (130 degrees Fahrenheit) is expelled from the flame duct during each individual launch and ultimately reaches the v-ditch feature located within the fenceline of SLC-4. The Space Force has indicated that this water is temporarily stored within the feature and dissipates rapidly (Kaisersatt, pers. comm., 2023e). The Service consequently assumes that water is no longer present within 24 hours of an individual launch. The temporarily stored water would not reach a depth level or hydroperiod that would support southwestern pond turtle breeding. The Service understands that associated hydrophytic vegetation may be present and the Space Force would conduct feature maintenance on a regular basis (Kaisersatt, pers. comm., 2023e). The v-ditch feature could constitute suitable transitory southwestern pond turtle habitat as a result and individuals may be attracted to the feature in response to increased water presence associated with more frequent launching. Any southwestern pond turtle that is within the v-ditch during a launch event has the potential to be injured or result in mortality from scalding water. V-ditch maintenance, including sediment and vegetation removal, may also result in the injury or death of southwestern pond turtles if present.

Exposure to launch-related contaminants could injure or kill southwestern pond turtle. As detailed in the project description in the 2017 biological opinion, SpaceX has constructed a civil diversion structure and retention basin at SLC-4 to minimize the amount of water entering Spring Creek from water release activities. The Space Force will ensure that SpaceX will continue to avoid and minimize these effects by implementing measures described in the 2017 biological assessment (MSRS 2017) which include: (1) SpaceX will follow the site-specific Stormwater Pollution Prevention Plan already implemented for SLC-4; (2) SpaceX will implement the Best Management Practices within the latest California Stormwater Quality Association's Stormwater Best Management Practices Handbook; (3) SpaceX will collect any rocket propellant in the retention basin using absorbent pads prior to discharge to the spray field; and (4) SpaceX will fully implement the procedures in VSFB's Hazardous Materials Emergency Response Plan in the event of a hazardous materials spill. The civil diversion structure and collection of fuel with absorbent pads should reduce the potential for effects on southwestern pond turtle that may be dispersing through Spring Canyon provided the various plans and practices to control contaminants and sedimentation are effective.

The Space Force anticipates the proposed project's launches would produce a diminutive amount of soot byproduct. If soot or other similar launch related byproducts come into contact with southwestern pond turtle or enter adjacent occupied waterbodies, it has the potential to injure or kill individuals. Contaminants in general have been identified as a significant threat in freshwater ecosystems through indirect and direct toxicity to organisms (Service 2023b, p. 57). Toxicology studies have resulted in negative effects including immune system suppression, smaller eggs, reduced growth rates of hatchlings, endocrine disruption (altered sex determination), and other physiological and behavioral effects (ODFW 2015, p. 65). Southwestern pond turtle can be exposed to toxins in both their aquatic and terrestrial habitats. Being that they are long-lived, higher order predators, southwestern pond turtles are understood to be particularly susceptible to contaminants through bioaccumulation. Previous research has documented that bioaccumulated contaminants in female turtles can be off-loaded to eggs through the yolking process (Beale et al. 2022, entire). Appropriate avoidance would include prevention of all chemical byproduct into aquatic and terrestrial environments and sites known to be contaminated should be cleaned up according to applicable federal, state and local laws and policies (ODFW 2015, p. 65). However, the Space Force references a comparable launch assessment (FAA 2020, entire) and expects that the actual amount of soot produced would be diminutive being that it would subsequently burn up in the exhaust plume (Kaisersatt, pers. comm., 2022). Consequently, the proposed action would not produce any discernable level of launch-related byproduct contamination and is unlikely to affect southwestern pond turtle or their habitat.

Capture and relocation of southwestern pond turtle in the area prior to individual launches may cause injury or death because of improper handling, containment, transport, or release into unsuitable habitat. There is the likelihood of disease transmission if an individual is introduced to a different population altogether including Pond Turtle Shell Disease (Lambert et al. 2021), or chytrid fungus, although there are no studies on freshwater turtles spreading chytrid. Although we do not have an estimated survivorship for translocated southwestern pond turtle, intraspecific competition, lack of familiarity with the location of potential breeding, feeding, and sheltering habitats, and increased risk of predation reduces survivorship of translocated wildlife in general. The Space Force will minimize effects by using Service Approved Biologists as proposed, limiting the duration of handling, requiring proper transport of individuals, and identifying suitable relocation sites (GM-8). The Space Force will also reduce any associated risk of spreading chytrid fungus during capture and relocation activities by requiring implementation of DAPTF (GM-8). The Service expects the relocation of individuals from vegetation management and water release areas to greatly reduce the overall level of injury and mortality, if any, which would otherwise occur. Having only experienced biologists engage in the activity would greatly reduce the potential for injury or mortality due to mishandling.

Water Extraction

At SLC-4, SpaceX would utilize an existing water-filled flame duct to reduce vibration impacts from noise on payloads. During Falcon 9 launches, approximately 70,000 gallons of water would be utilized per launch with approximately 40,000 gallons per landing. Using these estimates, for 16 launches and 2 terrestrial landings this would amount to 1.2 million gallons (3.68 ac-ft) to support personnel and operational activities at SLC-4 between October 1 and December 31, 2024.

The Space Force has recently clarified that the current water source for VSFB, including SLC-4, is via an existing connection between State Water and the VSFB water supply system. For the majority of the 91 days of the proposed project, the Space Force would source water from this connection. However, during annual maintenance that lasts approximately 2 weeks, VSFB utilizes four water wells in the San Antonio Creek Basin. The Service consequently assumes that across this period (14 days), up to 184,615 gallons (0.57 ac-ft) could be extracted from these wells in San Antonio Creek Basin.

Water withdrawal from the San Antonio Creek wells has the potential to reduce streamflow and water levels within San Antonio Creek. This could adversely affect all life stages of southwestern pond turtle downstream of Barka Slough by reducing associated wetland and riparian habitats supported by the existing groundwater level and extent of inundated area. However, referencing previous analysis (USGS 2019, p. 5) and associated discussion with hydrologists involved with the associated hydrological modeling (C. Faunt and G. Cromwell, USGS, pers. comm. 2021), the proposed project's 0.57 acre-feet extraction amount would not be anticipated to result in measurable decline of streamflow or associated aquatic habitat.

Factors including future surrounding water usage (e.g., collective existing and future launch program needs, surrounding agriculture, etc.) as well as increased variability of annual precipitation due to climate change, including shorter wet seasons and longer dry periods, may influence true effects (Myers et al. 2017, p. 15, 59). An additional hydrological model incorporating various precipitation scenarios predicts that an extraction amount of 921 acre-feet would decrease inundated area between 0.14 and 10.14 percent (AECOM 2019, p. 6). Similarly, given that the maximum project-related water extraction amount is less than 1 percent of the 921 acre-feet used for the supplemental model analysis, it is reasonably foreseeable that it would not result in a discernable reduction of inundated area. Although potential impacts to associated riparian terrestrial habitat were not initially characterized, based on the best available information (AECOM 2019; USGS 2019), the Service does not anticipate measurable decline in the quality or overall extent of these associated habitats as a result of the project proposed extraction amount at this time. However, there has been a level of habitat change within Barka Slough driven by increasing groundwater withdrawals from the San Antonio Creek groundwater basin for agriculture on and off VSFB. Since the 1980's, withdrawals have exceeded the recharge rate for the basin (Public Works 2020 as referenced in MSRS 2022d, p. 5). Since the 1950's, ground water levels have dropped between 33 to over 98 feet (USGS 2019 as referenced in MSRS 2022d, p. 5). The VSFB is now connected to State Water as their primary water source for all base needs with the exception of an annual maintenance period where water would be sourced from San Antonio wells for a period of approximately 2 weeks. The Space Force did not provide estimates for anticipated basewide water extraction during this period. Without this information, the Service is unable to make clear quantifiable reference for how the proposed project would add to the existing baseline of water extraction. To ensure no unanticipated effects occur during the 3-month project window, the Space Force will reference a previously established pre-project baseline for hydrodynamic data within San Antonio Creek and monitor hydrodynamic data (GM-9). The Space Force will use this data to ensure that the proposed project's water extraction is not measurably affecting flow rate or water level within San Antonio Creek.

Climate change

Reptiles are sensitive to the projected effects of climate change. Being that reptiles are ectotherms, altered temperatures could impact critical physiological processes. Western pond turtle nest sites and embryo development are sensitive to temperature because the species exhibit temperature-dependent sex determination (Service 2023b, p. 59). There is also the potential that rising temperatures could increase the number of warm days for developing embryos, potentially enhancing reproductive success in the wild. In other species of reptiles, studies focusing on the active season predict a largely positive response to warming because increases in temperature can prolong the active season, but results from a meta-analysis of winter warming on reptile traits were less clear, with some positive but some negative effects (Moss and MacLeod 2022, pp. 264-266). Benefits to reproduction may be outweighed by the cumulative negative impacts (e.g., isolation of populations, skewed sex ratios, loss of aquatic habitats, etc.) to individuals and their habitats (Service 2023b, p. 60). Following a review of recent research on rocket launch emissions on stratospheric ozone and global climate impacts (Ryan et al. 2022, entire), the Service anticipates that emissions produced by the proposed project has the potential to contribute to these projected effects. However, the Space Force did not provide any information or analysis regarding emissions produced by the proposed project. Until the Space Force is able to provide relevant information including project-specific emission analysis, the Service is unable to discuss associated effects further at this time.

Launch Noise and Overpressure

The Service anticipates that launch and static test fire events have the potential to create associated ground vibration within the vicinity of SLC-4. Any southwestern pond turtle that may be nesting or overwintering in areas near SLC-4 have the potential to be exposed to vibration. Southwestern pond turtle utilizes shallow nests (3.5 to 4.7 inches) and can dig into shallow leaf litter layer to overwinter meaning that associated vibration is unlikely to be attenuated by substrate. The Service assumes that potential launch-related vibration may be of low frequency which attenuates less readily than high frequency (Norton et al. 2011, p. 658). We cannot anticipate the level of substrate vibration that the proposed project may produce at this time but assume conservatively that low levels of vibration may occur routinely for a short period (from 7 seconds to up to 2 minutes on average every 5 days) during project operation in the area immediately surrounding SLC-4. We have no specific data on the response of nesting or overwintering southwestern pond turtle to varying levels or duration of exposure to launch operation vibration. We consequently use available research on the effects of vibration on related reptiles including the soft-shelled turtle (*Pelodiscus sinensis*) as a surrogate. In a laboratory study, soft-shelled turtle were exposed to vibration stress for 30 minutes at 2 hour intervals during the day for 28 days, at an average vibration level of 61.6 (+/-16.6) dB V and an average noise level of 73.6 (+/-4.8) dBA during day time (Hur and Lee 2010, p. 242). Exposure to long-term vibration produced significantly elevated stress hormone and glucose levels, which remained elevated for 28 days following cessation of stress. In addition, aspartate transferase (AST) and alanine transaminase (ALT), enzymes released in the blood when organs including the liver and spleen are damaged, were also significantly elevated following exposure (Hur and Lee 2010, p. 243). These findings are suggestive that routine launch-related vibration exposure may adversely affect southwestern pond turtle survival and population success, particularly following repeat vibration disturbance distress that occurs over time. The biological assessment did not provide vibration modeling for the purposes of this analysis to enable comparison to possible vibration exposure levels. Without this modeling, the Service cannot anticipate the specific vibration levels that the proposed project may produce but understands that in comparison to the referenced study, much shorter vibration duration and overall frequency of potential vibration events would occur within what we assume is only the immediate area surrounding SLC-4 from October 1 to December 31, 2024, during 16 launches, 2 boost-backs, and 2 static test fires. The effects observed in the study could occur at some level for southwestern pond turtles from the proposed project. The Space Force has also previously indicated to the Service that vibration sources (SLC-4) would be located at a sufficient distance from nearby riparian habitat that may support breeding or overwintering to preclude any associated effects that would result from routine vibration. As discussed in the Status of the Species above, typical southwestern pond turtle movements from season ponds are 0.21 mile and although considered atypical, dispersal distance of 3.1 miles have been documented. Disturbances to species of turtles that are overwintering, or are in brumation, have increased chances of mortality (Palmer et al. 2019). Using the available information, project-related vibration effects are possible and may impact a presumed low level of southwestern pond turtle within the immediate area of SLC-4. However, updated survey information including an assessment of occupied and suitable habitat, realized vibration monitoring, and vibration modeling are all needed at this time to help the Service assess potential effects.

The proposed project's launch operations would produce noise and overpressure levels that may adversely affect southwestern pond turtle. We have limited information on hearing sensitivity and hearing loss (aerial, underground, or underwater) for reptiles in general. There are no specific studies on the effects of noise and overpressure disturbance on the southwestern pond turtle while they are overwintering underground or underwater, however past research has demonstrated that the species perceives and responses to relatively low levels of noise disturbance (Bury and Germano 2008, p. 001.5). Although hearing capabilities of turtles is relatively poorly understood, recent research demonstrates that noise pollution in aquatic environments can cause hearing loss in closely related surrogate species. Researchers have previously exposed red-eared slider (*Trachemys scripta elegans*) to noise conditions of differing durations and volumes. One study involved sound exposure levels (SELs) of low frequency white noise (50-1000 hz) ranging between 155 and 193 dB and duration between 5 to 30 minutes. No temporary hearing loss occurred at the lowest SEL (155 dB) tested. However, temporary hearing loss (known as temporary threshold shift, TTS), was observed at SEL of 161 dB and higher (Salas et al. 2023, pp. 1007, 1009). Red-eared sliders tested did show recovery to baseline auditory condition could occur relatively quickly (i.e. within 30 minutes), but in some instances took more than 2 days, depending on the exposure level and individual variability (Salas et al. 2023, p. 1014). It is important to consider that while the available study showed recovery from underwater TTS in the frequency tested, other reptiles have shown incomplete recovery from aerial exposed TTS with variable frequency (Salas et al. 2023, p. 1013). Hearing loss that results from anthropogenic noise has the potential to impact sound-mediated reptile behavior including acoustic communication to attract mates, parental care, and navigation (Salas et al. 2023, p. 1004). Although TTS thresholds are known to be different in-air and underwater, using the best available information, we do not currently anticipate that project activities would result in hearing loss considering no temporary hearing loss occurred at 155 dB referencing the aforementioned research on red-eared sliders. This level is slightly higher than the maximum expected to be produced by the proposed project. This being said, additional information is still needed to help understand the potential for auditory harm at realized noise levels.

Southwestern pond turtles have been documented across VSFB and within features within the near vicinity of SLC-4 including Honda Creek and the Santa Ynez River. Potential marginal suitable breeding habitat may exists within Bear Creek. Noise modeling projects Honda Creek would receive levels up to 123 dB SPL_{max} of engine noise during the 16 launches and up to 5.0 psf (approximately 140-150 dB SPL) during 2 boost-backs (USSF, unpublished data, 2024b). Bear Creek would receive noise levels up to 128 dB SPL_{max} of engine noise during launches and understood overpressure levels of up to 5.0 psf (approximately 140-150 dB SPL) during 2 boost-backs (USSF, unpublished data, 2024b). Available noise modeling projects that the Santa Ynez River would receive up to 118 dB SPL_{max} of engine noise during launches and overpressure of up to 4.0 psf during boost-backs. These features are recognized to be the most proximate to SLC-4 and would experience the highest magnitude of noise and overpressure disturbance. Multiple other features which are known or thought to potentially support southwestern pond turtle, including Canada del Jolloru, Jalama Creek, San Antonio Creek, and Shuman Creek, are also all within the Launch Noise Effect Area with most also in the Overpressure Effect Area. These additional features would also experience routine levels of noise and overpressure disturbance at slightly lower levels. Any southwestern pond turtles present in upland dispersal habitat directly adjacent to SLC-4 may experience modeled noise levels of 150 dB SPL_{max} and overpressure of up to 9.5 psf. To summarize, southwestern pond turtles throughout the Launch Noise Effect Area would experience routine noise levels between 100 to 150 dB SPL_{max} (from 7 seconds to up to 2 minutes on average every 5 days between October 1 to December 31, 2024). Within the Overpressure Effect Area, southwestern pond turtle populations would also experience overpressure levels between 0.5 to 9.5 psf a total of two times between this same period. Although the specific acoustic thresholds of southwestern pond turtle are unknown, the Service anticipates that the species may perceive and behaviorally respond to launch noise. Southwestern pond turtle is considered to be extremely wary of noise and vibration disturbance and will rapidly flee from basking sites into the water when disturbed by minimal sound (e.g. people at distances of greater than 328 ft) (Bury and Germano 2008, p. 001.5). Analysis of disturbance types showed that southwestern pond turtle showed similar response to motor vehicle disturbance (Nyhof 2013, p. 53), which consist of low frequency noise anticipated to be similar to that produced during rocket launches. If southwestern pond turtles are disturbed frequently during their brumation, hormonal regulation and physiological processes may be disrupted. The Service considers undisturbed overwintering to be important to southwestern pond turtle's life cycle as it enables hormone regulation, which is tied to growth, metabolism, and reproduction. Since southwestern pond turtles are a long-lived species, there is a need for long-term monitoring to understand effects across different life events for southwestern pond turtle (e.g., locomotion, changes to habitat use, and chronic stress) to inform best management practices. However, given difficulties associated with detecting southwestern pond turtle to effectively monitor for potential effects for the duration of this consultation (three months), the Space Force will create a monitoring program to track southwestern pond turtle habitat occupancy and assess whether changes in the acoustic environment are impacting the distribution and population size of southwestern pond turtles over time (SWPT-2).

A small amount of literature exists on the impacts of anthropogenic noise on reptiles. It is unknown whether southwestern pond turtle would exhibit a stress response to the routine noise or overpressure disturbance associated with the proposed project. However, the Service considers that it is conservatively reasonable to expect they may exhibit a stress response considering that southwestern pond turtle is sensitive to sounds of humans at distances of greater than 300 feet, have been documented to preferentially select habitat that is located away from human disturbance, and exhibit decreased basking in areas with higher rates of vehicle disturbance (Service 2023b, p. 45). In the event that southwestern pond turtle exhibits a stress response to the proposed project's frequent exposure to high levels of noise and overpressure disturbance, this could cause routinely elevated levels of stress hormone over the project duration. Prolonged elevated stress hormone concentrations can have deleterious effects on species' growth, survival, reproduction, and immune function (Sapolsky et al. 2000; Tennessen et al. 2014; Rodgers 2020). The U.S. Army conducted a study on the response of Colorado checkered whiptail (*Aspidoscelis neotesselatus*) when exposed to intermittent noise disturbance from aircraft flyover noise. When exposed to a week of intermittent flyover noise up to 112.22 dB in comparison to a control week of no noise disturbance, the Colorado checkered whiptail was found to modify its behaviors by spending less time moving and more time eating, and also exhibited higher levels of corticosterone and ketone bodies (markers of stress) (Kepas et al. 2023). However, no specific thresholds of disturbance level or frequency are known. The Service considers that although the project may result in effects to southwestern pond turtle's stress hormone accumulation and associated behavior, deleterious physiological effects, and overall habitat degradation, until the novel effects of the project activity are studied, we are unable to adequately anticipate the magnitude of any specific response at this time.

In combination with the existing launch baseline on VSFB, the proposed project may contribute to potential long-term effects from chronic stress caused by routine acute launch disturbance across launch programs. Although the proposed project would only occur between October 1 and December 31, 2024, it may contribute to a degree to potential collective effects. Collective effects may include long-term population level effects including reduced reproductive success, survival, fitness, and spatial displacement. Although we do not have an estimated survivorship of displaced southwestern pond turtle, this could result in injury or death to individuals as a result of increased intraspecific competition, lack of familiarity with new locations of potential breeding, feeding, and sheltering habitats, and increased risk of predation. However, it is unknown how southwestern pond turtle would react to repetitive launch events of variable disturbance levels with increasing frequency. Improved monitoring information is needed to help identify thresholds that quantify what level of noise or frequency of disturbance would elicit stress hormone responses that may lead to negative population level impacts. Consequently, the Service cannot adequately determine the magnitude of potential collective effects with the addition of the proposed project on the southwestern pond turtle populations within the vicinity of VSFB at this time.

Potential mitigation and herbicide usage

Following review of the effects of the proposed action, the Service anticipates the proposed project could result in the temporary degradation in the quality of adjacent southwestern pond turtle overwintering habitat in the vicinity of VSFB due to associated noise and overpressure disturbance from routine launching. The proposed project also may contribute to potential population level collective effects that may occur over time. The potential mitigation actions for southwestern pond turtle include the creation of new breeding habitat at a 2:1 ratio (habitat enhanced: habitat affected) within the San Antonio Creek Oxbow Restoration ‘expansion area’ (Appendix A, Figure 4A). Mitigation actions that may occur as result of the project include site preparation via herbicide application, plowing, container plant installation, seeding, willow pole planting, and watering via water truck. These activities have the potential to affect southwestern pond turtle and could injure or kill individuals within these areas. The Service was not provided a list of potential herbicide products that may be used during restoration activities. Certain herbicides, have the potential to cause lethal or sub-lethal toxicity to all life stages of southwestern pond turtle if an exposure pathway exists. Southwestern pond turtle could be exposed to herbicides and surfactants in aquatic and dispersal habitats associated with restoration areas or contaminated runoff from treated areas. A commonly used product in riparian restoration is glyphosate which often is combined with a polyethoxylated tallowamine (POEA) surfactant. Using amphibians as an available surrogate, glyphosate products containing POEA surfactants have been shown to have both lethal and sub-lethal effects to amphibians including decreased size, increased time to metamorphosis, tail malformations, and gonadal abnormalities (Howe et al. 2004, pp. 1930-1933; Govindarajulu 2008, pp 3-8). Glyphosate and POEA readily bind to soil and sediments (Tush and Meyer 2016, p. 5784), and these chemicals may be less available to southwestern pond turtle in terrestrial habitats. Adverse effects to southwestern pond turtle from the use of herbicides can be minimized through proper application methods that reduce potential exposure pathways and other best management practices. Herbicide products that do not contain a surfactant or use a low-toxicity, non-POEA surfactant would also minimize effects (Howe et al. 2004, p. 1937; Govindarajulu 2008, p. 31). Without the ability to assess individual herbicides, application methods, or the potential restoration areas that may be utilized, the Service assumes herbicide usage within future southwestern pond turtle restoration areas may create potential for injury or mortality of southwestern pond turtle if present.

The proposed mitigation acreage within the Oxbow restoration area currently constitutes approximately 7 acres in total and is located entirely within the proposed project’s launch noise effect area (Appendix A, Figure 1A and 4A). Consequently, in the event launch noise is found to impact southwestern pond turtle abundance and distribution across any of the individual major riparian features, the proposed mitigation strategy may not serve to offset the observed effects effectively and quantifiably. However, the Service considers the Space Force’s commitment to ensure that objectives of the proposed mitigation are met and demonstrate clearly and quantifiably that no net loss in occupied southwestern pond turtle habitat and population size has occurred. In accordance with the Service’s compensatory mitigation policy (88 FR 31000; Service 2023c), the Space Force will develop restoration methods to ensure the objectives of the proposed mitigation (2:1 acreage offset) are met. These actions will be taken following mutual agreement by the Service and the Space Force to demonstrate they have achieved this goal to be consistent with this analysis.

Launch Operations Effects Off-Base (Mainland CA – eastern Santa Barbara, Ventura, and northern Los Angeles Counties)

Launch Noise and Overpressure

Southwestern pond turtles occupy the habitat within the Noise Effect and Overpressure Effect Areas off-base across Santa Barbara, Ventura, and Los Angeles counties. The southwestern pond turtle in these areas may infrequently experience 10 sonic booms, each separated by an average of 5 days, all of which we expect to reasonably be under 1.0 psf between October 1 and December 31, 2024. During the time of this project, southwestern pond turtles are expected be underwater or underground overwintering. When terrestrially overwintering, southwestern pond turtles may be shallowly underground or within leaf litter and may be exposed to launch noise and overpressure. When overwintering underwater, southwestern pond turtles may be in the shallow water, and may experience noise differently compared to being deep underwater. The extent of effects of noise and vibrations caused by sonic booms to southwestern pond turtles in brumation underground and underwater are unknown at this time. We expect general effects from sonic boom noise to be similar to those discussed above. However, based on the provided modeling information for the proposed project, any potential effects are unlikely to manifest and would be overall negligible considering the associated sonic boom level magnitude is understood to be far lower, of very short duration, likely comparable to ambient existing noise levels, and would occur relatively infrequently between October 1 to December 31, 2024. Continued monitoring of realized sonic boom and associated noise levels is necessary to ensure these assumptions are correct.

Effects of the Proposed Action on the California Red-legged Frog

Firebreak Maintenance

Effects related to SLC-4 firebreak maintenance activities for California red-legged frog are included in the existing Service PBO (8-8-12-F-49R) and all applicable avoidance, minimization, and monitoring measures required under the PBO would be implemented.

Launch Operations Effects on Base

Operational Lighting

The proposed project has the potential to generate effects associated with increased artificial lighting at night. The Service requested that the Space Force provide specific lighting levels that are currently being produced at SLC-4 during existing launch operations. This information has not yet been provided. In 2023, the vast majority of existing launches were conducted at night. The Service reviewed available historical light pollution satellite data (Visible Infrared Imaging Radiometer Suite (VIIRS) dataset 2017-2023; NASA 2024) and video footage from night launches of similar vehicles that demonstrate the potential magnitude of acute lighting levels generated from associated rocket flare. Following a review of this best available information, the proposed project has the potential to increase exposure to artificial light pollution in the vicinity of SLC-4.

No new lighting infrastructure would be added to SLC-4 as a result of the proposed project. However, increased operational usage of the existing SLC-4 facility to support up to 16 launches and 2 landings between October 1 to December 31, 2024, would reasonably increase average illumination of the site, particularly if launches operations continue to be scheduled at night. The Service reviewed the existing light pollution dataset (VIIRS) which demonstrates a significant increase in the lighting levels surrounding the vicinity of SLC-4 occurred between 2020 and 2023, potentially as a result of the large increase in past night operations to support 28 SpaceX launches in 2023. No previous design considerations were taken into the development of SLC-4 to help reduce novel associated light pollution. SLC-4 is located within 1 mile from Bear Creek and 2 miles from Honda Creek, with both features supporting California red-legged frog occupation and breeding. VIIRS data indicates that current SLC-4 operational lighting may be routinely illuminating associated California red-legged frog riparian and upland dispersal habitat as a result of associated sky-glow. Sky-glow is an increase in the apparent brightness of the night sky as a result of artificial lighting, often enhanced by clouds or fog. The Service understands that each night launch also has the potential to generate short term (approximately 1 to 3 minutes depending on if a terrestrial boost-back is involved) of higher levels of artificial night lighting as a result of associated rocket flare. Consequently, reviewing the available information for the purposes of this analysis, the proposed project is likely to increase the average number of nights that California red-legged frog habitat within Bear Creek, Honda Creek, and adjacent SLC-4 upland habitat may be illuminated by assumed low levels of site operation lighting and higher levels of acute rocket flare.

An increase in artificial night lighting associated with the proposed project could have adverse physiological and behavioral effects on California red-legged frogs. Although we have no specific data on the response of California red-legged frogs to artificial night lighting exposure, laboratory and field studies of related anurans indicate artificial lighting can result in changes in hormone production and growth, as well as altered activity levels including increased movement and foraging (Baker and Richardson 2006; Wise 2007; Hall 2016; May et al. 2019). An increase in artificial night lighting may also increase anuran predation rates if predators are able to better detect dispersing adult frogs that may move more in newly lit environments.

Numerous anurans have been shown to increase foraging activity surrounding permanent light sources (reviewed in Buchanan 2006), likely attributed to increased concentrations of prey levels resulting from insects’ attraction to the presence of ultraviolet light (Longcore and Rich 2017, p.

25). The number of insects attracted to a lamp is disproportionally affected by the emission of ultraviolet light, regardless of the proportion of ultraviolet radiation emitted (Barghini and Augusto Souze de Medeiros 2012, entire; B. Seymoure, pers. comm., 2023), indicating that even ‘low-UV’ lighting options attract insects. Permanent ultraviolet lighting adjacent to roadways or parking areas associated with SLC-4 launch facility may result in higher likelihood of vehicle strikes if California red-legged frogs increase foraging in these areas in combination with increased worker and vehicle presence. Launch operations may physically injure or kill California red-legged frog individuals if lighting surrounding the launch pad attracts them and they come within close vicinity of features including parking lots or the flame bucket. Considering the existing VIIRS data and being that SLC-4 is within the near vicinity to Honda Creek and Bear Creek, both of which are known to contain a moderately sized population of California red-legged frogs and breeding habitat, the Service reasonably anticipates that increased artificial lighting associated with the proposed project’s further increase in launching has the potential to result in the temporary degradation of both associated California red-legged frog riparian and upland habitat. To attempt to minimize these effects, the Space Force will require development of a lighting plan for the proposed project (GM-10). This plan will require that the project proponent retrofit the existing facility’s lighting with the intention to reduce scatter into natural, undeveloped areas to the maximum degree possible. This requirement will be accomplished through strategic placement of lights, and the use of shields, timers, and motion sensors to the maximum extent possible to minimize potential effects associated with novel persistent artificial light at night. The Service consequently expects that this lighting retrofit will help minimize anticipated associated effects to increased exposure to artificial light at night as a result of the proposed project.

Flame Duct Use and Vegetation Clearance

Each of the proposed 16 launches requires water release associated with the flame bucket with liquid water directed to the SLC-4 v-ditch feature and a minimum amount of water vapor directed towards Spring Creek. The maximum temperature of the water vapor would be 130 degrees Fahrenheit at the point it would reach Spring Canyon. Launches conducted between October 1 and December 31, 2024, and their associated water vapor releases may cause higher potential for injury or mortality of California red-legged frogs through scalding individuals in the Spring Creek area. The wet season would magnify these effects when California red-legged frogs are more active and are more likely to be present in Spring Canyon. However, between 2017-2022, the Space Force has performed 11 survey efforts within the Spring Canyon Vegetation Removal Area and found no suitable breeding habitat or California red-legged frog individuals (MSRS 2022a p. 28). It is therefore unlikely that California red-legged frog occupy the Vegetation Removal Area (or adjacent SLC-4 existing firebreaks) on a regular basis, other than for transitory upland habitat. SpaceX would minimize potential impacts by implementing minimization measures. Previous monitoring requirements included within the 2017 biological assessment included that a Qualified Biologist would conduct pre-activity surveys for California red-legged frog in the water release area following each launch (MSRS 2017, p. 14). Given the previous negative survey findings that followed 11 individual launches, the Space Force will now require a Qualified Biologist to perform one California red-legged frog survey annually during peak breeding season (November to May) in Spring Canyon when individuals are most likely to be present and detectable. If the Qualified Biologist does not encounter California red-legged frog at the time of this survey, the Space Force will not require any other subsequent pre-/post-launch surveys. If California red-legged frogs are present during the annual survey, the Space Force will require pre- and post-launch surveys and relocation of any California red-legged frog encountered for each subsequent launch event (CRLF-4). These avoidance measures should reduce the potential for California red-legged frog death or injury; however, biologists may not detect some individuals during pre-activity surveys resulting in California red-legged frog death or injury. We expect such effects would occur infrequently if ever.

Capture and relocation of California red-legged frogs in the area prior to individual launches may cause injury or death as a result of improper handling, containment, transport, or release into unsuitable habitat. Although we do not have an estimated survivorship for translocated California red-legged frogs, intraspecific competition, lack of familiarity with the location of potential breeding, feeding, and sheltering habitats, and increased risk of predation reduces survivorship of translocated wildlife in general. The Space Force will minimize effects by using Qualified Biologists as proposed, limiting the duration of handling, requiring proper transport of individuals, and identifying suitable relocation sites (GM-2). The Service expects the relocation of individuals from vegetation management and water release areas to greatly reduce the overall level of injury and mortality, if any, which would otherwise occur. Having only experienced biologists engage in the activity would greatly reduce the potential for injury or mortality due to mishandling.

SpaceX has constructed a civil diversion structure and retention basin to minimize the amount of water entering Spring Creek from water release activities. SpaceX will continue to avoid and minimize these effects by implementing measures described in the 2017 biological assessment (MSRS 2017) which include: (1) SpaceX will follow the site-specific Stormwater Pollution Prevention Plan already implemented for SLC-4; (2) SpaceX will implement the Best Management Practices within the latest California Stormwater Quality Association's Stormwater Best Management Practices Handbook; (3) SpaceX will collect any rocket propellant in the retention basin using absorbent pads prior to discharge to the spray field; and (4) SpaceX will fully implement the procedures in VSFB’s Hazardous Materials Emergency Response Plan in the event of a hazardous materials spill. The civil diversion structure and collection of fuel with absorbent pads should reduce the potential for effects to California red-legged frogs. Provided the various plans and practices to control contaminants and sedimentation are effective, these measures should also reduce the potential for such impacts on California red-legged frog habitat.

Approximately 17,500 gallons of hot water (130 degrees Fahrenheit) is expelled from the flame duct during each individual launch and ultimately reaches the v-ditch feature located within the fenceline of SLC-4. The Space Force has indicated that this water is temporarily stored within the feature and dissipates rapidly (Kaisersatt, pers. comm., 2023e). The Space Force will maintain SLC-4 features to be free of standing water to the maximum extent possible between launches to minimize the potential to attract California red-legged frog to the area (CRLF-1). The Service consequently understands that water would not present within 24 hours of an individual launch and that the temporarily stored water would not reach a depth level or hydroperiod that would support California red-legged frog breeding. Associated hydrophytic vegetation may be present and the Space Force would conduct feature maintenance on a regular basis (Kaisersatt, pers. comm., 2023e) that may occur between October 1 and December 31, 2024. The v-ditch feature may consequently constitute suitable transitory California red-legged frog habitat as a result and individuals may be attracted to the feature in response to increased water presence associated with the proposed project. Consequently, the Service assumes that any California red-legged frogs that come in contact with the v-ditch have the potential to be injured or result in mortality from associated contact with scalding water. The Service also assumes that v-ditch maintenance including sediment and vegetation removal may also result in the injury or death of adult California red-legged frogs if present.

The Space Force anticipates the proposed project's launches would produce a diminutive amount of soot byproduct. If soot or other similar launch related byproducts contact dispersing California red-legged frogs or enter adjacent occupied waterbodies, the Service assumes it has the potential to injure or kill California red-legged frogs due to their highly permeable skin and susceptibly to waterborne pollutants (Jung 1996, p. i; Llewelyn et al. 2019, p. 1). However, the Space Force references a comparable launch assessment (FAA 2020, entire) and expects that the actual amount of soot produced would be diminutive being that it would subsequently burn up in the exhaust plume (Kaisersatt, pers. comm., 2022). Consequently, the Service assumes that the proposed project's launch byproducts are unlikely to impact dispersing California red-legged frog or their aquatic habitats.

Water Extraction

At SLC-4, SpaceX would utilize an existing water-filled flame duct to reduce vibration impacts from noise on payloads. During Falcon 9 launches, approximately 70,000 gallons of water would be utilized per launch with approximately 40,000 gallons per landing. Using these estimates, the Service understands for 16 launches and 2 terrestrial landing this would amount to 1.2 million gallons (3.68 ac-ft) between October 1 and December 31, 2024, to support personnel and operational activities at SLC-4.

The Space Force has recently clarified that the current water source for VSFB, including SLC-4, is via an existing connection between State Water and the VSFB water supply system. For the majority of the 91 days of the proposed project, the Space Force would source water from this connection. However, during annual maintenance that lasts approximately two weeks, VSFB utilizes four water wells in the San Antonio Creek Basin. The Service consequently assumes that across this period (14 days), up to 184,615 gallons (0.57 ac-ft) could be extracted from these wells in San Antonio Creek Basin.

Water withdrawal from the San Antonio Creek wells has the potential to reduce streamflow and water levels within San Antonio Creek. This could adversely affect all life stages of California red-legged frog downstream of Barka Slough by reducing associated wetland and riparian habitats supported by the existing groundwater level and extent of inundated area. However, referencing previous analysis (USGS 2019, p. 5) and associated discussion with hydrologists involved with the associated hydrological modeling (C. Faunt and G. Cromwell, USGS, pers. comm. 2021), the proposed project's 0.57 acre-feet extraction amount would not be anticipated to result in measurable decline of streamflow or associated aquatic habitat.

Factors including future surrounding water usage (e.g., collective existing and future launch program needs, surrounding agriculture, etc.) as well as increased variability of annual precipitation due to climate change, including shorter wet seasons and longer dry periods, may influence true effects (Myers et al. 2017, p. 15, 59). An additional hydrological model incorporating various precipitation scenarios predicts that an extraction amount of 921 acre-feet would decrease inundated area between 0.14 and 10.14 percent (AECOM 2019, p. 6). Similarly, given that the maximum project related water extraction amount is less than 1 percent of the 921-acre feet used for the supplemental model analysis, it is not reasonably foreseeable that it would result in a discernable reduction of inundated area. Although potential impacts to associated riparian terrestrial habitat were not initially characterized, based on the best available information (AECOM 2019; USGS 2019), the Service does not anticipate measurable decline in the quality or overall extent of these associated habitats as a result of the project proposed extraction amount at this time. There has been a level of habitat change within Barka Slough driven by increasing groundwater withdrawals from the San Antonio Creek groundwater basin for agriculture on and off VSFB. Since the 1980's, withdrawals have exceeded the recharge rate for the basin (Public Works 2020 as referenced in MSRS 2022d, p. 5). Since the 1950's, ground water levels have dropped between 33 to over 98 feet (USGS 2019 as referenced in MSRS 2022d, p. 5). The Service also understands that there are additional launch programs currently permitted that represent the existing water extraction baseline. However, the Space Force did not provide the total permitted annual extraction amounts. Without this information, the Service is unable to make clear quantifiable reference for how the proposed project would add to the existing baseline of water extraction. Consequently, additional monitoring and analysis would be necessary to understand the impacts of the proposed project's extraction levels in the event the existing baseline continues to overdraft over time. To ensure no unanticipated effects occur during the 3-month project window, the Space Force will reference a previously established pre-project baseline for hydrodynamic data within San Antonio Creek and monitor hydrodynamic data (GM-9). The Space Force will use this data to ensure that the proposed project's water extraction is not measurably affecting flow rate or water level within San Antonio Creek.

Climate

Amphibians are vulnerable to the projected effects of climate change with leading threat factors including habitat loss, disease, and invasive species (Olson and Saenz 2013, entire). Amphibian species with narrow tolerances for temperature and moisture regimes may be at heightened risk.

Following a review of recent research on rocket launch emissions on stratospheric ozone and global climate impacts (Ryan et al. 2022, entire), the Service anticipates that emissions produced by the proposed project has the potential to contribute to these projected effects. However, the Space Force did not provide any information or analysis regarding emissions produced by the proposed project. Until the Space Force is able to provide relevant information including project specific emission analysis, the Service is unable to discuss associated effects further at this time.

Launch Vibration, Noise, and Overpressure

The Service anticipates that the proposed project's 16 launches, 2 landings, and 2 static test fire events have the potential to create associated ground vibration within the vicinity of SLC-4. We cannot anticipate the level of substrate vibration that the proposed project may produce at this time but assume conservatively that low levels of vibration may occur routinely for a short period (from 7 seconds to up to 2 minutes every 5 days) during the operation of SLC-4. The Service assumes that potential launch related vibration may be of low frequency which attenuates less readily than high frequency (Norton et al. 2011, p. 658). We have no specific data on the response of California red-legged frogs to varying levels or duration of exposure to launch operation vibration. We consequently use available research on the effects of vibration on related anurans (frogs) as a surrogate. In a laboratory study, researchers investigated the effects of low frequency vibrations on early embryonic development of African clawed frog (*Xenopus laevis*). The study demonstrated that vibrating embryos in petri dishes overnight during the embryo development process at three low frequency levels (7, 15, and 100 hertz) induced significant levels of physiological effects (heterotaxia defined by the abnormal position of the heart, gall bladder, and/or gut loop), with some treatments inducing neural tube defects as well as bent tail morphology (Vandenberg et al. 2012, pp. 3-5). Other research has demonstrated negative effects of anthropogenic vibration on anuran communication. Researchers carried out field based vibratory playbacks during 13 days from sunset until dawn when male common midwife toads (*Alytes obstetricans*) were calling. During vibratory playback stimuli, call rate of the common midwife toad significantly decreased with a smaller number of toads ceasing calling activity completely or abandoning their calling sites (Caorsi et al. 2019, p. 2). These findings suggest that if launch related vibration occurs during the breeding season, routine exposure to low frequency vibration may adversely affect California red-legged frogs and has the potential to negatively impact breeding success during launch operations. Launch operations on SLC-4 would occur within approximately 1 mile of California red-legged frog breeding habitat within Bear Creek and 2 miles from Honda Creek. The biological assessment did not provide vibration modeling for the purposes of this assessment. The Service cannot anticipate the specific vibration levels that the proposed project may produce. Although more information is needed to predict the magnitude of potential effects, the Service currently assumes that the proposed project would generate short term, infrequent vibration and the project site is located a sufficient distance from California red-legged frog breeding habitat to preclude any associated effects that would result from routine vibration.

The proposed project's launch operations would produce noise and overpressure levels that may adversely affect California red-legged frogs between October 1 and December 31, 2024. There are no studies on the effects of noise and overpressure on California red-legged frogs, but available literature on the effects of noise disturbance on anurans in general has grown in recent years (Zaffaroni-Caorsi et al. 2022, entire). A previous study reviewed the effects of noise exposure on bullfrogs, which are closely related to California red-legged frogs. Although no specific acoustic thresholds were determined during the study, researchers exposed American bullfrogs to sound levels greater than 150 dB SPL for 20 to 24 hours straight, which produced observable damage to their inner ears (Simmons et al. 2014a, p. 1629). Bullfrogs' inner ears showed physical signs of recovery between 3 to 9 days after noise exposure (Simmons et al. 2014b). A moderate population of breeding California red-legged frogs are known to occur approximately 1 mile north of SLC-4 within Bear Creek and 2 miles south within Honda Creek. California red-legged frogs would receive noise and overpressure levels of up to 128 dB SPL_{max} and 5.0 psf at Bear Creek with 123 dB SPL_{max} and 5.0 psf at Honda Creek (Appendix A, Figures 1B and 2C; MSRS 2022a, MSRS 2024a, p. 104). Any California red-legged frogs present in upland habitat in the immediate vicinity of SLC-4 may experience modeled noise levels of 150 dB SPL_{max} with overpressure up to 9.5 psf. Multiple additional known populations of California red-legged frog within major riparian features (e.g. Santa Ynez River, San Antonio Creek, Shuman Creek, and Canada de Jolla, and Jalama Creek) occur over 4 miles from SLC-4 and would receive noise and overpressure disturbance of reduced levels. In summary, California red-legged frog within the vicinity of VSFB would experience noise levels between 100 to 150 SPL_{max} between 1 to 2 minutes on average once every 5 days during up to 16 full launches. They would experience simultaneous boost-back overpressure levels between 0.5 to 9.5 psf a total of two times during this same period. Populations would also receive levels of 100 to roughly 125 dB SPL_{max} (Appendix A, Figure 1B; MSRS 2022a, p. 53) during 2 separate static test fires for 7 seconds within this five-day period. Although the proposed project's maximum noise levels are only slightly lower than those documented to produce observable damage to bullfrog ears, the duration of the noise events would be much shorter than the exposure duration used in this study. However, the specific acoustic thresholds of California red-legged frog are unknown. If the proposed project's noise levels did result in hearing damage to California red-legged frogs, it may temporarily deafen them. The Service assumes the California red-legged frog inner ear recovery period may be similar to the 3- to 9-day recovery period exhibited by bullfrogs. If the proposed project's noise levels physically damage the inner ears of California red-legged frog and given that the project's noise events would occur on average every 5 days, this may lead to routine deafening. Routine deafening of a substantial portion of breeding populations within the most proximate features including Bear Creek and Honda Creek may alter California red-legged frogs' ability to effectively communicate across the breeding season when frogs are calling with the potential to result in overall lower likelihood of reproductive success. California red-legged frogs that exhibit hearing loss may have a decreased ability to detect danger which increases their risk of predation. However, without refined specific acoustic threshold information, the Service is unable to determine if the proposed project will result in routine deafening of the specified California red-legged frog populations. The Service considers that although specific acoustic thresholds are not available, the bullfrog surrogate study used higher noise levels (greater than 150 dB SPL) with significantly longer exposure duration (20 to 24 hours). The same study reported that shorter duration (4 hours) of levels below 150 dB SPL did not produce observable morphological damage (Simmons et al. 2014b). Using this available information, the Service does not currently anticipate that project activities would result in hearing loss. This being said, additional information is needed to help understand the potential for auditory harm at realized noise levels.

Being that observed call rate changes could be correlated with hearing loss, the Service has reviewed the Space Force's previous short-term California red-legged frog call rate monitoring conducted following a single Falcon 9 launch event (MSRS 2022b, entire; MSRS 2023, pp. 12, 15-16). Although monitoring documented notable increases in call rate following an individual launch, data was collected over an insufficient time period (6 days) to be able to analyze results in a meaningful manner. To address the need for better information and the potential for effects, the Space Force will implement long-term, passive bioacoustic monitoring during the California red-legged frog breeding season to characterize the baseline noise environment and determine if there are changes to call rate that may indicate inner ear damage (CRLF-7). This additional monitoring will help detect changes in calling behavior to ensure consistency with this analysis.

In addition to call rate, changes in other signal characteristics including amplitude, frequency, duration, and complexity may be impacted with the introduction of novel noise disturbance. Changes (increases or decreases) to an individual's signal characteristics may represent energetic and vocal performance trade-offs. Receiver interpretation of altered signals may influence assessment of signaler quality. This could impact the fitness of anuran populations over the duration of the proposed project (three months during the 2024 breeding season). Anurans rely heavily on acoustic signals to attract females and to defend resources against rivals. Previous research looking at traffic noise has demonstrated a trade-off between call rate and call duration in *Hyla versicolor* (Schwartz et al. 2002). Females were found to prefer calls that were delivered at high rates with longer durations (Gerhardt et al. 1996; Gerhardt and Brooks 2009), suggesting that environmental factors that influence the tradeoff of call rate and call duration could influence overall fitness. Multiple related frog species have been shown to alter call amplitudes during motorbike noise exposure (Cunnington and Fahrig 2010). The energetic costs of calling increases exponentially with call amplitude with an approximate doubling in energetic cost for each 3 dB increase in amplitude (Parris 2002). Previous work suggests that increased energetic costs of calling may inhibit growth rate as a result of allocating more energy towards call effort (Given 1988). This may result in lower reproductive output (Gibbons and McCarthy 1986) and increased risk of desiccation (Heatwole et al. 1969 as referenced in Yi and Sheridan 2019) both of which can lead to decreases in population size. Potential changes in signal frequency could also reduce transmission distance and overall reduce signal efficiency. In bird species, adjustments in signal frequency can decrease song complexity which can profoundly affect reproductive success (Montague et al. 2013). Preliminary monitoring of California red-legged frog during high launch years (e.g. 2023 and early 2024) has not shown immediate declines in breeding populations in Honda Creek and Bear Creek (MSRS 2024a, p. 110). However, confounding factors, including the notable rehydration of breeding habitat on VSFB during the

2023-2024 rain year after consecutive years of extreme drought between 2012 and 2022 (Palmer Drought Severity Index; NOAA 2024a) may reasonably be influencing current population numbers. This would mean potential associated effects may not be detected over the short-term without proper statistical analysis. Although more information is needed regarding how rocket noise disturbance may impact California red-legged frog signaling performance and overall fitness, using the best available information, the proposed routine noise disturbance over the duration of the proposed project (three months) has the potential to impact the breeding success of California red-legged frog during the 2024 breeding season. We currently anticipate observable impacts during the three-month project duration would be to an overall limited degree.

Similarly, launch noise and overpressure associated with sonic booms may impact all California red-legged frogs in the action area by altering their physical behavior. California red-legged frogs may react to individual project related launch noise and overpressure created by sonic booms by startling or remaining immobile making them more susceptible to predation or desiccation. They may also react to launch related disturbances by diving into water or retreating away from the affected areas. Overpressure disturbance would occur infrequently (twice) during the three-month period and be separated by at least five days. However, the proposed project's boost-back overpressure disturbance in combination with routine launch ascent noise disturbance and separate static test fires would subject local California red-legged frog populations to novel disturbance frequency. Acute disturbance on average every five days across the three-month period of the proposed project has the potential to induce novel effects as a result of repetitive (chronic) stress.

In certain frog species, acute stress has been shown to induce an immediate increase in stress hormone (corticosterone) production (Hammond et al. 2018). Chronic stress, such as frequent exposure to noise and overpressure disturbance, can cause chronically high levels of stress hormone (Troïanowski et al. 2017). Prolonged elevated stress hormone concentrations can have deleterious effects on growth, survival, reproduction, and immune function (Sapolsky et al. 2000; Tennessen et al. 2014). Relatively recent research demonstrates that increases in advertisement calling rate may be correlated with stress hormone production, which can result in an overall tradeoff in energy otherwise allocated for immunocompetence (Troïanowski et al. 2017; Park and Do 2022). Research has documented cases of anuran spatial displacement in response to traffic noise playback experiments (Caorsi et al. 2017, pp. 9, 14), with different movement effects depending on land cover type (Nakano et al. 2018, entire). Somewhat conversely, it has been suggested that noise can trigger tonic immobility, a paralysis-like fear response, in anurans as a result of increased stress levels (Tennessen et al. 2014, p. 6) which may make them more vulnerable to predation. The U.S. Army conducted a study on the response of Colorado checkered whiptail when exposed to intermittent noise disturbance from aircraft flyover noise. When exposed to a week of intermittent flyover noise up to 112.22 dB in comparison to a control week of no noise disturbance, the Colorado checkered whiptail was found to modify its behaviors by spending less time moving and more time eating, and also exhibited higher levels of corticosterone and ketone bodies (markers of stress) (Kepas et al. 2023). The study also suggests that noise disturbance that occurs during the breeding season may induce higher levels of impact when energy would otherwise be invested into developing offspring. Consequently, the Service considers that repetitive stress incurred during the wet season, when California red-legged frogs are more active, may magnify the effect of these behavioral responses by altering breeding behaviors such as migration and calling. However, no specific thresholds of disturbance level or frequency are known. The Service considers that although the project may result in effects to dispersal behavior, calling, and stress hormone accumulation that could have deleterious physiological effects and overall degrade the quality of existing habitat, until the novel effects of the project activity are studied, we are unable to adequately anticipate the magnitude of any specific response at this time.

The Space Force provided preliminary audiogram analysis which suggests there would not be overlap in the species' hearing sensitivity and low frequency noise produced by rocket launches. Specifically, the provided audiogram analysis suggests that California red-legged frog may only be able to perceive a negligible portion of the launch noise, hearing less than 25 dB (the human equivalent of whispering) across the entire launch event (MSRS 2024a, p. 106). However, subsequent subject matter expert review of this material indicates the provided hearing curve and corresponding weighting function are not established and there is still significant uncertainty around the hearing capabilities of California red-legged frog (J. Tennessen, pers. comm., 2022). Consequently, the specific disturbance levels and frequency thresholds that may impact California red-legged frogs are unknown and must still consider that the species may reasonably perceive and experience a stress response from associated launch disturbance.

In combination with the existing launch baseline on VSFB, the proposed project may contribute to potential long-term effects from chronic stress caused by routine acute launch disturbance across launch programs. Although the proposed project would only occur between October 1 and December 31, 2024, it may contribute to a degree to potential collective effects. Collective effects may include long-term population level effects including reduced reproductive success, survival, fitness, and spatial displacement. Although we do not have an estimated survivorship of displaced California red-legged frogs, this could result in injury or death to individuals as a result of increased intraspecific competition, lack of familiarity with new locations of potential breeding, feeding, and sheltering habitats, and increased risk of predation. However, it is unknown how California red-legged frogs would react to repetitive launch events of variable disturbance levels with increasing frequency. Improved monitoring information is needed to help identify thresholds that quantify what level of noise or frequency of disturbance would elicit stress hormone responses that may lead to impacts to breeding and reproduction or other negative population level effects. Consequently, the Service cannot adequately determine the magnitude of potential collective effects with the addition of the proposed project on the residential and breeding California red-legged frog populations within the vicinity of VSFB at this time.

Following review of the effects of the proposed action, the Service anticipates the proposed project would likely result in the temporary degradation in the quality of adjacent California red-legged frog aquatic and dispersal habitat in the vicinity of VSFB due to associated noise and overpressure disturbance from routine launching. The proposed project also may contribute to potential population level collective effects that may occur over time. The potential mitigation actions for California red-legged frog include the creation of new breeding habitat at a 2:1 ratio (habitat enhanced: habitat affected) within the San Antonio Creek Oxbow Restoration 'expansion area' (Appendix A, Figure 4A). The Space Force indicates that previous restoration methods have proven successful at creating deep water aquatic habitat, suitable for California red-legged frog breeding and riparian woodland that simulate naturally occurring high-flow channels within approximately 2 acres of former agriculture land. Recent survey efforts have successfully detected 19 California red-legged frogs at this site, demonstrating that California red-legged frogs can newly colonize these areas for breeding several years after restoration site establishment (Kaisersatt, pers. comm. 2023b, entire). Biologists documented several male frogs calling, indicating that the site may be used for future breeding. Mitigation actions that may occur as result of the project include site preparation via herbicide application, plowing, container plant installation, seeding, willow pole planting, and watering via water truck. These activities have the potential to affect California red-legged frogs. An existing biological opinion (2016-F-0103; Service 2018) addresses the associated effects of this portion of the proposed action for California red-legged frog, and the Space Force will implement all required avoidance, minimization, and monitoring measures from that biological opinion. However, the proposed mitigation acreage constitutes approximately seven acres in total and is located entirely within the proposed project's launch noise effect area (Appendix A, Figure 1A and 4A). Consequently, in the event more frequent launch noise associated with the proposed project is found to impact California red-legged frog abundance and distribution, the proposed mitigation strategy may not serve to effectively quantifiably offset observed effects. The Space Force has not yet identified other locations of mitigation activities that may contribute to the Space Force's goal of no net loss at this time. However, the Service considers that the Space Force's commitment to ensure they meet the objectives of the proposed mitigation and are able to clearly demonstrate quantifiably that no net loss in occupied California red-legged frog habitat and population size, as stated in the Description of the Proposed Action above, has occurred. In accordance with the Service's compensatory mitigation policy (88 FR 31000; Service 2023c), the Space Force will develop restoration methods to ensure the objectives of the proposed mitigation (2:1 acreage offset) are met. Restoration activities will align with the objectives of the California red-legged frog Conservation Strategy (Service, *in prep*) with the goal of achieving no net loss to the species (Kephart, in litt., 2022, p. 3; MSRS 2024a, p. 113). These actions will be taken following mutual agreement by the Service and the Space Force to demonstrate they have achieved this goal to be consistent with this analysis.

Launch Operations Effects Off-Base (Mainland CA – eastern Santa Barbara, Ventura, and northern Los Angeles Counties)

Launch Noise and Overpressure

California red-legged frogs occupy the habitat within the Overpressure Effect Areas off-base across eastern Santa Barbara, Ventura, and Los Angeles counties. California red-legged frog in these areas may infrequently experience 10 sonic booms, each separated by an average of 5 days, all of which we expect to be under 1.0 psf between October 1 and December 31. We expect general effects from sonic boom noise to be similar to those discussed above but understand that based on the provided modeling information for the proposed project, any potential effects are unlikely to manifest and would be overall negligible considering the sonic boom's associated noise level magnitude is far lower, of very short duration, likely comparable to ambient existing noise levels, and would occur relatively infrequently between October 1 to December 31, 2024. Continued monitoring of realized sonic boom and associated noise levels is necessary to ensure these assumptions are correct.

Regarding off-base climate effects, see discussion above.

Effects of the Proposed Action on the Western Snowy Plover

Launch Operations Effects on Base

Operational Lighting

The proposed project has the potential to generate effects associated with increased artificial lighting at night. The Service requested that the Space Force provide specific lighting levels that are currently being produced at SLC-4 and on adjacent habitat including Surf Beach from existing launch operations to help inform the Service's ability to anticipate potential for lighting effects from the proposed project. This information has not yet been provided. The majority of recent launches from SLC-4 have been conducted at night and that the proposed project could potentially conduct all 16 launches at night. The Service reviewed available historical light pollution satellite data (Visible Infrared Imaging Radiometer Suite (VIIRS) dataset 2017-2023; NASA 2024a; b), photos of Falcon-9 flare during a night launch, and video footage from night launches of rocket vehicles that demonstrate the potential magnitude of acute lighting levels generated from associated rocket flare. Following a review of this best available information, the proposed project has the potential to increase western snowy plover exposure to artificial light pollution in the vicinity of SLC-4. No new lighting infrastructure would be added to SLC-4 as a result of the proposed project. However, increased operational usage of the existing SLC-4 facility to support up to 16 launches between October 1 to December 31, 2024, could reasonably increase average illumination of the vicinity of SLC-4 as a result of associated sky-glow as previously defined.

The Service reviewed the existing light pollution dataset (VIIRS) which demonstrates an apparent significant increase in the average lighting levels in the vicinity surrounding SLC-4 that occurred between 2017 and 2023 (NASA 2024a; b), potentially as a result of the large increase in past night operations to support 28 SpaceX launches in 2023. No previous design considerations were taken into the development of lighting infrastructure on SLC-4 to help reduce novel associated light pollution. SLC-4 is located 0.8 mile from adjacent western snowy plover habitat in South Surf Beach. Although refined specific light monitoring information is needed, the VIIRS data indicates that SLC-4 operational lighting may be routinely illuminating adjacent habitat, including nearby beaches, at low levels. In addition, each night launch has the potential to generate short term (approximately 1 to 3 minutes depending on if a terrestrial boost-back is involved) of higher levels of artificial night lighting as a result of associated rocket flare. Although we understand there is a clear potential for project associated lighting to increase, without clear light-monitoring information, the Service is currently unable to anticipate specific lighting levels to help us reasonably predict the magnitude of potential effects from the proposed project. Reviewing the best available information for the purposes of this analysis, the proposed project has the potential increase the number of days that western snowy plover overwintering habitat on Surf beach could be illuminated by low levels of site lighting and higher levels of acute rocket flare as a result of associated sky-glow.

Increased project-related lighting on Surf Beach could include effects to western snowy plover roosting success. Previous research has demonstrated that significant declines were found in the likelihood of plovers roosting in locations where exposure to artificial night lighting exceeded routine illuminance levels as low as approximately one half a full moon (threshold of 50 millilux (mlx) irradiance for effect, with 50 percent of their peak probability of presence above 100 mlx) (Simons et al. 2021, p. 5). The study suggests that the disruption of behaviors related to roosting associated with elevated levels of artificial night lighting are likely a result of perceived increased predation risk in illuminated coastal areas. This is consistent with existing research on related shorebird nocturnal behavior, where data suggests that species use darkness as a refuge to help avoid detection from nocturnal predators (Mouritsen 1992, entire). Without the ability to reference lighting levels, the low levels of routine Surf Beach illumination resulting from increased operation usage of SLC-4 site lighting in combination with 16 ascent and 2 landing events of anticipated higher illumination levels from rocket flare produced between October 1 to December 1, 2024, has the reasonable potential to degrade adjacent Surf Beach western snowy plover roosting habitat. In the event that routine lighting was found to be occurring in these areas, it is possible that these areas would be considered less suitable by the species to support successful roosting. The area most likely to be exposed to increased project-related lighting would be South Surf Beach, although the existing data indicates that the entirety of Surf Beach may be affected (NASA 2024a; b). This effect has the potential to be significant for the species as Surf Beach is an important overwintering location for western snowy plover, supporting 146 roosting plovers in 2024 (refer to Table 3, Condition of Status of Species).

Following discussion of the available data with lighting experts, the Service understands that VIIRS data cannot alone be used to compare to the aforementioned identified lighting thresholds in existing literature as a result of differences in lighting unit (radiance). Additionally, VIIRS data should not be used to assess lighting trends within smaller sample areas (e.g. Surf Beach alone) due to issues of scale. Following review of existing data, specialists recommended that site specific light monitoring would be needed to ground truth experienced light levels and duration. Consequently, more information is needed for the Service to clearly predict the magnitude of potential impacts at this time. The Service currently expects that the proposed project would constitute degradation of Surf Beach roosting habitat but that effects should be reduced with the implementation of SLC-4 lighting retrofits proposed (GM-10).

Launch Noise

The Service conferred with avian hearing experts on the launch noise parameters of the proposed project. Potential effects from repeated launch noise disturbance events between 100-130 dB SPL associated with 16 launch ascents and between 140-150 dB SPL during two boost-backs include hearing damage from short exposure noise exposure, communication masking, and harassment (annoyance) that could result in changes in species abundance and distribution (Dooling, R., pers. comm. 2024). Following review of the available information, the Service anticipates that the proposed project's routine launch noise would likely result in temporary degradation of western snowy plover overwintering habitat between October 1 and December 31, 2024, from these effects.

Repetitive launch noise disturbance events have the potential to damage western snowy plover hair cell receptors and result in hearing loss. Auditory damage across species can occur, even if low frequency noise is not thought to be readily perceptible (Kugler et al. 2014; Williams 2014). Available recommended guidelines indicate that avian hearing damage can occur during single impulse (blast) levels of 140 dB(A) and multiple impulse noise source types (e.g. jackhammer, pile driver) levels of 125 dB(A) (Dooling and Popper 2007, p. 25). A-weighted and unweighted decibels are not equivalent, and no approximate conversion was provided for the purposes of this analysis. Consequently, the Service assumes that 125 dB(A) is roughly equivalent to 120 dB SPL and that noise sources used to generate this guidance are of low-frequency, generally similar to rocket disturbance. The Service anticipates that, due to its direct adjacency to SLC-4, potential impacts would be higher across Surf Beach, with the highest potential impacts expected at South Surf Beach. Approximately half of Surf Beach would be exposed to noise levels greater than 120 dB SPL during each launch ascent (Appendix A, Figure 1C). All of Surf Beach would be exposed to noise levels up to 150 dB SPL during the two boost-backs (Appendix A, Figure 2D).

Existing research shows that birds show some resistance to hearing damage, particularly as a result of their ability to regenerate auditory hair cells (Stone and Rubel 2000, p.1; Dooling et al. 2008, entire). However, the magnitude, duration, and frequency of noise disturbance events would likely play a role in the potential to induce routine hearing loss and can also vary by species. The Service does not have data on the specific acoustic thresholds of the western snowy plover and consequently have reviewed available research conducted on other avian species as a surrogate. Previous research has demonstrated that when the Japanese quail (*Coturnix coturnix*) was exposed to a 1.5 kHz octave band noise at 116 dB SPL for four hours, individuals showed hearing loss of up to 50 dB SPL immediately following exposure, with hearing loss most severe at frequencies at and above 1 kHz and with considerable variation between subjects (Niemiec et al. 1994). This indicates that following exposure at these levels, quails would need normal noises to be 50 dB SPL louder to hear them. Quail and other avian species have the ability to regenerate auditory hair cells following acoustic trauma (Ryals and Rubel 1988; Dooling et al. 2008). Niemiec et al (1994) demonstrated that quail hearing improved and recovered within 8 to 10 days following exposure. This is a longer period than is being considered during the proposed project (acute launch noise disturbance on average every 5 days). Following repeat exposure, the amount of time it took for quail's hearing to recover increased. Although birds show recovery of sensitivity and hair cell receptors, the amount of hearing loss and recovery rates differ among avian species (Ryals et al. 1999; Beason 2004). Ryals et. al (1999) conducted a comparative study that tested different bird species (including quail and budgerigars (*Melopsittacus undulatus*) under similar noise exposure of 112-118 dB SPL for 12 hours. Quails showed significantly greater susceptibility to hearing loss and acoustic trauma with a permanent threshold shift of approximately 20 dB SPL as long as one year following exposure (Ryals et al. 1999, p. 74). In comparison budgerigars showed much faster recovery, to within 10 dB SPL within three days. Existing literature also indicates that there is considerable variation among species in the amount of acoustic trauma and the time involved in hearing loss and recovery and that these differences cannot be predicted from a species' appearance or behavior (Ryals et al. 1999; Dooling and Popper 2007, p. 26). The Service has reviewed the available avian auditory damage estimated guidelines and available literature. Being that the proposed project's noise levels exceed 120 dB SPL (ranging up to an understood 150 dB SPL_{max}) and the anticipated frequency of disturbance (on average a launch every 5 days) may occur faster than potential unknown hearing recovery time, the Service considers that repetitive exposure to high intensity noise disturbance, perceived or not, has the reasonable potential to cause routine hearing damage in western snowy plover between October 1 and December 31, 2024. Effects may occur across a large portion of Surf Beach which was most recently estimated to support approximately 146 overwintering western snowy plovers during this period (refer to Table 3, Condition of Status of Species).

The Service recognizes that these auditory harm guideline estimates were developed using both domesticated avian and small mammal studies, and that there is considerable variation between species. There are no available studies identifying the specific acoustic thresholds that may cause damage to the western snowy plover or the anticipated recovery time if hearing loss does occur as a result of the proposed project. The Service also understands that the Space Force is conducting a study to investigate possible changes in western snowy plover acoustic responses to increased launch frequency, establish baseline vocalizations in 2024, and analyze potential communication disruptions from rocket launches (Govtribe 2024; Miller 2024). Although an appropriate off-site reference population would be necessary when accounting for the current elevated rate of launch disturbance on VSFB and considering that behavioral response cannot alone predict hearing loss, changes in vocal performance may still be helpful to understand if the project may be causing routine impacts to western snowy plover hearing and consequently, communication. Previous work has demonstrated that deafened birds can develop abnormal species-specific calls (Heaton et al. 1999, p. 1), although this may not be readily demonstrated in species that lack complex song such as shorebirds.

In the event hearing loss occurs from a single launch, the short duration proposed between repetitive launch disturbance events could reasonably preclude the species' ability to regenerate the acoustic hair cells and recover their full hearing ability. Considering that VSFB serves as an important stop-over site for western snowy plover across the species range, potential effects to overwintering western snowy plover's hearing could result in impacts on the species' population as a result of possible disruption in communication, masking, increased vigilance or distraction leading to decreased foraging effort, and the decreased ability to detect predators. Although we will need to review the results of the future western snowy plover communication study (Govtribe 2024; Miller 2024) to help determine whether hearing loss and communication impacts may be occurring, more information is needed to help assess magnitude of potential effects.

In the event repetitive launch noise events significantly influenced long-term hearing loss as was demonstrated with the aforementioned study on quail (Ryals et al. 1999, p. 74), there is a potential that effects could result in decreased reproductive success and long-term survival across the majority of VSFB population. The proposed project however is limited from October 1 to December 31, 2024, and using the available information the Service does not currently anticipate associated impacts to western snowy plover breeding populations at this time.

In the event that the proposed project does not result in auditory harm, western snowy plover may still be annoyed to the extent that overwintering populations abundance and distribution across VSFB is impacted. The proposed project's disturbance frequency has the potential to displace western snowy plover populations, potentially stimulating migration away from noisy areas. Although we do not have an estimated survivorship of displaced western snowy plover, this could result in injury or death to individuals as a result of increased intraspecific or interspecific competition, lack of familiarity with new locations of potential breeding, feeding, and sheltering habitats, and increased risk of predation. All of which reduces survivorship of displaced individuals in general. The Space Force has suggested that the species would only minimally perceive launch noise disturbance referencing an established audiogram for the domesticated mallard duck (MSRS 2024a, p. 131-132). The Service has reviewed this information in tandem with past monitoring results of the Falcon 9 launches and boost-backs at SLC-4. The proposed project will have similar launch noise and sonic boom disturbance levels as it is the same launch vehicle from the same location. Biologists monitored the June 18, 2022 Falcon 9 SARah-1 mission with boost-back and first stage recovery at SLC-4 that created an estimated sonic boom overpressure of 2.57 psf which converts to an instantaneous noise disturbance of 135.8 dB SPL_{max} at the western snowy plover monitoring location on South Surf Beach (Robinette and Rice 2022, p. 13). They noted that during the individual launch, incubating western snowy plovers reacted to both the launch ascent noise and the sonic boom produced by the return flight of the first-stage with more intense reactions to the sonic boom including hunker response (Robinette and Rice 2022, p. 1). Biologists reported no difference in bird abundance before and after launch and boost-back (Robinette and Rice 2022 pp. 1–2, 13). The biological assessment also includes that in 2023 video camera monitoring, western snowy plover behaviorally responded to varying degrees to all launch events with 92 percent of all annual monitoring demonstrating an alert response, 11 percent demonstrating startle response, 7 percent demonstrating a hunker response. No nesting western snowy plover flushed off nests during launch noise events (MSRS 2024a, p. 135). However, the lack of a flush response does not adequately support that the species is not perceiving or distressed by launch noise events being that this species is known to exhibit very high levels of nest tenacity. The Service reviewed available literature supporting that western snowy plover will maintain body position under extreme weather (with adults documented to be completely buried under sand during gale force winds sitting on eggs without flushing; Farrar et al. 2012, entire). In addition, the Service reviewed available monitoring information that California least tern, a more closely related shorebird surrogate than the domesticated mallard duck that was used in the provided audiogram analysis, does exhibit a full flush response to launch noise alone (MSRS 2024a, p. 142). Consequently, using this information, the Service anticipates that overwintering western snowy plovers are likely capable of perceiving and behaviorally responding to the proposed project's launch noise and sonic boom disturbance. In the event launch noise disturbance of sufficient magnitude occurs frequently enough to annoy western snowy plover, the Service anticipates this could result in changes in species abundance and distribution during the overwintering period. The Service worked to compile available western snowy plover data from 2018 to 2023, in which 2023 experienced significantly higher launch levels than historic averages. Although necessary statistical analyses of long term western snowy plover data (Service 2023a; refer to Reporting Requirement 2, p. 85) have not yet been provided, referencing available monitoring information for purposes of comparison the Service considers that in 2023, Surf Beach (both North and South Surf Beach sites) appear to have experienced an atypical increase in nest abandonment and a decrease in nest establishment (Service, compiled 2018-2023 data by VFWO, 2024d). Additional analysis utilizing available data between 2020 and 2023 indicates a declining trend in western snowy plover residency time during the breeding season within the south base sites more proximate to SLC-4 when compared with north base sites, which largely remained constant (Service, unpublished data from AFWO, 2024e). More information, including the aforementioned required statistical analysis of long-term dataset, is needed to help more confidently speak to any observed trends as they may relate to overwintering populations.

The Service has also requested comparable shorebird monitoring data from other rocket launch facilities in Cape Canaveral, Florida as well as Boca Chica, Texas. The Service was unable to obtain any available comparable long-term shorebird monitoring from Cape Canaveral which has historically launched similar vehicles at a more frequent rate than VSFB. Boca Chica, Texas supports the SpaceX Starship Heavy facility. This facility launches a much larger rocket that produces significantly higher disturbance levels and includes unique effects such as a physical debris cloud. The Service also understands that this facility underwent 'intensive' testing as well as launching between 2021-2022 (Newstead and Hill 2022, p. 12), but it is unclear specifically how frequent associated disturbance events occurred. Understanding the differences between this launch facility and SLC-4 at VSFB, the Service has reviewed what we consider the best current available comparable shorebird monitoring information that may help inform future effects in relation to potential changes in species distribution and abundance resulting from more frequent rocket launching. Available reporting from the Boca Chica facility indicates there have been significant observed declines in overwintering piping plover (*Charadrius melodus*) abundance, with a decrease of approximately 54 percent (from over 308 to below 142) between 2018 to 2021 (CBBEP 2021; Attachment 1, p. 4). Following this finding, statistical analysis conducted across numerous piping plover overwintering sites confirmed that Boca Chica was the only site to experience severe decline of overwinter piping plover abundance in 2019 and 2020, but then rebounded in 2021 when SpaceX Superheavy rocket launches were required to temporarily stop (Newstead and Hill 2022, pp. 12-14). The top model for Boca Chica included the 'launch year' covariate. Additional available reporting has also indicated that the population of snowy plover (*Charadrius nivosus*) nesting in the area has declined during years with Starship Heavy launch activity. No specific disturbance thresholds have been identified and the Service is currently unable to anticipate the potential magnitude of effects on overwintering western snowy that may result from up to 16 Falcon-9 launches between October 1 to December 31, 2024, occurring on average every 5 days. However, the Service anticipates that the proposed action may result in short-term adverse effects including behavioral reactions to overwintering western snowy plover. Non-observable physiological responses of western snowy plover to noise disturbance may include an increased heart rate or altering of metabolism and hormone balance. These responses may cause energy expenditure, reduced feeding, and habitat avoidance or displacement that results in increased vulnerability to predation (Radle 2007, p. 5). Consequently, using the best available information at this time, the Service anticipates that the proposed project has the potential to impact the abundance and distribution of overwintering western snowy plover on VSFB in the event the magnitude and frequency of the project's launch disturbance annoys them to an extent they no longer consider the habitat suitable. We are unable to assess the magnitude of these specific effects at this time until more monitoring information is available. However, we anticipate that the project, at a minimum, would constitute temporary degradation of western snowy plover overwintering habitat between October 1 and December 31, 2024.

The proposed project has the potential to contribute to long-term adverse effects that result from routine intermittent acute noise disturbance. The proposed project would contribute to the disturbance frequency of the existing launch noise disturbance baseline. In recent history, VSFB has supported an average of 6.2 launches per year with a notable increase to the maximum of 29 realized launches 2023. Although no information is available on potential western snowy plover population response to specific noise disturbance thresholds at certain temporal frequency, western snowy plovers do appear to demonstrate sensitivity to frequent noise disturbance. Biological monitors reported that a 20-minute fireworks display (lower levels of more frequent acute noise; variable intermittent disturbances that ranged from 59 dB to 80 dB for 20 minutes) at Coal Oil Point Reserve in Goleta, California, visibly agitated western snowy plovers (BRC 2018, entire). Camera footage captured western snowy plovers displaying stress responses (i.e., shallow breathing, frantic head turning, flushing) during the noise events. Although this described disturbance profile is at notably lower noise levels than the proposed project and occurs significantly more frequently than the proposed project, we use this information as one of the best available references when considering the species tolerance thresholds for disturbance frequency. Chronically elevated stress hormone concentrations can have deleterious effects on species. Responses may cause energy expenditure, reduced feeding, reproductive losses, bodily injury resulting in increased vulnerability to predation, and habitat avoidance (Radle 2007, p. 5). Referencing current best available information, the Service considers that although the project has the potential to contribute to collective effects and result in population level effects (both over the short and long term), we are unable to anticipate the magnitude of potential response at this time.

Due to the location of the SLC-4 facility in relation to the subject western snowy plover habitat on Surf Beach, western snowy plovers may also experience visual disturbance from launch operations. We expect effects would not be greater than the noise disturbance effects occurring simultaneously as described above. Associated lighting effects are discussed separately above.

Climate effects

Western snowy plovers are vulnerable to the projected effects of climate change with leading threat factors including habitat loss due to sea level rise as well as reduced habitat suitability, nest survival, overwinter survivorship, and quality of nesting and roosting habitats (Service 2019, p. 7). Following a review of recent research on rocket launch and associated returning satellite emissions on the depletion of stratospheric ozone and global climate impacts (Maloney et al. 2022; Ryan et al. 2022; Ferreira et al. 2024), available information indicates that projected increases in rocket launches would have the potential to significantly contribute to these effects. Recent research demonstrates that air pollutants released by rocket launches in the upper atmosphere, their re-entry, and associated space debris, can have a disproportionate effect on global warming (Ryan et al. 2022). Produced modeling demonstrates various scenarios that all indicate rocket produced black carbon would increase stratospheric temperatures, change the global circulation by altering subtropical jet streams, and reduce the total ozone column (Maloney et al. 2022). Researchers anticipate with the current rate of projected rocket launch increases, impacts on the ozone layer have the potential to be substantial. Calculations indicate that after a decade of projected global rocket launch increases, ozone loss in the upper atmosphere would be equivalent to 16 percent of the ozone layer recovery previously achieved (Ryan et al. 2022; EPA 2024).

Considering the potential for increased global temperatures, the western snowy plover may experience variable effects. Recent research indicates that extended cold weather can decrease overwintering populations, with a higher rate of female plover mortality (Stenzel et al. 2023, entire). Current climate projections predict that west coast of California winter weather will experience increasing mean temperatures and substantially fewer instances of anomalously cold weather events which could contribute to the growth of western snowy plover populations (Stenzel et al. 2023, p. 10). Alternatively, climate change induced sea level rise will directly impact the extent and distribution of western snowy plover habitat and is considered to be an effect of much greater magnitude (reviewed in Stenzel et al. 2023, p. 10). Without the specific proposed project's emission analysis that would be needed, the Service uses the defined action area to attempt to minimally speak to potential effects to western snowy plover on VSFB and has reviewed several potential scenarios using sea level rise modeling. The NOAA Sea Level Rise viewer indicates that VSFB is considered to be an area of low vulnerability with respect to the threat of sea level rise (NOAA 2024b). However, under a one-foot sea level rise scenario, approximately 23 acres (13 acres on north base and 10 acres of south base) of the 1,611 available acres of occupied western snowy plover habitat on VSFB could be lost. Under a two-foot sea level scenario, approximately 43 acres (25 acres on north base and 18 acres on south base) of an identified 1,611 available acres of suitable occupied habitat could be lost.

However, the Space Force did not provide any information or analysis regarding upper atmospheric emissions produced by the proposed project. Until the Space Force is able to provide relevant information including project specific emission analysis as required (50 CFR 402.14(c)(1)(iv) to ensure the proposed activity is not likely to jeopardize the continued existence of federally listed species or adversely modify designated critical habitat (7(a)(2)), the Service is unable to further discuss this effect at this time.

Proposed mitigation

In the event of observed population declines (as described in WSPL 2-4), the Space Force would implement proposed mitigation actions for western snowy plover which include predator control in the Predator Management Area (Appendix A, Figure 4B), including trapping, shooting, and tracking known western snowy plover predators with particular focus on raven removal at and adjacent to VSFB beaches. An existing biological opinion (8-8-12-F-11R; Service 2015) analyzes and permits these actions, and the Space Force will implement all required avoidance, minimization, and monitoring measures. The potential mitigation is located within the proposed project's launch noise effect area (Appendix A, Figure 1A and 4B). Consequently, in the event launch noise is found to impact western snowy plover's abundance and distribution, the potential proposed mitigation strategy may not be effective to quantifiable offset observed effects. The Space Force has not yet identified other mitigation actions that they would take to provide assurances of their goal of no net loss at this time. However, the Service considers that the Space Force's commitment to ensure they meet the objectives of the proposed mitigation and are able to clearly demonstrate quantifiably that no net loss in occupied western snowy plover habitat and population size, as stated in the Description of the Proposed Action above, will result from project activities (Kephart, in litt., 2022, p. 3; MSRS 2024a, p. 141). In the event the proposed predator control mitigation alone does not quantifiably demonstrate no net loss, the Space Force will pursue other beneficial actions including recovery opportunities outlined in the western snowy plover recovery plan (Service 2007c) or 5-year review (Service 2019). These actions to reach no net loss criteria will be taken following mutual agreement by the Service and the Space Force to demonstrate they have achieved this goal to be consistent with this analysis.

Launch Operations Effects Off-base – Mainland CA

Western snowy plover occupies the habitat within the Overpressure Effect Areas off-base across eastern Santa Barbara, Ventura, and Los Angeles counties. The western snowy plover in these areas may infrequently experience 10 sonic booms, each separated by an average of 5 days, all of which we expect to be under 1.0 psf between October 1 and December 31. We expect general effects from sonic boom noise to be similar to those discussed above but understand that based on the provided modeling information for the proposed project, any potential effects are unlikely to manifest and would be overall negligible considering the sonic boom's associated noise level magnitude is far lower, of very short duration, is assumed to be comparable to ambient existing noise levels, and would occur relatively infrequently between October 1 to December 31, 2024. Continued monitoring of realized sonic boom and associated noise levels is necessary to ensure these assumptions are correct.

We also understand that the Overpressure Effect Area includes various sonic boom trajectories consisting of a very narrow band across Santa Rosa Island and Santa Cruz Island (Appendix A, Figure 2H). The Space Force has indicated that they anticipate this portion of the Overpressure Effect Area to receive irregular and infrequent disturbance across what we understand is a very small spatial area. We currently do not anticipate effects to overwintering plovers on the Channel Islands due to the very limited spatial extent depicted as well as what we understand should be very infrequent (5 times) and low level (generally under 2 psf) sonic booms. Since initiation of consultation, additional sonic boom modeling information and public testimony exists in relation to sonic booms occurring on the Channel Islands (CCC 2024). However, the Service has not been provided any updated project description information by the Space Force. Consequently, to help clarify, monitoring of realized sonic boom spatial extent and magnitude is necessary in these areas to ensure the Service's understanding of the proposed action and action area are correct.

Regarding off-base climate effects, see discussion above.

Effects on Recovery

Southwestern pond turtle

As previously discussed, the southwestern pond turtle is not listed under the Act; however, it is currently proposed threatened and under federal review for listing under the Act (88 FR 68370). We consequently have not yet developed a recovery plan for southwestern pond turtle to assess its recovery status or how VSFB may factor into such status. However, a peer reviewed species status assessment (Service 2023b) and a range-wide conservation strategy (WPTRWCC 2020) are available for reference. Based on these documents, the recovery of southwestern pond turtle would focus on coordinating strategy implementation efforts, conducting distribution and abundance surveys, identify priority conservation areas, ameliorate and manage identified threats, and carefully consider potential population augmentation.

Temporary adverse effects may occur as a result of the proposed action and include potential impact and degradation of habitat to southwestern pond turtle populations within the near vicinity of VSFB. The proposed project may contribute to potential collective effects that impact southwestern pond turtle abundance and distribution over time. We are unable to anticipate the magnitude of potential effects from increased launch frequency at this time with the available information.

The Space Force will survey and provide both estimates on southwestern pond turtle population levels as well as quantify types of associated southwestern pond turtle habitat within identified impacted major riparian features (SWPT-2) to help meet identified current goals. The Service currently anticipates that the amount of habitat that will temporarily be disturbed relative to the known distribution of the species within its larger range would not result in a substantial reduction in the future recovery of the species if listed. In addition, the Space Force's commitment to enhance southwestern pond turtle habitat at a 2:1 ratio in the event of observed declines will help reduce the magnitude of effects on the species distribution. Although adverse effects are likely to occur as a result of the proposed action, we do not anticipate they will diminish VSFB's anticipated contribution to the recovery of the southwestern pond turtle at this time.

California Red-legged Frog

We do not anticipate the proposed project would interfere with the specific recovery goals for Core Area 24 (Santa Maria-Santa Ynez River) provided in the Service's 2002 recovery plan for the species. Although the function of VSFB major riparian features (e.g. Honda Creek, Bear Creek, and the Santa Ynez River) is not specified within the recovery plan, the recovery plan states the goal of protecting existing California red-legged frog populations within Core Area 24 (Service 2002, p. 75). The Service anticipates that project operations will result in overall temporary habitat degradation from frequent launch disturbance events across a larger portion of occupied California red-legged frog breeding habitat across the vicinity of VSFB and most likely within features including Bear Creek and Honda Creek due to their proximity to SLC-4. The proposed project may contribute to potential collective effects that impact California red-legged frog abundance and distribution over time. We are unable to anticipate the magnitude of potential effects from increased launch frequency at this time with the available information.

However, based on the available information and minimization measures, including potential mitigation and the Space Force's commitment to ensure no net loss to the species, we expect adverse effects to the recovery of California red-legged frogs would be low. Although adverse effects are likely to occur as a result of the proposed action, we do not anticipate they will diminish the VSFB population's contribution to the recovery of the California red-legged frog at this time.

Western Snowy Plover

The proposed project does not include any construction activities and thus will not physically remove any western snowy plover habitat; however, we anticipate that project operations would result in temporary habitat degradation across occupied western snowy plover overwintering habitat, with the highest levels of routine disturbance and degradation associated across Surf Beach. Although potential effects from the novel frequency of proposed launch noise disturbance may occur, we are unable to anticipate the magnitude of potential effects at this time with the available information. With the Space Force's commitment to mitigation actions ensuring no net loss if a population decline is detected, we do not anticipate the proposed action will diminish the VSFB population's contribution to the recovery of the western snowy plover. With this assurance, we do not currently anticipate that the proposed project would interfere with the recovery goals provided in the 2007 recovery plan for the species (Service 2007c, entire).

Summary of Effects

Southwestern pond turtle

In summary, we expect adverse effects to southwestern pond turtle may occur due to the proposed action between October 1 and December 31, 2024. Project elements including firebreak maintenance from SLC-4, flame ducts and vegetation management in Spring Canyon, launch-related byproducts, and engine noise and overpressure from launch operations all have the potential to impact the species. Effects to the species can include direct effects such as mortality and injury, chronic stress, and habitat degradation. The proposed action's launch noise and overpressure effects populations of the species found on and off VSFB.

The Space Force will maintain existing SLC-4 firebreaks and these activities could occur at any time of year. The existing firebreak areas would be unlikely to support nesting or overwintering habitat due to compact soils but assume that they could occur on the periphery of the road edge where vegetation maintenance may occur. Firebreak maintenance may injure or kill overwintering turtles or destroy nests found within the buffers of the road but not likely within the road itself. With our current understanding of southwestern pond turtle distribution and Space Force's avoidance and minimization measures, the Service consequently anticipates associated likelihood of effects would be low.

The Project's associated flame bucket and deluge system may produce temporary high intensity flame and steam that could result in the injury or mortality of any overwintering southwestern pond turtles within Spring Canyon during launch or test fire events. With our current understanding of southwestern pond turtle distribution and Space Force's avoidance and minimization measures, the Service consequently anticipates associated likelihood of effects would be low.

Launch-related soot or other chemical byproducts that come into contact with southwestern pond turtle habitat may affect southwestern pond turtles over the long term through bioaccumulation. However, the Space Force anticipates the amount of soot produced would be diminutive (Kaisersatt, pers. comm., 2022) and that the civil diversion structure and collection of fuel with absorbent pads should reduce potential effects. Using this provided information, the Service consequently assumes associated likelihood of effects would be low.

The Space Force would authorize a maximum of 0.57 acre-feet of water extraction from San Antonio Creek Basin per year to support the project. Using existing hydrological modeling and past discussion with USGS hydrologists for reference, the Service does not anticipate measurable decline in the quality or overall extent of these associated habitats as a result of this extraction at this time.

Project operational noise and overpressure disturbance from routine launching may result in behavioral and physiological responses in overwintering southwestern pond turtle that may be present in the action area. The Service cannot adequately determine the anticipated impacts of how the proposed project's launch disturbance events in combination with the existing launch disturbance baseline from other launch operations in the near vicinity may affect overwintering southwestern pond turtle populations located across base and off-base until the novel effects of the project activity are studied.

Based on the available information and minimization measures, including potential mitigation ensuring no net loss, we expect adverse effects to the recovery of southwestern pond turtles would be low. Although adverse effects are likely to occur as a result of the proposed action, we do not anticipate they will diminish the VSFB population's contribution to the recovery of the southwestern pond turtles at this time.

California Red-legged Frog

In summary, we expect adverse effects to California red-legged frog are likely to occur due to the proposed action. The project's associated flame bucket and deluge system may produce temporary high intensity flame and steam that could result in the injury or mortality of any California red-legged frogs within Spring Canyon during launch or test fire events. Given the previous negative survey findings that followed 11 individual launches, the Space Force will now require a Qualified Biologist to perform one California red-legged frog survey annually during peak breeding season (November to May) in Spring Canyon when individuals are most likely to be present and detectable. Avoidance measures employed during launches should reduce the potential for California red-legged frog death or injury; however, biologists may not detect some individuals during pre-activity surveys resulting in California red-legged frog death or injury. We expect such effects would occur infrequently.

Increased periods of standing water within the flame duct or v-ditch within SLC-4 associated with increased launch frequency may attract California red-legged frog to the area. We expect

California red-legged frog may be injured or killed if attracted to and found within these features as a result of scalding water.

In the event enough soot or other similar launch related byproducts contact dispersing California red-legged frogs or enter adjacent occupied waterbodies, the Service assumes it has the potential to injure or kill California red-legged frogs due to their highly permeable skin and susceptibly to waterborne pollutants (Jung 1996, p. i; Llewelyn et al. 2019, p. 1). However, the Space Force anticipates the amount of soot produced would be diminutive (Kaisersatt, pers. comm., 2022) and that the civil diversion structure and collection of fuel with absorbent pads should reduce potential effects. Using this provided information, the Service consequently assumes associated likelihood of effects would be low.

The Space Force would authorize a maximum of 0.57 acre-feet of water extraction from San Antonio Creek Basin per year to support the project. Using existing hydrological modeling and past discussion with USGS hydrologists for reference, the Service does not anticipate measurable decline in the quality or overall extent of these associated habitats as a result of this extraction at this time.

Project operational lighting, vibration, noise, and overpressure, from routine launching may induce behavioral and physiological responses in California red-legged frog that may be present in the action area. Increased lighting could attract California red-legged frog to SLC-4 and result in increased vehicle strikes. An increase in artificial night lighting may also increase anuran predation rates if predators are able to better detect dispersing adult frogs that may move more in newly lit environments. Using the best available information, the Service does not anticipate launch noise levels would induce routine deafening or physiological effects on California red-legged frog populations within occupied features on base at this time. However, the Service considers that portions of the Space Force's population could experience negative effects from routine exposure to sensory pollutants (vibration, noise, overpressure) and with potential repetitive (chronic) production of stress hormone. In combination with the existing launch baseline on VSFB, the proposed project may contribute to potential long-term effects from chronic stress caused by routine acute launch disturbance across existing launch programs. We are unable to anticipate the potential magnitude of species' response at this time. To help address the need for better information, the Space Force will implement passive bioacoustic monitoring during the California red-legged frog breeding season to characterize calling behavior baseline (bioacoustics baseline) and determine if there are unanticipated changes/response (CRLF-7).

Following review of the effects of the proposed action, the Service anticipates the proposed project is likely to result in the temporary degradation in the quality of adjacent California red-legged frog riparian and upland dispersal habitat due to launch operations and associated sensory pollutants. In the event the Space Force detects an unanticipated decline in California red-legged frog distribution and abundance or changes in call signal characteristic, not directly attributed to other factors (e.g., drought or wildfire), they will implement mitigation actions for California red-legged frog by creating new breeding habitat at a 2:1 ratio (habitat enhanced: habitat affected). The Service considers the Space Force's commitment to ensure they meet the objectives of the proposed mitigation and are able to clearly demonstrate that no net loss in occupied California red-legged frog habitat or population size has resulted from project activities.

Based on the available information and minimization measures, including potential mitigation ensuring no net loss, we expect adverse effects to the recovery of California red-legged frogs would be low. Although adverse effects are likely to occur as a result of the proposed action, we do not anticipate they will diminish the VSFB population's contribution to the recovery of the California red-legged frog at this time.

Western Snowy Plover

In summary, we expect adverse effects to western snowy plover may occur due to the proposed action. Project operational lighting, noise, overpressure disturbance from routine launching between October 1 and December 31, 2024, would degrade occupied overwintering western snowy plover habitat across VSFB with the highest effects expected across Surf Beach. The proposed project has the potential to induce auditory harm as well as behavioral and physiological responses in overwintering western snowy plover that may be present in the action area. The Service cannot adequately determine the magnitude of effects to overwintering western snowy plover populations located across Surf Beach until the novel effects of the project activity are studied. However, with commitment to mitigation actions in place ensuring no net loss if the Space Force detects a population decline, we do not anticipate the proposed action will diminish the VSFB population's contribution to the recovery of the western snowy plover.

CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, tribal, local or private actions that are reasonably certain to occur in the action area considered in this biological opinion. We do not consider future Federal actions that are unrelated to the proposed action in this section because they require separate consultation pursuant to section 7 of the Act. We are unaware of any future State, tribal, local or private actions that are reasonably certain to occur in the action area.

CONCLUSION

The regulatory definition of "to jeopardize the continued existence of the species" focuses on assessing the effects of the proposed action on the reproduction, numbers, and distribution, and their effect on the survival and recovery of the species being considered in the biological opinion. For that reason, we have used those aspects of the California red-legged frog, and western snowy plover as the basis to assess the overall effect of the proposed action on the species.

This conclusion includes our conference opinion addressing proposed southwestern pond turtle. Regulations allow for an opinion issued at the conclusion of a conference to be adopted as a biological opinion when the species is listed or critical habitat is designated, but only if no significant new information is developed (including that developed during the rulemaking process on the proposed listing or critical habitat designation) and no significant changes to the Federal action are made that would alter the content of the opinion (50 CFR 402.10(d)).

Our conclusions are contingent on the implementation of the project as described in this biological opinion, including the implementation of the proposed monitoring and mitigation plan. If the applicant fails to implement these plans as described in this biological opinion or is otherwise unable to offset declines to listed species consistent with management plan intent within timeframes specified in the terms and conditions of this document, we will consider this conclusion invalid.

Southwestern pond turtle

Reproduction

The proposed project would not result in the physical loss of southwestern pond turtle breeding habitat. However, the Service anticipates that the proposed project would constitute temporary degradation of southwestern pond turtle habitat across VSFB, particularly in features most adjacent to SLC-4 including Bear Creek, Honda Creek, and portions of the Santa Ynez River due to sensory pollutants (e.g., noise, overpressure, and potential for vibration) associated with the proposed action’s increase in launch operations. Until the novel effects of the project activity are studied, the Service is unable to anticipate the specific response at this time using available information. If the proposed project’s increased launch frequency demonstrates declines from established population baselines across riparian features, the Space Force will implement mitigation as described at the San Antonio Creek Oxbow Restoration expansion area to ensure no net loss in southwestern pond turtle occupied breeding habitat and overall population size. We expect the Space Force will demonstrate successful colonization and breeding within the San Antonio Creek Oxbow Restoration expansion area to offset potential project impacts at a 2:1 ratio. Should the Oxbow Restoration site not meet mitigation requirements depicted in the project description, we expect that the Space Force will implement other recovery objectives coordinated with the Service that quantifiably demonstrate no net loss to be consistent with this effects analysis. We consequently conclude that the proposed project would not reduce overall southwestern pond turtle reproduction on VSFB or rangewide.

Numbers

We are unable to determine the exact number of southwestern pond turtles that could occur in the action area that the proposed project may affect because existing survey data are insufficient to estimate population numbers. Proposed project activities could affect individual southwestern pond turtles by injury or death. Project operations may result in routine stress on southwestern pond turtle populations within Honda Creek, Bear Creek, and portions of the Santa Ynez River that may reasonably cause sublethal effects that lead to gradual decline over the long term. Until the novel effects of the project activity are studied, the Service is unable to anticipate the specific response at this time using available information. The number of southwestern pond turtles that the proposed activities may affect is unknown, but the Service anticipates would likely constitute a moderate portion of the total VSFB population. However, we assume this number would be relatively small across the entirety of the species' range. Additionally, if the proposed project's increased launch frequency demonstrates a reduction in southwestern pond turtle numbers the Space Force will implement mitigation as described at the San Antonio Creek Oxbow Restoration expansion area to ensure no net loss in southwestern pond turtle abundance. Should the Oxbow Restoration site not quantifiably meet mitigation requirements depicted in the project description, we expect that the Space Force will implement other recovery objectives coordinated with the Service that quantifiably demonstrate no net loss to be consistent with this effects analysis. Therefore, we conclude that the proposed project would not appreciably reduce the number of southwestern pond turtles on VSFB or rangewide.

<u>Distribution</u>

The proposed project would likely constitute temporary degradation of occupied aquatic and terrestrial southwestern pond turtle habitat across Vandenberg, particularly within features adjacent to SLC-4 including Honda Creek, Bear Creek, and the Santa Ynez River due to sensory pollutants (e.g., noise, overpressure, potential vibration) associated with the proposed action's operations. Until the novel effects of the project activity are studied, the Service is unable to anticipate specific species' response at this time using available information. If the proposed project's increased launch frequency demonstrates a reduction in species abundance and distribution in these features, the Space Force indicates they will implement mitigation as described at the San Antonio Creek Oxbow Restoration expansion area to ensure no net loss in occupied habitat. However, the proposed mitigation site is in north base, over ten miles from Honda Creek. The Space Force has not identified other locations of mitigation activities that may contribute to the Space Force's goal of no net loss at this time. Consequently, in the event the proposed project results in reduced occupation of southwestern pond turtles within Honda Creek, Bear Creek, or the Santa Ynez River, this may constitute a large reduction in the overall distribution of the species across south base and across the entire VSFB population. However, any observed reduction would not appreciably reduce the distribution rangewide. We consequently conclude that the proposed project may reduce southwestern pond turtle distribution in the action area and across VSFB but would not appreciably reduce distribution rangewide.

<u>Recovery</u>

The southwestern pond turtle is not currently listed under the Act; however, it is currently proposed threatened and under federal review for listing under the Act (88 FR 68370). We consequently have not yet developed a recovery plan for southwestern pond turtle to assess its recovery status or how VSFB may factor into such status. Using the available information and considering minimization measures, including mitigation ensuring no net loss, we expect adverse effects to the recovery of southwestern pond turtles on VSFB would be low. We expect the Space Force will demonstrate successful implementation and subsequent species abundance within the San Antonio Creek Oxbow Restoration expansion area to offset impacts. Should the Oxbow Restoration site not meet mitigation requirements depicted in the project description, we expect that the Space Force will implement other recovery objectives coordinated with the Service that quantifiably demonstrate no net loss to be consistent with this effects analysis. Therefore, we conclude that the proposed action would not appreciably reduce the likelihood of recovery of the southwestern pond turtle on VSFB or rangewide.

Conclusion

After reviewing the current status of the southwestern pond turtle, the environmental baseline for the action area, the effects of the proposed action and the cumulative effects, it is the Service's biological opinion that the action, as proposed, is not likely to jeopardize the continued existence of the southwestern pond turtle, because:

1. We anticipate that project effects could reduce the reproductive success of southwestern pond turtles at the local population level. However, the Space Force's commitment to monitor and mitigate reductions of individuals to meet their proposed goal of no net loss, the project would not appreciably reduce numbers of the southwestern pond turtles locally across VSFB or rangewide.
2. We anticipate that project effects could reduce the number of southwestern pond turtles at the local population level. However, the Space Force's commitment to monitor and mitigate reductions of individuals to meet their proposed goal of no net loss, the project would not appreciably reduce numbers of the southwestern pond turtles locally across VSFB or rangewide.
3. The project has the potential to reduce the species' distribution locally across VSFB but is not anticipated to appreciably reduce the distribution rangewide.
4. Although a recovery plan for southwestern pond turtle does not exist yet, we do not anticipate the proposed project would interfere with likely recovery objectives because of the Space Force's commitment to monitor and mitigate reductions of individuals to meet their proposed goal of no net loss. Consequently, the project would not cause any effects that would appreciably preclude our ability to recover the species.

California Red-legged Frog

Reproduction

The proposed project would not result in the physical loss of California red-legged frog breeding habitat. However, the proposed project may constitute routine degradation of breeding habitat across the action area, particularly within features adjacent to SLC-4 including Bear Creek, Honda Creek, and portions of the Santa Ynez River due to sensory pollutants (e.g., lighting, noise, overpressure, and potential for vibration) associated with the proposed action's increase in launch operations. Until the novel effects of the project activity are studied, the Service is unable to anticipate the specific response at this time using available information. If the proposed project's increased launch frequency demonstrates a reduction in reproductive success, the Space Force has indicated that they will implement mitigation as described at the San Antonio Creek Oxbow Restoration expansion area to ensure no net loss in California red-legged frog occupied breeding habitat and overall population size. We expect the Space Force will demonstrate successful colonization and breeding within the San Antonio Creek Oxbow Restoration expansion area to offset potential project impacts at a 2:1 ratio. Should the Oxbow Restoration site not meet mitigation requirements depicted in the project description, we expect that the Space Force will implement other recovery objectives coordinated with the Service that quantifiably demonstrate no net loss to be consistent with this effects analysis. We consequently conclude that the proposed project would not reduce overall California red-legged frog reproduction on VSFB, in the Northern Transverse Ranges and Tehachapi Mountains Recovery Unit, or rangewide.

Numbers

We are unable to determine the exact number of California red-legged frogs that could occur in the action area that the proposed project may affect because existing survey data are insufficient to estimate population numbers, and the numbers of individuals in the action area likely vary from year to year. Proposed project activities could affect individual California red-legged frogs to the point of injury or death. Project operations may result in routine stress on the California red-legged frog population in the action area, particularly within Honda Creek, Bear Creek, and portions of the Santa Ynez River. Although the proposed project would only occur between October 1 and December 31, 2024, in combination with the existing baseline, it may contribute to cumulative sublethal effects that cause decline over the longer term. Until the novel effects of the project activity are studied, the Service is unable to anticipate the specific response at this time using available information. The number of California red-legged frogs that the proposed activities may affect would likely constitute a moderate portion of the total VSFB population. However, we assume this number would be relatively small across the entirety of the species' range. Additionally, if the proposed project's increased launch frequency demonstrates a reduction in California red-legged frog numbers the Space Force will implement mitigation as described at the San Antonio Creek Oxbow Restoration expansion area to ensure no net loss in California red-legged frog abundance. We expect the Space Force will demonstrate successful colonization and subsequent species abundance within the San Antonio Creek Oxbow Restoration expansion area to offset impacts. Should the Oxbow Restoration site not meet mitigation requirements depicted in the project description, we expect that the Space Force will implement other recovery objectives coordinated with the Service that quantifiably demonstrate no net loss to be consistent with this effects analysis. Therefore, we conclude that the proposed project would not appreciably reduce the number of California red-legged frog on VSFB, in the Northern Transverse Ranges and Tehachapi Mountains Recovery Unit, or rangewide.

Distribution

The Service anticipates that proposed project would constitute routine degradation of occupied aquatic California red-legged frog habitat across the action area, particularly within Honda Creek, Bear Creek, and the Santa Ynez River due to sensory pollutants (e.g., lighting, noise, overpressure, potential vibration) associated with the proposed action's operations. Until the novel effects of the project activity are studied, the Service is unable to anticipate specific response in potential distribution of California red-legged frog at this time using available information. If the proposed project's increased launch frequency demonstrates a reduction in species abundance and distribution in these features, the Space Force indicates they will implement mitigation as described at the San Antonio Creek Oxbow Restoration expansion area to ensure no net loss in occupied habitat. However, the proposed mitigation site is in north base, over ten miles from Honda Creek. The Space Force has not identified other locations of mitigation activities that may contribute to the Space Force's goal of no net loss at this time. Consequently, in the event the proposed project results in reduced occupation of California red-legged frog within Honda Creek, Bear Creek, or the Santa Ynez River, this may constitute a large reduction in the overall distribution of the species across south base and across the VSFB population as a whole. We do not anticipate that any observed reduction would appreciably reduce the distribution across the Northern Transverse Ranges and Tehachapi Mountains Recovery Units, or rangewide. We consequently conclude that the proposed project may reduce California red-legged frog distribution in the action area and across VSFB but would not appreciably reduce distribution within the Northern Transverse Ranges and Tehachapi Mountains Recovery Unit, or rangewide.

Recovery

We do not anticipate that the proposed project would interfere with the specific recovery goals for Core Area 24 (Santa Maria-Santa Ynez River) provided in the Service's 2002 recovery plan for the species. Although the function of select features within the proposed action area including Bear Creek, Honda Creek, and the Santa Ynez River are not specified, the recovery plan states the goal of protecting existing California red-legged frog populations within Core Area 24 (Service 2002, p. 75). Using the available information and considering minimization measures, including potential mitigation ensuring no net loss, we expect adverse effects to the recovery of California red-legged frogs on VSFB would be low. We expect the Space Force will demonstrate successful colonization and subsequent species abundance within the San Antonio Creek Oxbow

Restoration expansion area to offset impacts. Should the Oxbow Restoration site not meet mitigation requirements depicted in the project description, we expect that the Space Force will implement other recovery objectives coordinated with the Service that quantifiably demonstrate no net loss to be consistent with this effects analysis. Therefore, we conclude that the proposed action would not appreciably reduce the likelihood of recovery of the California red-legged frog on VSFB, in the Northern Transverse Ranges and Tehachapi Mountains Recovery Unit, or rangewide.

Conclusion

After reviewing the current status of the California red-legged frog, the environmental baseline for the action area, the effects of the proposed action and the cumulative effects, it is the Service's biological opinion that the action, as proposed, is not likely to jeopardize the continued existence of the California red-legged frog, because:

1. We anticipate that project effects could reduce the reproductive success of California red-legged frogs at the local population level. However, the Space Force's commitment to monitor and mitigate reductions of individuals to meet their proposed goal of no net loss, the project would not appreciably reduce numbers of the California red-legged frog locally across VSFB, or rangewide.
2. We anticipate that project effects could reduce the number of California red-legged frogs at the local population level. However, the Space Force's commitment to monitor and mitigate reductions of individuals to meet their proposed goal of no net loss, the project would not appreciably reduce numbers of the California red-legged frog locally across VSFB, or rangewide.
3. The project has the potential to reduce the species' distribution locally across VSFB but is not anticipated to appreciably reduce the distribution rangewide.
4. We do not anticipate the proposed project would interfere with the specific recovery goals for Core Area 24 because of the Space Force's commitment to monitor and mitigate reductions of individuals to meet their proposed goal of no net loss. Consequently, the project would not cause any effects that would appreciably preclude our ability to recover the species.

Western Snowy Plover

Reproduction

The proposed project would not result in the physical loss of western snowy plover habitat. However, the Service anticipates that the proposed project would constitute routine degradation of overwintering habitat across the action area, particularly within Surf Beach due to sensory pollutants (e.g., lighting, noise, overpressure) associated with the proposed action's increase in launch operations. Until the novel effects of the project activity are studied, the Service is unable to anticipate the specific response to western snowy plover breeding success at this time using available information. The proposed project is occurring outside of the species' breeding period and consequently the Service does not anticipate impacts to the reproductive success of the species at this time. Consequently, we do not anticipate the proposed action will appreciably reduce the reproductive capacity of western snowy plover populations locally on VSFB or rangewide.

Numbers and Distribution

VSFB constitutes nearly 25 percent of western snowy plover in RU5 and approximately 10 percent of the western snowy plover population rangewide. Additional information and analysis are needed to understand how western snowy plover populations may be impacted over the overwintering season and over time as a result of habitat degradation associated with the proposed project's novel disturbance frequency. The Service also considers that Space Force's proposed western snowy plover mitigation (increased predator control), if triggered, would be implemented within the impacted area and may not serve to effectively preclude overall changes in species distribution. In the event the proposed project results in reduced occupation of western snowy plover at South Surf Beach, this could constitute a reduction in the overall distribution of the species across south base and across the VSFB population. The Space Force has not identified other locations of mitigation activities that may contribute to the Space Force's goal of no net loss at this time. However, with the Space Force's commitment to implementing mitigation actions ensuring no net loss in place, any observed reduction would not appreciably reduce the numbers or distribution within RU5 or rangewide. We consequently conclude that the proposed project may reduce western snowy plover distribution in the action area and across VSFB, but we do not anticipate the proposed action will appreciably reduce the numbers or distribution of western snowy plover populations within RU5 or rangewide.

Recovery

Due to both the numbers of western snowy plover and quantity of habitat supported, VSFB plays a critical role in the species' recovery. We anticipate that project operations would result in temporary habitat degradation across occupied western snowy plover overwintering habitat, with the highest levels of routine disturbance and degradation associated with Surf Beach adjacent to SLC-4. Although potential effects from the novel frequency of proposed launch noise disturbance may occur, we are unable to anticipate the magnitude of effects at this time with the available information. However, with the Space Force's commitment to mitigation actions ensuring no net loss if a population decline is detected, we do not anticipate the proposed action will diminish the VSFB population's contribution to the recovery of the western snowy plover at this time. With this assurance, we do not currently anticipate that the proposed project would interfere with the recovery goals provided in the 2007 recovery plan for the species (Service 2007c, entire).

Conclusion

After reviewing the current status of the western snowy plover, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is the Service's biological opinion that the action, as proposed, is not likely to jeopardize the continued existence of the western snowy plover, because:

1. We do not anticipate that this project would reduce the reproductive success of western snowy plover at the local population level given that the proposed project would occur outside of the breeding season. Consequently, the project would not appreciably reduce the reproductive success of the western snowy plover locally across VSFB, or rangewide.
2. We anticipate that project effects could reduce the number of western snowy plover at the local population level. However, the Space Force's commitment to monitor and mitigate reductions of individuals to meet their proposed goal of no net loss, the project would not appreciably reduce numbers of the western snowy plover locally across VSFB, or rangewide.
3. The project may reduce the species' distribution locally across VSFB but is not anticipated to appreciably reduce the distribution in RU5 or rangewide.
4. We do not anticipate the proposed project would interfere with the specific recovery goals for western snowy plover at this time because of the Space Force's commitment to monitor and mitigate reductions of individuals to meet their proposed goal of no net loss. Consequently, the project would not cause any effects that would appreciably preclude our ability to recover the species.

INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered and threatened wildlife species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Harass" means an "intentional or negligent act or omission which creates [a] likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering" (50 CFR. 17.3). Harm in the definition of "take" in the Act means an act which actually kills or injures wildlife. Such [an] act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering (50 CFR 17.3). Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not the purpose of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this incidental take statement and occurs as a result of the action as proposed. Being that section 9 of the Act does not prohibit take of proposed or candidate animal species, an incidental take statement provided with a conference opinion does not become effective unless the Service adopts the opinion once the listing is final (50 CFR 402.10(d)).

AMOUNT OR EXTENT OF TAKE

Southwestern pond turtle

We anticipate that some southwestern pond turtle could be taken as a result of the proposed action. We expect the incidental take to be in the form of capture, injury, harass, harm and mortality and the associated degradation of suitable habitat resulting from increased frequency of launch disturbance. We cannot quantify the precise number of southwestern pond turtle that may be taken as a result of the actions that Space Force has proposed because southwestern pond turtle move over time; for example, animals may have entered or departed the action area since the time of pre-construction surveys. The protective measures proposed by Space Force are likely to prevent direct mortality or injury of most individuals during launch operations at SLC-4. In addition, finding a dead or injured southwestern pond turtle is unlikely. Consequently, we are unable to reasonably anticipate the actual number of southwestern pond turtle that would be taken by the proposed project; however, we must provide a level at which formal consultation would have to be reinitiated. The Environmental Baseline and Effects Analysis sections of this biological opinion indicate that adverse effects to southwestern pond turtle would likely be low given the species is anticipated to be overwintering during proposed project activities with unknown but potential moderate abundance in the near vicinity of SLC-4 (e.g. Honda Creek, Bear Creek, Santa Ynez River and Jalama Creek). We, therefore, anticipate that take of southwestern pond turtle may also be low. We also recognize that for every southwestern pond turtle found dead or injured, other individuals may be killed or injured that are not detected, so when we determine an appropriate take level, we are anticipating that the actual take would be higher, and we set the number below that level.

Similarly, for estimating the number of southwestern pond turtle that would be taken by capture, we cannot predict how many may be encountered for reasons stated earlier. While the benefits of relocation (i.e., minimizing mortality) outweigh the risk of capture, we must provide a limit for take by capture at which consultation would be reinitiated because high rates of capture may indicate that some important information about the species in the action area was not apparent (e.g., it is much more abundant than thought). Conversely, because capture can be highly variable, depending upon the species and the timing of the activity, we do not anticipate a number so low that reinitiation would be triggered before the effects of the activity were greater than what we determined in the Effects Analysis.

Therefore, the Space Force must contact our office immediately to reinitiate formal consultation if they observe any of the following scenarios during Launch Operations (Table 5):

i. The southwestern pond turtle established baseline (SWPT-1) is 15 or more individuals across an individual feature and a greater than 20 percent (up to 8 individuals) decline from baseline is observed during the proposed project.

ii. The southwestern pond turtle established baseline (SWPT-1) is less than 15 individuals and a greater than 25 percent decline from baseline is observed during the proposed project;
iii. Two individuals (adult or juvenile) or one nest of southwestern pond turtle are found killed, wounded, or destroyed over the course of operations;
iv. and/or five individuals (adult or juvenile) or one nest of southwestern pond turtle are relocated over the course of operations.

Project activities that are likely to cause additional take should cease as the exemption provided pursuant to section 7(o)(2) may lapse and any further take could be a violation of section 4(d) or 9.

Table 5. Summary of incidental take for the southwestern pond turtle life stages during Launch Operations of the proposed project.

Life Stage	***Quantity during Operations***	***Type of Take***
Adults or juveniles (Within Honda Creek, Bear Creek, Jalama Creek, or Santa Ynez River)	Scenario 1- If the Established Baseline* is greater than 15 individuals: 20% decline (up to 8 individuals) from established baseline during proposed project. OR Scenario 2 – If the Established Baseline* is less than 15 individuals: 25% decline from established baseline during proposed project.	Habitat modification disrupting sheltering/breeding
Adults or juveniles	2 during project operations	Killed or wounded (including during capture and relocation)
Nest	1 during project operation	Killed or wounded (including during capture and relocation)
Adults or juveniles	5 during project operation	Captures and relocation
Nest	1 during project operation	Relocation

*Established Baseline within monitoring plan described in SWPT-2 for each unique major riparian feature.

California Red-legged Frog

We anticipate that some California red-legged frogs could be taken as a result of the proposed action. We expect the incidental take to be in the form of capture, injury, harass, harm and mortality and associated degradation of suitable habitat resulting from increased frequency of launch disturbance. We cannot quantify the precise number of California red-legged frogs that may be taken as a result of the actions that Space Force has proposed because California red-legged frogs move over time; for example, animals may have entered or departed the action area since the time of pre-construction surveys. The protective measures proposed by Space Force are likely to prevent direct mortality or injury of most individuals during launch operation at SLC-4. In addition, finding a dead or injured California red-legged frog is unlikely. Consequently, we are unable to reasonably anticipate the actual number of California red-legged frogs that would be taken by the proposed project; however, we must provide a level at which formal consultation would have to be reinitiated. The Environmental Baseline and Effects Analysis sections of this biological opinion indicate that adverse effects to California red-legged frog may be moderate given the potential for moderate abundance of California red-legged frog in the near vicinity of SLC-4 (e.g. Honda Creek, Bear Creek, Santa Ynez River and Jalama Creek). We, therefore, anticipate that take of California red-legged frogs may also be moderate. We also recognize that for every California red-legged frog found dead or injured, other individuals may be killed or injured that are not detected, so when we determine an appropriate take level, we are anticipating that the actual take would be higher, and we set the number below that level.

Similarly, for estimating the number of California red-legged frog that would be taken by capture, we cannot predict how many may be encountered for reasons stated earlier. While the benefits of relocation (i.e., minimizing mortality) outweigh the risk of capture, we must provide a limit for take by capture at which consultation would be reinitiated because high rates of capture may indicate that some important information about the species in the action area was not apparent (e.g., it is much more abundant than thought). Conversely, because capture can be highly variable, depending upon the species and the timing of the activity, we do not anticipate a number so low that reinitiation would be triggered before the effects of the activity were greater than what we determined in the Effects Analysis.

Therefore, the Space Force must contact our office immediately to reinitiate formal consultation if they observe any of the following scenarios during Launch Operations (Table 6):

i. The California red-legged frog established baseline (CRLF-5ai) is 15 or more individuals across an individual feature and a greater than 20 percent (up to 8 frogs) decline from baseline is observed during the proposed project.
ii. The California red-legged frog established baseline (CRLF-5ai) is less than 15 individuals and a greater than 25 percent decline from baseline is observed during the proposed project;
iii. Two adult or juvenile California red-legged frogs are found killed or wounded over the course of operations;
iv. and/or 10 adults or juveniles are captured and relocated over the course of operations.

Project activities that are likely to cause additional take should cease as the exemption provided pursuant to section 7(o)(2) may lapse and any further take could be a violation of section 4(d) or 9.

Table 6. Summary of incidental take for the California red-legged frog life stages during Launch Operations of the proposed project.

Life Stage	***Quantity during Operations***	***Type of Take***
Adults or juveniles (Within Honda Creek, Bear Creek, Jalama Creek, or Santa Ynez River)	Scenario 1- If the Established Baseline* is greater than 15 individuals: 20% decline (up to 8 frogs) from established baseline during proposed project. OR Scenario 2 – If the Established Baseline* is less than 15 individuals: 25% decline from established baseline during proposed project.	Habitat modification disrupting sheltering/breeding
Adults or juveniles	2 during proposed project	Killed or wounded (including during capture and relocation)
Adults or juveniles	10 during proposed project	Captures and relocation

*Established Baseline within monitoring plan described in CRLF-5ai for each unique major riparian feature.

Western Snowy Plover

We anticipate that all western snowy plovers present in the action area could be harassed as a result of the proposed action. We expect the incidental take to be in the form of injury if project operations annoys or disturbs the species to a degree that results in changes to overwintering behavior patterns including sheltering and feeding; physiological responses that result in bodily injury; and associated degradation of suitable overwintering habitat resulting from increased frequency of launch disturbance. We cannot quantify the precise number of individuals that may be taken due to fluctuations in population. Take may rise to a statistically significant level of decreased western snowy plover overwintering occupancy from the established baseline across the entirety of Surf Beach. If the Space Force observes a statistically significant decline from baseline (WSPL-2), proposed mitigation efforts would need to be effective in quantifiably offsetting the impact to result in no net loss to the species to be considered consistent with this analysis.

However, in the event that mitigation efforts are not successful, the Space Force must contact our office immediately to reinitiate formal consultation if they observe the following scenario:

i. The Space Force observes a 10 percent reduction in the abundance, spatial distribution, or occupancy time of overwintering adults across South VSFB Beaches when compared to the 10-year established baseline (see Term and Condition #11b below; WSPL-1) across the duration of the proposed project that are unrelated to defined scenarios in WSPL-3.

Project activities that are likely to cause additional take should cease as the exemption provided pursuant to section 7(o)(2) may lapse and any further take could be a violation of section 4(d) or 9.

REASONABLE AND PRUDENT MEASURES

The measures described below are non-discretionary and must be undertaken by the Space Force or made binding conditions of any grant or permit issued to the applicant, as appropriate, for the exemption in section 7(o)(2) to apply. The Space Force has a continuing duty to regulate the activity covered by this incidental take statement. If the Space Force (1) fails to assume and implement the terms and conditions or (2) fails to require the applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. To monitor the impact of incidental take, the Space Force must report the progress of the action and its impact on the species to the Service as specified in the incidental take statement [50 CFR 402.14(i)(3)]. Pursuant to 402.14(i)(2-3), reasonable and prudent measures may include measures implemented inside or outside of the action area that avoid, reduce, or offset the impact of incidental take.

The Service believes the following reasonable and prudent measures are necessary and appropriate to minimize the impacts of the incidental take of southwestern pond turtle, California red-legged frog, and western snowy plover:

1. The Space Force must ensure that biologists used for survey, monitoring, training, and capture and relocation tasks are skilled and experienced.
2. The Space Force must reduce potential for injury or mortality of southwestern pond turtles, California red-legged frogs, and western snowy plovers.
3. The Space Force must monitor and communicate effects to ensure they are consistent with this analysis.
4. The Space Force must offset or require the project proponent to offset all impacts of the take on the western snowy plover, California red-legged frog, and southwestern pond turtle inside the action area.

TERMS AND CONDITIONS

To be exempt from the prohibitions of section 9 of the Act, the Space Force must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline reporting and monitoring requirements. These terms and conditions are non-discretionary.

The following term and condition implement reasonable and prudent measure 1:

1. The Space Force must request Service approval of any biologist who will conduct activities related to this biological opinion at least 30 days prior to any such activities

being conducted. The Space Force must use the Biologist Authorization Request Field Experience Tracking Form (Appendix B) and provide biologist resumes listing their experience and qualifications to conduct specific actions that could potentially affect listed species and their habitats). A Qualified Biologist(s) is more likely to reduce adverse effects based on their expertise with the covered species. Please be advised that possession of a 10(a)(1)(A) permit for the covered species does not substitute for the implementation of this measure. Authorization of Service Approved Biologists is valid for this consultation only.

The following terms and conditions implement reasonable and prudent measure 2:

2. As a part of the prepared lighting management plan for SLC-4 (GM-10), the Space Force must consult with a lighting specialist (e.g. designated by the Illuminating Engineering Society of North America or the U.S. Green Building Council) to ensure light pollution is minimized to the maximum degree possible. Best management practices must include using the minimum number of lumens to accomplish lighting needs. The Space Force must also reduce the effects of ultraviolet lighting on California red-legged frogs on all external permanent site lighting. To accomplish this, the Space Force may choose lighting with either no ultraviolet emissions or equip fixtures with an ultraviolet filter on external permanent site lighting. These actions will help avoid attracting insects and subsequent California red-legged frog individuals to SLC-4 (refer to Longcore and Rich 2017).
3. In addition to GM-8 (Vegetation clearance), the Space Force must schedule any routine vegetation clearance or firebreak maintenance to occur at least 48 hours outside of forecasted and realized precipitation events (greater than 0.25 inch during a 24-hour period according to National Weather Service 72- hour forecast) to help reduce potential for injury for dispersing California red-legged frog and southwestern pond turtle.
4. If southwestern pond turtle nests or overwintering individuals are found during clearance surveys of SLC-4 firebreak maintenance or Spring Canyon vegetation maintenance, and the individuals and nests are not in threat of being destroyed, injured, or killed, then a 100-foot buffer around nests and overwintering individuals must be enforced. If any overwintering individual or nest is in threat of being destroyed, injured, or killed, then the individual or nest must be relocated in coordination with the Service. If a location for nest relocation cannot be identified, then the Space Force must work with the Service to find partners able to safekeep the nest until overwintering season is over. The Space Force must immediately communicate with the Service in the event that buffers are enforced and prior to any necessary relocation.
5. To minimize potential injury and mortality to California red-legged frog and southwestern pond turtle during any v-ditch maintenance activities, the Space Force must require a biologist first survey the feature and subsequently monitor work activities to relocate individuals of these species found.

6. To reduce potential injury of southwestern pond turtle during potential future restoration work which may use herbicide products, the Space Force must adhere to the following measures:
    a. The Space Force must only use chemical control of invasive plants when other methods are determined to be ineffective or would create greater environmental impacts than chemical control. The Space Force must evaluate herbicide use on a project-by-project basis with consideration of (and preferences given towards) integrated pest strategies whenever possible to minimize potential impacts.
    b. The Space Force must require that 30 CES/CEIEA staff familiar with southwestern pond turtle biology review and approve all individual chemicals to be used within suitable habitat. When developing proposed restoration projects, the Space Force must consider all potential for exposure pathways of any chemical product and associated degradation products to occupied species' habitat including but not limited to product persistence and mobility within various soil types. If working within the vicinity of occupied aquatic habitat, the Space Force must use products demonstrated to have low mobility and are considered to be non-toxic or practically non-toxic to aquatic species. If using glyphosate, the Space Force must either use this product without a surfactant or with a non-POEA surfactant like AgriDex®.
    c. The Space Force must not apply herbicides/pesticides within 48 hours of a predicted (greater than 50 percent chance forecast) significant rain event (0.25 inch or greater with 24-hour period). The National Weather Service 72-hour forecast must be consulted for the project area.
    d. The Space Force must follow all chemical label specifications and adhere to best management practices identified by the California Invasive Plant Council (Cal-IPC 2015). Marker dyes must be utilized in all herbicide mixtures so workers can readily see spills, drift, or misapplication. To avoid chemical drift, no foliar spray applications may be conducted when wind speeds exceed 12-mph. Foliar spray applications must use directed sprayers with low-pressure, large droplet nozzles (Cal-IPC 2015).
    e. The Space Force must require that personnel conducting herbicide treatments possess a current qualified applicator license.

The following terms and conditions implement reasonable and prudent measure 3:

7. The Space Force must provide or require the project proponent to provide adequate funding and support staff to implement the following monitoring requirements. Determination of supporting staff needs will be at the discretion of 30 CES.
8. The Space Force must continue monitoring experienced noise and sonic boom levels within consistent monitoring locations both on VSFB and previously established off base areas of mainland California to ensure realized levels of each static fire, launch, and boost-back are consistent with what was considered within this analysis. Monitoring locations must include Surf Beach, Honda Creek, Bear Creek, Santa Ynez River, and

Jalama Creek as well as Santa Rosa and Santa Cruz Islands. This information must be included in a clear table in the final report and include psf to SPL_{max} conversions whenever applicable.

9. The Space Force must implement light monitoring at SLC-4 and surrounding habitat to ensure light pollution effects are consistent with this analysis. The Space Force must use a sky-quality camera (e.g. GONet) to collect anticipated sky-glow light data produced by the proposed project. Monitoring specifics must include the following:
    a. The Space Force must establish 2 monitoring locations within open California red-legged frog transitory habitat 100 feet from SLC-4 and 2 monitoring locations within Surf Beach (one in South Surf Beach and one in North Surf Beach)
    b. The Space Force must collect lighting data during hours of darkness during i) the first 2 weeks of normal project operations at SLC-4; ii) 3-night launches and; ii) 2-night launches with boost-back landing (if these occur during the proposed project). Associated weather data (e.g. fog) must also be provided during associated monitoring events.
    c. The Space Force must provide collected lighting data to the Service as soon as it becomes available and summarize all findings in the Annual report.

    The Service can provide lighting specialist contacts to help establish this monitoring program to ensure monitoring design meets requirements. A description of light monitoring program will be provided to the Service before the start of the proposed project.
10. The Space Force must implement vibration monitoring to ensure effects to California red-legged frog and southwestern pond turtle are consistent with assumptions made in this analysis. Vibration monitoring specifics must include the following:
    a. Vibration data logger sensors (similar to those used at standard construction sites) must be placed in the following locations: i) Spring Canyon ii) Bear Creek directly adjacent to suitable California red-legged frog breeding habitat, and iii) San Antonio Creek adjacent to the Oxbow restoration site.
    b. At each location, a sensor must be placed above ground as well as below ground (at 1 foot depth) to ensure vibratory impacts to aestivating California red-legged frog and southwestern pond turtle are not occurring.
    c. Vibration monitoring must occur during at least 3 individual launches as well as during the 2 launches with boost-backs. Launch ascents during boost-back events can be used to meet the 3-launch requirement.
    d. The Space Force must provide collected vibration data to the Service as soon as it becomes available and summarize all findings in the Annual report.
11. To determine whether sound levels from the proposed project are causing auditory harm to western snowy plover populations on Surf Beach, the Space Force must establish a controlled monitoring design to help determine realized effects. The monitoring design may involve the use of non-native avian surrogates exposed to realized or simulated launch noise compared to control conditions. Additionally, the Space Force must coordinate with researchers that have previous experience with examining hair cell loss in avian basilar papilla (e.g. Stone and Rubel 2000; Dooling et al. 2008; Sato et al. 2024,

etc.) and review monitoring design with the Service to be completed prior to 2025. The Space Force must also provide the results of the aforementioned western snowy plover communication study (Govtribe 2024; Miller 2024) to help determine whether hearing loss and communication impacts may be occurring as soon as those results are available.

12. As stated in GM-1, the Space Force must sample water quality in lower Spring Canyon once annually whenever ponded water is present to ensure no project related byproducts (i.e., launch combustion residue, operations-related run-off, etc.) have entered the waterway in a manner not previously considered in this analysis. In the event that water does not adequately pond to collect a sample, the Space Force must instead conduct soil sampling to achieve the intent of this measure. If the Space Force finds that project related water or soil contamination has occurred, the Space Force must coordinate with the Service, address sources of input, and remediate within 30 days.
13. Monitoring/Mitigation Plan:
    a) The Space Force must develop a proposed monitoring plan (CRLF-5, SWPT-1 and 2, WSPL-1) as it relates Falcon-9 operation at SLC-4 across this three-month project. Monitoring activities must be conducted between October 1 and December 31, 2024, will, at a minimum, include the following:
        1. Noise ground truthing monitoring as described in Term and Condition 8;
        2. Light monitoring as described in Term and Condition 9;
        3. Vibration monitoring as described in Term and Condition 10;
        4. Full development of auditory harm monitoring design depicted in Term and Condition 11;
        5. Water quality (or soil) sampling monitoring as described in Term and Condition 12;
        6. Proposed California red-legged frog surveys and monitoring (CRLF-4 to 7 with required control reference site) which can occur during the breeding season;
            i. California red-legged frog bioacoustics monitoring: As part of the proposed monitoring plan, the Space Force must include the California red-legged frog bioacoustics monitoring design. The Space Force must ensure that bioacoustic monitoring conducted is designed to best address confounding factors in order to appropriately characterize potential impacts of launch, static fire, and SLC-4W landing events on calling behavior. Being that the bioacoustics baseline was unable to be established prior to high existing rates of launching in 2024, the Space Force must also identify and include at least one necessary appropriate control site outside of the Launch Noise impact area (as originally proposed in CRLF-(a)ii) prior to the start of the proposed project for purposes of signal characteristic comparison. Data collected between October 1 and December 31, 2024, must include applicable call characteristics (e.g., changes in signal rate, call frequency, amplitude, call timing, call duration, etc.) and other relevant site variables (e.g. climate data, water temperature, etc.) to serve in purposes of analysis

as well in the development of the California red-legged frog bioacoustics baseline.

7. Overwintering western snowy plover window surveys and camera/human monitoring.
    i. The Space Force must collect overwintering western snowy plover population information by continuing to conduct winter window surveys.
    ii. The Space Force must deploy at least two landscape level cameras trained on areas known to support high levels of overwintering western snowy plover populations on Surf Beach OR require human monitoring of populations whenever possible. Camera/human monitoring must occur during three launches (including two boost-backs and that occur during both night and day-time) to understand behavioral reactions of the species during the overwintering season.

The Space Force must provide this plan to the Service for review prior to the implementation of the proposed project to ensure it is consistent with expectations made within this analysis, including that potential project related short and long-term effects are detectable and clearly defined.

Monitoring Plan Associated Analysis

Using collected data during the project and other available long-term data, the Space Force must prepare a multivariate statistical analysis of the potential changes in aforementioned species populations trends. This analysis must be provided as soon as it is available in 2025, appropriately within the annual report, and prior to any further proposed increase in launch cadence. This will help address previous requirements that the Service has not yet received (Service 2023; Reporting Requirement 2). In coordination with the Service, this analysis must be conducted by an experienced independent third party who is funded by the Space Force or the project proponent and are provided (a) available historical population data (b) frequency of launches and on-base boost-back landings over different time scales; (c) seasonality of launches and sensitive times of year for respective species; (d) geospatial variability; (e) required off-base control reference site data; (f) climatic and oceanographic patterns (e.g. El Niño, Pacific Decadal Oscillation, storms, ocean temperature); (g) required realized levels of acoustic and lighting monitoring data; (h) and patterns of other variables including (as relevant to the respective species), but not limited to, breeding rates, beach width, and forage base or food web trends. Relevant population trends to analyze include, but are not limited to, population sizes and locations for California red-legged frog and western snowy plover. The Space Force must develop a comprehensive plan to collect sufficient data on species information for the southwestern pond turtle to address the analyses above during the appropriate seasons for the species. The Space Force must then use this information to conduct a similar analysis (as described for the California red-legged frog and western snowy plover) when this data is available in 2025. Multivariate statistical analysis is necessary to help both detect take (e.g. atypical population declines, changes in spatial distribution that may be otherwise difficult to discern) as well as determine if observed changes in populations may be a result of the proposed project.

13b) The Space Force must provide an update to the existing long-term monitoring plan (refer to Condition 8 within Service 2023a) that pertains to Falcon-9 operation at SLC-4 by December 31, 2024, to address effects across all seasons to begin full implementation no later than January 1, 2025. The Space Force must also update the existing monitoring plan to include aforementioned language described in the 'Monitoring Plan Associated Analysis' to be conducted on an annual basis. The Space Force must coordinate with the Service to develop and approve the updated plan prior to implementation. The following topics must be updated in the existing plan:

California red-legged frog (CRLF-5) and southwestern pond turtle (SWPT-1 and 2)

The California red-legged frog and southwestern pond turtle portions of the monitoring plan must explain how they will clearly establish baseline of these species' average population levels within each of the major impacted breeding features (Honda Creek, Bear Creek, Santa Ynez River, Canada del Jolloru, and Jalama Creek). The Space Force must clearly explain how past or new survey data is being utilized to establish a reasonable baseline and include the survey area and methodology used. To ensure consistent data collection for analysis, all subsequent surveys must utilize the same established methodology within each impacted breeding feature.

i. California red-legged frog bioacoustics monitoring: As part of the proposed monitoring plan, the Space Force must include the California red-legged frog bioacoustics monitoring design. The Space Force must clearly define how they will establish California red-legged frog calling behavior baseline (bioacoustics baseline) within select impacted breeding features closest to SLC-4 (Honda Creek, Bear Creek, Santa Ynez River, and Jalama Creek).

ii. As part of the southwestern pond turtle monitoring plan, the Space Force must incorporate clear methodology on how they plan to survey, monitor, and track southwestern pond turtle populations (e.g. mark-recapture, transmitter, etc.). The Space Force must also provide an established methodology to identify overwintering, breeding, basking, and nesting habitat within the vicinity of SLC-4 and within identified impacted major riparian features (e.g. Honda Creek, Bear

Creek, Santa Ynez River, and Jalama Creek) by the end of the proposed project (December 31, 2024) for planned implementation no later than January 1, 2025.

Western snowy plover (*WSPL -1*)

The western snowy plover section of the monitoring plan must also include a clear, established baseline for metrics including i) number of roosting (overwintering) adults on South and North VSFB beaches. This would be an update to the existing plan's baseline related to breeding metrics (e.g. ii) breeding adults, iii) nest attempts, and iv) hatching success rate). This baseline is needed to help detect and determine the magnitude of potential project related effects. This baseline will be the mean (with 95 percent confidence interval) established over the most recent 10-year period with relatively low levels of launches per year (2011-2020) and include available data across the entirety of Surf Beach.

14. The Space Force must update the existing mitigation plan (refer to Condition 7 within Service 2023a) and provide it to the Service by December 31, 2024. The plan must also reiterate scenarios when this additional mitigation would not occur as described in SWPT-4, CRLF-9, and WSPL-3. The plan must include specific quantifiable success criteria the Space Force will obtain within 5 years' time from when the proposed project triggers mitigation that will serve to address the Space Force's goal of no net loss in species' distribution and abundance. In the event the Space Force does not obtain the success criteria, the Space Force must reduce project effects to align with our analysis until alternative effective mitigation is achieved.
    a. The plan must detail mitigation actions, including how the Space Force will calculate mitigation acreages (California red-legged frog and southwestern pond turtle) and identify what additional areas on or off-base would be restored in the event mitigation threshold triggers are met (in addition to required Oxbow Restoration site depicted in Term and Condition 15). The Space Force must include these additional identified restoration areas to provide assurances their proposed 2:1 acreage ratio (habitat enhanced: habitat affected) would be able to be readily met if needed as proposed in the project description.

The following terms and conditions implement reasonable and prudent measure 4:

15. The Space Force must offset or require the project proponent to offset associated temporary habitat degradation as analyzed for species that are likely to be adversely affected by the proposed project as follows:

    Offset for Western snowy plover

    The Space Force must fund or require the project proponent to fund at least one full-time staff position to conduct predator control across known western snowy plover occupied VSFB beaches between at least October 1 through December 31, 2024. The implementation of this work is expected to help demonstrate mitigation efficacy to achieve quantifiable no net loss in western snowy plover abundance and distribution as analyzed.

To provide additional assurances, the Space Force must fund or require the project proponent to fund off-base recovery work equivalent to predator control across 8 km of shoreline to offset project impacts on the take of roosting western snowy plover and degradation of its overwintering habitat from October 1 through December 31, 2024. For this specific consultation, the Service and the Space Force worked collectively to agree that the Space Force or the project proponent will fund an amount of at least $73,680 towards off base projects that support western snowy plover recovery. This amount was calculated using the total basewide VSFB 2024 predator management costs incurred during the breeding season applied to the 8 km of Surf Beach across the three-month duration of the proposed project. The Service will provide the Space Force a list of identified currently available western snowy plover recovery projects to select from to apply this off-base funding mitigation amount prior to January 1, 2025.

The Space Force must report on the status of mitigation implementation during the proposed project's annual report.

Offset for southwestern pond turtle/California red-legged frog:

For this specific consultation, the Service and the Space Force worked collectively to agree that the Space Force or the project proponent will fund the proposed mitigation involving restoration of the 7-acre Oxbow Restoration site with work to begin in 2025. The implementation of this work will also help demonstrate mitigation efficacy to quantifiably achieve no net loss in California red-legged frog abundance and distribution as analyzed.

As specified above, separate from the Oxbow restoration work, the Space Force must identify the additional restoration areas which would be utilized to meet their proposed 2:1 acreage mitigation ratio (as described in CRLF-10 and SWPT-5). The Space Force must include clear depiction of these areas in the proposed mitigation plan and must fund or require that the project proponent fund this additional future work in the event that described mitigation threshold triggers are met (CRLF-8 or SWPT-3).

REPORTING REQUIREMENTS

Pursuant to 50 CFR 402.14(i)(3), the Space Force must report the progress of the action and its impact on the species to the Service as specified in this incidental take statement.

The Space Force must submit a final report to the Service's Ventura Fish and Wildlife Office via electronic mail within 90 days following completion of the proposed project. The reports must describe all activities that were conducted under this biological opinion, including activities and conservation measures that were described in the proposed action and required under the terms and conditions, and discuss any problems that were encountered in implementing conservation measures or terms and conditions and any other pertinent information. The report(s) must also include the following information:

1. Documentation of any impacts of the proposed activities on southwestern pond turtle, California red-legged frog, and western snowy plover; results of biological surveys and observation records; documentation of the number of individuals of any life stage of southwestern pond turtle, California red-legged frogs, or western snowy plovers injured or killed; the date, time, and location of any form of take; approximate size and age of those individuals taken; and a description of relocation sites or rehabilitation outcomes for captured individuals.
2. The Space Force must include a discussion of the progress with the implementation of their monitoring plan. This must include survey and monitoring information of the populations of southwestern pond turtle and California red-legged frog populations within major riparian features (e.g. Honda Creek, Bear Creek, Santa Ynez River, and Jalama Creek); and of overwintering western snowy plovers within South and North Base. This discussion must include a summary of all monitoring activities and address any observed changes in population and distribution trends documented over time that may be associated with long-term effects of increased launch frequency (See Term and Condition 13 and associated analysis). The discussion must also address any potential improvements to the monitoring plan design efficacy, including advances in technology that may aid in sublethal effects detection for consistency with the above analysis.
    a. The California red-legged frog and southwestern pond turtle monitoring discussion must also include: (*i*) date and times of launches and static test fires that impacted Honda Creek, Bear Creek, Santa Ynez River, and Jalama Creek as well as received noise levels at each feature of static test fire, launch, and sonic boom events (including psf conversions to SPL_{max}); (*ii*) documentation and an analysis of effects by the activities evaluated in this biological opinion (see Term and Condition 13a); (*iii*) discussion of project effects that result in take of California red-legged frog or southwestern pond turtle as well as any observed changes to habitat use pattern, reproduction, or behavior over the course of the project as a result of routine launch disturbance; and, (*iv*) any other pertinent information as required by this biological opinion.
        i. This discussion must include the bioacoustics monitoring results within Honda Creek, Bear Creek, Santa Ynez River, and Jalama Creek. The report must include software analysis methods (can refer to Higham et al. 2020, Kruger et al. 2016) used to document changes in signal characteristics as well as estimate chorus size. The report will include results and discussion of any changes to California red-legged frog calling

behavior (e.g., changes in signal rate, call frequency, amplitude, call timing, call duration, etc.) in comparison with the established California red-legged frog bioacoustics baseline, the required off-base control site for reference, as well as any simultaneous observed changes in California red-legged frog annual population data within each feature.

b. The western snowy plover monitoring discussion must include: (*i*) date and times of launches and static test fires that impacted Surf Beach as well as received noise levels of static test fire, launch, and sonic boom events including psf conversions to SPL_{max}; (*ii*) documentation and an analysis of effects by the activities evaluated in this biological opinion (see Term and Condition 13a) (*iii*) discussion of effects that result in take of western snowy plover as well as any observed changes to habitat use pattern or behavior of birds. Note that this discussion must address any observed changes in population and distribution trends documented over the course of this project that may be associated with long-term effects of increased launch disturbance; and (*v*) any other pertinent information as required by this biological opinion.

3. The Space Force must include a description of mitigation activities implemented and any relevant coordination with the Service. The Space Force must include discussion of the status of and whether implemented mitigation has attained applicable success criteria outlined in Term and Condition 15. The Space Force must also include quantifiable metrics to clearly demonstrate that they have achieved no net loss in species abundance or overall distribution to ensure that mitigation efforts are consistent with this analysis.
4. Results from noise monitoring (Term and Condition 8); Light monitoring (Term and Condition 9); Vibration monitoring (Term and Condition 10); Progress report of auditory harm monitoring design development and implementation (Term and Condition 11); Water quality (or soil) monitoring (Term and Condition 12); Pre-project baseline comparison with annual hydrodynamic data results for San Antonio Creek water extraction as specified in Avoidance and Minimization Measure GM-9.
5. The Space Force must submit federally listed species observations over the course of the project to the California Natural Diversity Database (CNDDB).

The report should also include a discussion of any problems encountered implementing the terms and conditions and other protective measures, recommendations for modifying the terms and conditions to enhance the conservation of federally listed species, and any other pertinent information.

DISPOSITION OF DEAD OR INJURED SPECIMENS

As part of this incidental take statement and pursuant to 50 CFR 402.14(i)(1)(v), upon locating a dead or injured southwestern pond turtle, California red-legged frog, or western snowy plover, initial notification within 3 working days of its finding must be made by telephone and in writing to the Ventura Fish and Wildlife Office (805-644-1766). The report must include the date, time, location of the carcass, a photograph, cause of death or injury, if known, and any other pertinent information.

The Space Force must take care in handling injured animals to ensure effective treatment and care, and in handling dead specimens to preserve biological material in the best possible state. The Space Force must transport injured animals to a qualified veterinarian. Should any treated southwestern pond turtle, California red-legged frog, or western snowy plover survive, the Space Force must contact the Service regarding the final disposition of the animal(s).

The remains of southwestern pond turtles, California red-legged frogs, or western snowy plovers, must be placed with educational or research institutions holding the appropriate State and Federal permits, such as the Santa Barbara Natural History Museum (Contact: Paul Collins, Santa Barbara Natural History Museum, Vertebrate Zoology Department, 2559 Puesta Del Sol, Santa Barbara, California 93460, (805) 682-4711, extension 321), Western Foundation of Vertebrate Zoology (Contact: Linnea S. Hall, Ph.D., Executive Director, Western Foundation of Vertebrate Zoology, 439 Calle San Pablo Camarillo, CA 93012, (805) 388-9944), or the Cheadle Center for Biodiversity and Ecological Restoration (CCBER) (CCBER, Herpetological Collection, University of California, Santa Barbara, Harder South, Building 578, MS-9615 Santa Barbara, CA 93106-9615.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to use their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. The conservation recommendations below are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information and can be used by the Space Force to fulfill their 7(a)(1) obligations.

1. We recommend that the Space Force work with project proponents to design the launch schedule such that launches, particularly launches with associated boost-backs involving terrestrial landing, occur to the maximum extent possible outside of sensitive breeding windows for listed species. Previous monitoring and comparable literature indicate that routine and frequent exposure to disturbance during these sensitive windows and corresponding accumulation of stress hormone has the potential to significantly impact long-term breeding success and overall population level fitness. In the event that impacts to breeding success, abundance, and distribution are observed in response to increased launch cadence, we strongly recommend proactively working with project proponents on designing the launch schedule to avoid sensitive windows to help preclude associated effects and build in temporal separation between disturbance events to minimize the induced stress on species.
2. The Space Force has indicated there is uncertainty in modeling projections as a result of atmospheric conditions (MSRS 2024a, p. 99). We recommend that prior to any further implementation of launches with easterly trajectories with identified mainland sonic boom potential, that the Space Force require the project proponent to explore partnership with NASA's Neil A. Armstrong Flight Research Center that have demonstrated

experience with aircraft sonic boom research and attenuation. Service staff have previously spoken to interested parties at this research center and can help facilitate this connection with your team. This partnership could help with model projection accuracy and subsequently also prove valuable to address future improvements in vehicle design and operational optimization. To ensure consistency with this analysis, we recommend that the Space Force implement measures for making decisions on launch time and trajectory based on this coordination and analysis of available data to avoid and minimize to the maximum degree possible the spatial extent and severity of sonic booms experienced both on and off-base.

3. Correspondingly, we recommend that the Space Force proactively require their project proponents to design launch vehicles (and SLCs) to attenuate sensory pollutants, similar to what is being done with aircraft at another installation (i.e., Edwards Air Force Base, X-59 Quiet SuperSonic Technology; NASA 2022, entire). Design considerations in combination with new sensory pollutant attenuation technologies may prove to be pertinent based on a growing body of evidence that suggests noise, vibration, and light can have detrimental impacts on natural ecosystems as previously discussed.
4. We recommend and encourage the Space Force to proactively coordinate with the Service as they learn new information related to this proposed project and during the early stages of future project development. This will improve efficiencies for both agencies and promote the development of meaningful recommendations to avoid and minimize impacts to listed species.
5. We recommend that the Space Force proactively conduct a small-scale California red-legged frog egg-mass relocation study into the existing Oxbow Restoration site. Previous survey efforts have not yet demonstrated that California red-legged frog will utilize these areas for breeding (Evans 2022, p. 4; Kephart 2022, p. 2). This study could help determine whether manual facilitation of California red-legged frog establishment to ensure no-net loss of species abundance is achievable.
6. We recommend that the Space Force continue to coordinate with researchers familiar with study design involving short- and long-term ecological effects of sensory pollutants in the development of the effects monitoring plan for the project. We also recommend that the Space Force implement a basewide monitoring strategy to address the potential for compounding impacts of collective launches across the base.
7. We recommend that the Space Force work with researchers to develop a habitat suitability model that addresses launch disturbance frequency. The Space Force could use a model to inform the number, spacing, and distribution of the collective launch scheduling to make appropriate management decisions to reduce effects. We recommend modeling results incorporate sensitive time windows, such as breeding seasons, and be used to inform launch scheduling to promote recovery goals and adhere to the Space Force's 7(a)(1) obligations.
8. We recommend that proposed southern sea otter monitoring be conducted by a NMFS-approved Protected Species Observer trained in marine mammal science.
9. We recommend that the Space Force coordinate with National Park Service partners to inform them of potential project related impacts to Channel Islands and coordinate

required noise monitoring locations (Recommended Contact - Annie Little, Channel Islands National Park, Supervisory Natural Resource Manager, 1901 Spinnaker Drive Ventura, CA 93001, Office: 805-658-5763, annie_little@nps.gov)

10. We recommend that the Space Force continue to monitor and assess potential effects of project launch and associated boost-back activities on the adjacent western monarch butterfly overwintering site located in Spring Canyon and elsewhere in the near vicinity. We recommend that monitoring of the on-base monarch butterfly populations be conducted in a manner sufficient to assess potential changes in habitat use patterns and population levels. As applicable, we would recommend that the Space Force address observed effects by incorporating management actions that benefit the species. We recommend that the Space Force implement measures outlined in Appendix C.
11. We recommend that the Space Force conduct vegetation and firebreak maintenance around SLC-4 outside of identified southwestern pond turtle nesting and overwintering periods to the maximum degree practicable. These seasons are generally thought to align with early fall (September); however, guidance can vary geographically and by feature type. Consequently, VSFB biologists familiar with the local population of southwestern pond turtle should be consulted to identify the best period to avoid unintentional impacts to aestivating or nesting southwestern pond turtle if suitable habitat is identified within the vicinity of SLC-4.

The Service requests notification of the implementation of any conservation recommendations so we may be kept informed of actions minimizing or avoiding adverse effects or benefitting listed species or their habitats.

REINITIATION NOTICE

This concludes formal consultation on the action(s) outlined in the reinitiation request. As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, the exemption issued pursuant to section 7(o)(2) may have lapsed and any further take could be a violation of section 4(d) or 9. Consequently, we recommend that any operations causing such take cease pending reinitiation.

If you have any questions regarding this matter, please contact our Section 7 inbox by electronic mail at fw8venturasection7@fws.gov with the project title and reference number (2022-0013990-S7-001-R001) in the subject line.

Sincerely,

Stephen P. Henry
Field Supervisor

LITERATURE CITED

[30 CES] 30th Civil Engineer Squadron. 2021. Programmatic Biological Assessment: Effects of Activities Conducted at Vandenberg Space Force Base, California, on 15 Federally Listed Threatened and Endangered Species. July 1, 2021. Vandenberg Space Force Base, California. 351 pp.

[30 CES] 30th Civil Engineer Squadron. 2023. Programmatic Biological Assessment: Effects of activities conducted at Vandenberg Space Force Base, California, on 15 federally listed threatened and endangered species. TAB A4; Southern Sea Otter Avoidance and Minimization and corresponding Effects Analysis. Updated May 19, 2023.

AECOM. 2019. Biological Assessment: Potential effects to California red-legged frog, tidewater goby, and unarmored threespine stickleback, Vandenberg Dunes Golf Courses Project, Vandenberg Space Force Base Santa Barbara County, California. Prepared by AECOM, Santa Mar. 26 pp.

Alvarez, J. A., D. G. Cook, J. L. Yee, M. G. Van Hattem, D. R. Fong, and R. N. Fisher. 2013. Comparative microhabitat characteristics at oviposition sites of the California red-legged frog (*Rana draytonii*). Herpetological Conservation and Biology 8(3):539–551.

Ashton, D. T., A. J. Lind, and K. E. Schlick. 1997. Western pond turtle (*Clemmys marmorata*). natural history. Forest Service. Pacific Southwest Research Station. Arcata, California. 22 pp.

Atwood, A.L. 1993. California gnatcatchers and coastal sage scrub: The biological reasons for listing. Interface between ecology and land development in California. Southern California Academy of Sciences, Los Angeles.

Baker, B. J., and J. M. L. Richardson. 2006. The effect of artificial light on male breeding-season behaviour in green frogs, *Rana clamitans melanota*. Canadian Journal of Zoology 84(10):1528–1532.

Barry, S. J., and H. B. Shaffer. 1994. The Status of the California Tiger Salamander (*Ambystoma californiense*) at Lagunita: A 50-Year Update. Journal of Herpetology 28(2):159.

Beale, D. J., K. Hillyer, S. Nilsson, D. Limpus, U. Bose, J. A. Broadbent, and S. Vardy. 2022. Bioaccumulation and metabolic response of PFAS mixtures in wild-caught freshwater turtles (*Emydura macquarii macquarii*) using omics-based ecosurveillance techniques. Science of The Total Environment 806:151264.

Beason, R. 2004. What can birds hear? U.S. Department of Agriculture National Wildlife Research Center-Staff Publication. 78 pp.

Bellefleur, D., P. Lee, and R. A. Ronconi. 2009. The impact of recreational boat traffic on Marbled Murrelets (*Brachyramphus marmoratus*). Elsevier Ltd. Journal of Environmental Management 90(1):535.

Belli, J. P. 2016. Movements, habitat use, and demography of western pond turtles in an intermittent central California stream. M.S., San Jose State University, United States, California. Available online: <https://www.proquest.com/docview/1767450666/abstract/2869D02CC2874500PQ/1>. Accessed May 20, 2024.

[BRC] BioResource Consultants Inc. 2018. Western snowy plover surveys and nest monitoring — Coal Oil Point Reserve, Goleta, California. Ojai, California. 10 pp.

[BRRC] Blue Ridge Research and Consulting, LLC. 2020. Noise Study for Relativity Space Terran 1 Operations at Vandenberg Air Force Base Site B330. 37 pp.

Buchanan, B. W. 2006. Observed and potential effects of light pollution on anuran amphibians. Chapter 9 in Longcore, T., and C. Rich (Eds). Ecological Consequences of Artificial Night Lighting. Island Press; Ecological Consequences of Artificial Night Lighting. 192–220 pp.

Bulger, J. B., N. J. Scott, and R. B. Seymour. 2003. Terrestrial activity and conservation of adult California red-legged frogs *Rana aurora draytonii* in coastal forests and grasslands. Biological Conservation 110(1):85–95.

Bury, R. B. 1972. Habits and home range of the Pacific pond turtle, *Clemmys marmorata*, in a stream community. University of California, Berkeley, Berkeley, California.

Bury, R. B. 1986. Feeding ecology of the turtle, *Clemmys marmorata*. Society for the Study of Amphibians and Reptiles. Journal of Herpetology 20(4):515–521.

Bury, R. B., and D. J. Germano. 2008a. Conservation biology of freshwater turtles and tortoises. A. Rhodin, P. Pritchard, P. P. van Dijk, and R. Saumure, editors. Chelonian Research Monographs. 5. Available online: <http://www.iucn-tftsg.org/cbftt/>.

Bury, R. B., H. H. Welsh, D. J. Germano, and D. T. Ashton. 2012. Western pond turtle: biology, sampling techniques, inventory and monitoring, conservation, and management. Northwest fauna 7, Society for Northwestern Vertebrate Biology, Olympia, Washington. vii, 128 pp.

Bury, R. B., H. H. Welsh, D. J. Germano, and D. T. Ashton. 2012. Western pond turtle: biology, sampling techniques, inventory and monitoring, conservation, and management. Northwest fauna 7, Society for Northwestern Vertebrate Biology, Olympia, Washington. vii, 128 pp.

California Coastal Commission Meeting, Calabassas California on August 8, 2024. Figures presented by Staff Biologist Walt Deppe during CD-0003-24 (United States Space Force to increase SpaceX launches from 6 to 36) and public testimony on experienced sonic booms on channel islands. Available online recording, figure shown at timestamp 03:14:00, accessible online at <https://cal-span.org/meeting/ccc_20240808/>.

[CalIPC] California Invasive Plant Council. 2015. Best Management Practices for Wildland Stewardship: Protecting Wildlife When Using Herbicides for Invasive Plant Management. Cal-IPC Publication 2015-1. California Invasive Plant Council, Berkeley, CA. Available online: <https://www.cal-ipc.org/resources/library/publications/herbicidesandwildlife/>. Accessed May 20, 2024.

Caorsi, V., V. Guerra, R. Furtado, D. Llusia, L. R. Miron, M. Borges-Martins, C. Both, P. M. Narins, S. W. F. Meenderink, and R. Márquez. 2019. Anthropogenic substrate-borne vibrations impact anuran calling. Scientific Reports 9(1):19456.

Caorsi, V. Z., C. Both, S. Cechin, R. Antunes, and M. Borges-Martins. 2017. Effects of traffic noise on the calling behavior of two Neotropical hylid frogs. S. Lötters, editor. PLOS ONE 12(8):e0183342.

Casler, B. R., C. E. Hallett, M. A. Stern, and M. Platt. 1993. Snowy plover nesting and reproductive success along the Oregon coast - 1993. Unpublished report for the Oregon Department of Fish and Wildlife-Nongame Program, Portland, and the Coos Bay District Bureau of Land Management. Coos Bay, Oregon. 26 pp.

[CBBEP] Coastal Bend Bays Estuary Program. 2021. Comments on SPACEX Draft Programmatic Environmental Assessment for Starship/Super Heavy Program addressed to Ms. Stacey Zee, SpaceX. Attachments of Piping Plover abundance, trend, and survival at Boca Chica 2018-2021 and Nesting of Snowy and Wilson's Plovers at Boca Chica 2017-2021. Letter dated November 1, 2021.

Christie, N. E., and N. R. Geist. 2017. Temperature effects on development and phenotype in a free-living population of western pond turtles (*Emys marmorata*). Physiological and Biochemical Zoology 90(1):47–53.

[CNDDB] California Natural Diversity Database. 2024. Data for western spadefoot. Occurrence 1101. Rarefind: A database application for the California Department of Fish and Wildlife, Natural Heritage Program.

Crump, D. E. 2001. Western pond turtle (*Clemmys marmorata pallida*) nesting behavior and habitat use. Master of Science, San Jose State University, San Jose, CA, USA. Available online: https://scholarworks.sjsu.edu/etd_theses/2210. Accessed January 16, 2024.

Cunnington, G. M., and L. Fahrig. 2010. Plasticity in the vocalizations of anurans in response to traffic noise. Acta Oecologica 36(5):463–470.

Davidson, C., H. B. Shaffer, and M. R. Jennings. 2001. Declines of the California red-legged frog: climate, UV-B, habitat, and pesticides hypotheses. Ecological Applications 11:464–479.

Davis, R., T. Williams, and F. Awbrey. 1988. Sea Otter Oil Spill Avoidance Study. Minerals Management Service. Accessed August 2, 2021, online at <https://babel.hathitrust.org/cgi/pt?id=uc1.31822008830200&view=1up&seq=77&q1=response>. 78 pp.

Dimmitt, M. A., and R. Ruibal. 1980. Environmental Correlates of Emergence in Spadefoot Toads (Scaphiopus). Society for the Study of Amphibians and Reptiles. Journal of Herpetology 14(1):21–29.

Dooling, R. J., M. L. Dent, A. M. Lauer, and B. M. Ryals. 2008. Functional Recovery After Hair Cell Regeneration in Birds. Pages 117–140 in R. J. Salvi, A. N. Popper, and R. R. Fay, editors, Volume 33. Springer Handbook of Auditory Research, Springer New York, New York, NY. Available online:< http://link.springer.com/10.1007/978-0-387-73364-7_4>. Accessed June 6, 2024.

Dooling, R. J., and A. N. Popper. 2007. The Effects of Highway Noise on Birds. Report prepared for the California Department of Transportation Division of Environmental Analysis. 74 pp.

eBird. 2024. eBird: An online database of bird distribution and abundance. Marbled Murrelet observations searched July 17, 2024. Available online: <https://ebird.org/map/marmur?neg=true&env.minX=&env.minY=&env.maxX=&env.maxY=&zh=false&gp=false&ev=Z&excludeExX=false&excludeExAll=false&mr=1-12&bmo=1&emo=12&yr=all>.

[EPA] Environmental Protection Agency. 2024. International Actions to Protect the Ozone Layer; the Montreal Protocol. Available online: <https://www.epa.gov/ozone-layer-protection/international-actions-montreal-protocol-substances-deplete-ozone-layer>.

Ernst, C. H., and J. E. Lovich. 2009. Turtles of the United States and Canada. JHU Press, Baltimore. 840 pp.Google-Books-ID: nNOQghYEXZMC.

Ewert, M. A., D. R. Jackson, and C. E. Nelson. 1994. Patterns of temperature-dependent sex determination in turtles. Journal of Experimental Zoology 270(1):3–15.

[FAA] Federal Avian Administration. 2020. Draft Environmental Assessment for SpaceX Falcon Launches at Kennedy Space Center and Cape Canaveral Air Force Station. 110 pp.
Farrar, J. D., A. A. Kotaich, D. J. Lauten, K. A. Castelein, and E. P. Gaines. 2012. Snowy Plover Buried Alive by Wind-Blown Sand. Notes. Western Birds 43:189–191.
Feldman, M. 1982. Notes on reproduction in *Clemmys marmorata*. Herpetological Review 13:10–11.
Fellers, G. M. 2005. *Rana draytonii* Baird and Girard, 1852b California red-legged frog. Pages 552-554 in M. Lannoo (editor). Amphibian declines the conservation status of United States species. University of California Press. Berkeley, California.
Fellers, G. M., A. E. Launer, G. Rathbun, S. Bibzien, J. Alvarez, S. Sterner, R. B. Seymour, and M. Westphal. 2001. Overwintering Tadpoles in the California Red-legged Frog (*Rana aurora draytonii*). Herpetological Review 32(3):156–157.
Ferreira, J. P., Z. Huang, K. Nomura, and J. Wang. 2024. Potential Ozone Depletion From Satellite Demise During Atmospheric Reentry in the Era of Mega-Constellations. Geophysical Research Letters 51(11):e2024GL109280.
Finneran, J. J., and A. K. Jenkins. 2012. Criteria and thresholds for U.S. Navy acoustic and explosive effects analysis. Prepared for Space and Naval Warfare Systems Center Pacific. 65 pp.
Gerhardt, H. C., and R. Brooks. 2009. Experimental analysis of multivariate female choice in gray treefrogs (*Hyla versicolor*): Evidence for directional and stabilizing selection. Evolution 63(10):2504–2512.
Gerhardt, H. C., M. L. Dyson, and S. D. Tanner. 1996. Dynamic properties of the advertisement calls of gray tree frogs: patterns of variability and female choice. Behavioral Ecology 7(1):7–18.
Germano, D. J. 2010. Ecology of western pond turtles (*Actinemys marmorata*) at sewage-treatment facilities in the San Joaquin Valley, California. Southwestern Association of Naturalists. The Southwestern Naturalist 55(1):89–97.
Germano, D. J., and G. B. Rathbun. 2008. Growth, population structure, and reproduction of western pond turtles (*Actinemys marmorata*) on the central coast of California. Chelonian Conservation and Biology 7(2):188–194.
Germano, D. J., and J. D. Riedle. 2015. Population structure, growth, survivorship, and reproduction of *Actinemys marmorata* from a high elevation site in the Tehachapi Mountains, California. Herpetologica 71(2):102–109.
Gibbons, M. M., and T. K. McCarthy. 1986. The reproductive output of frogs *Rana temporaria* (L.) with particular reference to body size and age. Journal of Zoology 209(4):579–593.
Given, M. F. 1988. Growth rate and the cost of calling activity in male carpenter frog. Behavioral Ecology and Sociobiology 22:153–160.
Godin, O. A. 2008. Sound transmission through water–air interfaces: new insights into an old problem. Taylor & Francis. Contemporary Physics. Available online: <https://www.tandfonline.com/doi/abs/10.1080/00107510802090415>. Accessed August 6, 2024.
Goodman, R. H. Jr., and G. R. Stewart. 2000. Aquatic home ranges of female western pond turtles, *Clemmys marmorata*, at two sites in southern California. Chelonian Conservation and Biology 3:743–745.

Govindarajulu, P. P. 2008. Literature review of impacts of glyphosate herbicide on amphibians: What risks can the silvicultural use of this herbicide pose for amphibians in B.C.? Wildlife Report No. R-28. British Colombia, Ministry of Environment. Victoria, B.C. Grismer, L. 2002.

Govtribe. 2024. Natural Resources Support - Plover Audio Monitoring at Vandenberg SFB, CA; Solicitation # W9126G-24-2-SOI-2875 due June 6, 2024.

Hall, A. 2016. Acute Artificial Light Diminishes Central Texas Anuran Calling Behavior. The American Midland Naturalist 175:183–193.

Hammond, T. T., Z. A. Au, A. C. Hartman, and C. L. Richards-Zawacki. 2018. Assay validation and interspecific comparison of salivary glucocorticoids in three amphibian species. Conservation Physiology 6(1). Available online: <https://academic.oup.com/conphys/article/doi/10.1093/conphys/coy055/5107756>.

Hanak, E., J. Lund, J. Mount, R. Howitt, P. Moyle, A. Dinar, B. Gray, and B. "Buzz" Thompson. 2011. Managing California's water: from conflict to reconciliation. Public Policy Institute of California, San Francisco, California. Available online: <https://www.ppic.org/publication/managing-californias-water-from-conflict-to-reconciliation/>. Accessed August 25, 2022.

Hayes, M. P., and M. R. Jennings. 1988. Habitat correlates of distribution of the California red-legged frog (*Rana aurora draytonii*) and the foothill yellow-legged frog (*Rana boylii*): Implications for management. Pages 144-158 in R. Sarzo, K.E. Severson, and D.R. Patton (technical coordinators). 458 pp.

Hayes, M. P., and M. R. Tennant. 1985. Diet and feeding behavior of the California red legged frog *Rana aurora draytonii* (Ranidae). The Southwestern Naturalist 30:601–605.

Hays, D., K. McAllister, S. Richardson, and D. Stinson. 1999. Washington state recovery plan for the western pond turtle. Washington Department of Fish and Wildlife, Olympia, Washington.

Hays, D., K. McAllister, S. Richardson, and D. Stinson. 1999. Washington state recovery plan for the western pond turtle. Washington Department of Fish and Wildlife, Olympia, Washington.

Heaton, J. T., R. J. Dooling, and S. M. Farabaugh. 1999. Effects of deafening on the calls and warble song of adult budgerigars (*Melopsittacus undulatus*). The Journal of the Acoustical Society of America 105(3):2010–2019.

Heatwole, H., F. Torres, S. Blasini De Austin, and A. Heatwole. 1969. Studies on anuran water balance—I. Dynamics of evaporative water loss by the coquí, *Eleutherodactylus portoricensis.* Comparative Biochemistry and Physiology 28(1):245–269.

Holland, D. C. 1991. A synopsis of the ecology and status of the western pond turtle (*Clemmys marmorata*) in 1991.

Holland, D. C. 1994. The western pond turtle; habitat and history, 1993-1994 final report. Portland, OR. Available online: <https://www.osti.gov/servlets/purl/171287/>.

Holte, D. L. 1998. Nest site characteristics of the western pond turtle, *Clemmys marmorata*, at Fern Ridge Reservoir, in west central Oregon. Oregon State University, Corvallis, OR. publisher: Oregon State University.

Howe, CM., M. Berrill, B. D. Pauli, C. C. Helbing, K. Werry, and N. Veldhoen. 2004. Toxicity of glyphosate-based pesticides to four North American frog species. Environmental

Toxicology and Chemistry 23(8):1928–1938.
Hur, J. W., and J. Y. Lee. 2010. Effects of Chronic Vibration Stress on Liver, Kidney and Testes of the Soft-Shelled Turtle *Pelodiscus sinensis*. Journal of Applied Animal Research 37(2):241–245.
Jennings, M. R., and M. P. Hayes. 1985. Pre-1900 overharvest of California red-legged frogs (*Rana aurora draytonii*): The inducement for bullfrog *(Rana catesbeiana*) introduction. Herpetological Review 31:94–103.
Jennings, M. R., and M. P. Hayes. 1994. Amphibian and reptile species of special concern in California. Report to the California Department of Fish and Game, Inland Fisheries Division, Rancho Cordova, California. 255 pp.
Jung, R. E. 1996. The potential influence of environmental pollution on amphibian development and decline. PhD Dissertation; University of Wisconsin-Madison. Available online: <https://digital.library.unt.edu/ark:/67531/metadc690315/>. 141 pp.
Kepas, M. E., L. O. Sermersheim, S. B. Hudson, A. J. J. Lehmicke, S. S. French, and L. M. Aubry. 2023. Behavior, stress, and metabolism of a parthenogenic lizard in response to flyover noise. (March):1–13.
Kugler, K., L. Wiegrebe, B. Grothe, M. Kössl, R. Gürkov, E. Krause, and M. Drexl. 2014. Low-frequency sound affects active micromechanics in the human inner ear. Royal Society Open Science 1(2):140166.
Lambert, M. R., O. Hernández-Gómez, A. R. Krohn, A. Mutlow, L. Patterson, E. B. Rosenblum, M. Timmer, J. Willis, and J. Bushell. 2021. Turtle Shell Disease Fungus (*Emydomyces testavorans*): First Documented Occurrence in California and Prevalence in Free-Living Turtles. The American Society of Ichthyologists and Herpetologists. Ichthyology & Herpetology 109(4):958–962.
Lauten, D. J., K. A. Castelein, J. D. Farrar, A. A. Kotaich, and E. P. Gaines. 2010. The Distribution and Reproductive Success of the Western Snowy Plover along the Oregon Coast - 2010. The Oregon Biodiversity Information Center Institute for Natural Resources, Portland State University/INR, Portland, Oregon. 62 pp.
Llewelyn, V. K., L. Berger, and B. D. Glass. 2019. Permeability of frog skin to chemicals: effect of penetration enhancers. Heliyon 5(8):e02127.
Longcore, T., and C. Rich. 2017a. Artificial Night Lighting and Protected Lands. Ecological Effects and Management Approaches. Natural Resource Report NPS/NRSS/NSNS/NRR— 2017/1493. National Park Service, Fort Collins, Colorado. Revised August 2017. 43 pp. Available online: <https://irma.nps.gov/DataStore/DownloadFile/582058>.
Lovich, J. E., M. Quillman, B. Zitt, A. Schroeder, D. E. Green, C. Yackulic, P. Gibbons, and E. Goode. 2017. The effects of drought and fire in the extirpation of an abundant semi-aquatic turtle from a lacustrine environment in the southwestern USA. EDP Sciences. Knowledge & Management of Aquatic Ecosystems (418):18.
Lund, J. R., E. Hanak, W. Fleenor, R. Howitt, J. Mount, and P. Moyle, editors. 2007. Envisioning futures for the Sacramento-San Joaquin Delta. Public Policy Institute of California, San Francisco. 285 pp.
Maloney, C. M., R. W. Portmann, M. N. Ross, and K. H. Rosenlof. 2022. The Climate and Ozone Impacts of Black Carbon Emissions from Global Rocket Launches. Journal of

Geophysical Research: Atmospheres 127(12): e2021JD036373.
Manzo, S., E. G. Nicholson, Z. Devereux, R. N. Fisher, C. W. Brown, P. A. Scott, and H. B. Shaffer. 2021. Conservation of northwestern and southwestern pond turtles: threats, population size estimates, and population viability analysis. Journal of Fish and Wildlife Management 12(2):485–501.
Márquez, R., J. F. Beltrán, D. Llusia, M. Penna, and P. M. Narins. 2016. Synthetic rainfall vibrations evoke toad emergence. Elsevier. Current Biology 26(24):R1270–R1271.
May, D., G. Shidemantle, Q. Melnick-Kelley, K. Crane, and J. Hua. 2019. The effect of intensified illuminance and artificial light at night on fitness and susceptibility to abiotic and biotic stressors. Environmental Pollution 251:600–608.
Miller, J. 2024. Acoustic behavioral response of nesting western snowy plovers to rocket launches in restored coastal dunes at VSFB; Project Proposal. Bren PhD Symposium.
Montague, M. J., M. Danek-Gontard, and H. P. Kunc. 2013. Phenotypic plasticity affects the response of a sexually selected trait to anthropogenic noise. Behavioral Ecology 24(2):343–348.
Moss, J. B., and K. J. MacLeod. 2022. A quantitative synthesis of and predictive framework for studying winter warming effects in reptiles. Oecologia 200(1):259–271.
Mouritsen, K. N. 1992. Predator Avoidance in Night-Feeding Dunlins *Calidris alpina*: A Matter of Concealment. Ornis Scandinavica 23(2):195.
[MSRS] ManTech SRS Technologies Inc. 2016. California Red-Legged Frog Habitat Assessment, Population Status, and Chytrid Fungus Infection in Jalama Creek and the Santa Ynez River on Vandenberg Air Force Base, California. 49pp.+appendices.
[MSRS] ManTech SRS Technologies Inc. 2017. Biological Assessment for Launch, Boost- Back and Landing of the Falcon 9 First Stage at SLC-4, Vandenberg Air Force Base, California. ManTech SRS Technologies, Lompoc, California. 65 pp.
[MSRS] ManTech SRS Technologies Inc. 2020. San Antonio Road West Bridge Maintenance Mitigation Year 1 Annual Report. 15 pp.
[MSRS] ManTech SRS Technologies Inc. 2021a. Biological assessment of Army Extended Range Cannon Artillery II at Vandenberg Air Force Base, California to support Endangered Species Act Section 7 consultation with the United States Fish and Wildlife Service. Lompoc, California. 67 pp.
[MSRS] ManTech SRS Technologies Inc. 2021b. Annual Report for 2021; 2017-F-0480 – Launch, Boost-back, and Landing of the Falcon 9 First Stage at SLC-4 at Vandenberg Space Force Base, Santa Barbara County, California. 5 pp.
[MSRS] ManTech SRS Technologies Inc. 2022a. Biological Assessment for the Falcon 9 Cadence Increase at Space Launch Complex 4 and Offshore Landing Locations, Vandenberg Space Force Base, California. 99 pp.
[MSRS] ManTech SRS Technologies Inc. 2022b. Biological Acoustic Monitoring of California Red-legged Frogs for the 2 February 2022 SpaceX Falcon 9 NROL-87 at Vandenberg Space Force Base, California. April 25, 2022. 10 pp.
[MSRS] ManTech SRS Technologies Inc. 2022c. Biological Assessment for the Phantom Launch Program at Space Launch Complex 5, Vandenberg Space Force Base, California. 86 pp.
[MSRS] ManTech SRS Technologies Inc. 2022d. Gambel's Watercress Habitat Characterization

on Vandenberg Space Force Base, California. 163 pp.
[MSRS] ManTech SRS Technologies Inc. 2024a. Biological Assessment for Falcon 9 Cadence Increase and SLC-6 Modifications at Vandenberg Space Force Base, California. 2nd Version updated and provided June 27, 2024.
[MSRS] ManTech SRS. 2024b. SpaceX Annual Report. 2023. Activities Pursuant to Biological Opinion 2017-F-0480 – Launch, Boost-back, and Landing of the Falcon 9 First Stage at Space Launch Complex-4 at Vandenberg Space Force Base, Santa Barbara County, California. Report updated June 18, 2024.
Myers, M. R., D. R. Cayan, S. F. Iacobellis, J. M. Melack, R. E. Beighley, P. L. Barnard, J. E. Dugan, and H. M. Page. 2017. Santa Barbara area coastal ecosystem vulnerability assessment. CASG-17-009. Available Online at: <https://caseagrant.ucsd.edu/sites/default/files/SBA-CEVA-final-0917.pdf>. 207 pp.
Nakano, Y., M. Senzaki, N. Ishiyama, S. Yamanaka, K. Miura, and F. Nakamura. 2018. Noise pollution alters matrix permeability for dispersing anurans: Differential effects among land covers. Global Ecology and Conservation 16:6.
[NASA] National Aeronautics and Space Administration. 2022. Ames' Contributions to the X-59 Quiet SuperSonic Technology Aircraft. Updated March 21, 2022. Available online: <https://www.nasa.gov/feature/ames/x-59>. Accessed November 28, 2022.
[NASA] U.S. National Aeronautics and Space Administration. 2024a. VIIRS - NASA's VIIRS/NPP Lunar BRDF-Adjusted Nighttime lights yearly. Historic data layers collected between 2017-2023. Application Developed by Jurij Stare, Version 2.8.24. Available online: <https://www.lightpollutionmap.info/>. Accessed March 1, 2024.
[NASA] U.S. National Aeronautics and Space Administration. 2024b. Radiance Trends of Surf Beach. VIIRS - NASA's VIIRS/NPP Lunar BRDF-Adjusted Nightime lights yearly. Historic data layers collected between 2017-2023. Application Developed by Jurij Stare, Version 1.0.8 (2023-10-11 02:58:19). Available online: <https://www.lighttrends.lightpollutionmap.info/>. Accessed March 1, 2024.
[Navy] U.S. Department of the Navy. 2017. Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III).
Newstead, D., and B. Hill. 2022. Insights into the habitat use, abundance, and distribution of Piping plover and Red knots on the Texas. Coastal Bend Bays Estuary Report to Canadian Wildlife Service, contract 3000738588. Dated October 4, 2022.
Nicholson, E. G., S. Manzo, Z. Devereux, T. P. Morgan, R. N. Fisher, C. Brown, R. Dagit, P. A. Scott, and H. B. Shaffer. 2020. Historical museum collections and contemporary population studies implicate roads and introduced predatory bullfrogs in the decline of western pond turtles. PeerJ 8:e9248.
Niemiec, A. J., Y. Raphael, and D. B. Moody. 1994. Return of auditory function following structural regeneration after acoustic trauma: Behavioral measures from quail. Hearing Research 79(1–2):1–16.
[NOAA] National Oceanic and Atmosphere Administration. 2024a. NOAA National Centers for Environmental information, Climate at a Glance: Palmer Drought Severity Index for Santa Barbara County between 2010 to 2024; Time Series, published July 2024, retrieved on July 21, 2024 at <https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/county/time-series>.

[NOAA] National Oceanic and Atmosphere Administration. 2024b. Sea Level Rise Viewer v. 3.0.0. NOAA Coastal Services Center. Modified March 12, 2024. Metadata on 1 and 2 foot sea level rise extracted and analyzed in ArcGIS pro for VSFB. Accessible online at <https://coast.noaa.gov/slr>.

Norton, J. N., W. L. Kinard, and R. P. Reynolds. 2011. Comparative vibration levels perceived among species in a laboratory animal facility. Journal of the American Association for Laboratory Animal Science: JAALAS 50(5):653–659.

Nyhof, P. 2013. Basking Western Pond Turtle Response to Trail Use in Mountain View, California. Master of Science, San Jose State University, San Jose, CA, USA. Available online: <https://scholarworks.sjsu.edu/etd_theses/4302>. Accessed March 6, 2024.

[ODFW] Oregon Department of Fish and Wildlife. 2015. Guidance for conserving Oregon's native turtles including best management practices. Oregon Department of Fish and Wildlife.

Oelze, M. L., W. D. O'Brien, and R. G. Darmody. 2002. Measurement of Attenuation and Speed of Sound in Soils. Soil Science Society of America Journal 66(3):788–796.

Olson, D. H., and D. Saenz. 2013. Climate Change and Amphibians. (March, 2013). U.S. Department of Agriculture, Forest Service, Climate Change Resource Center. Available online: <www.fs.usda.gov/ccrc/topics/wildlife/amphibians/>.

Page, G. W., F. C. Bidstrup, R. J. Ramer, and L. E. Stenzel. 1986. Distribution of wintering snowy plovers in California and adjacent states. Western Birds 17(4):145–170.

Page, G. W., and L. E. Stenzel, editors. 1981. The breeding status of the snowy plover in California. Western Birds 12(1):1–40.

Page, G. W., L. E. Stenzel, J. S. Warriner, J. C. Warriner, and P. W. Paton. 2009. Snowy Plover (*Charadrius nivosus*) Behavior, The Birds of North America (P.G. Rodewald, Ed.). Available online: <https://birdsna.org/Species-Account/bna/species/snoplo5>. Accessed September 11, 2017.

Palmer, J. L., M. Brenn-White, S. Blake, and S. L. Deem. 2019. Mortality in Three-Toed Box Turtles (*Terrapene mexicana triunguis*) at two Sites in Missouri. Frontiers. Frontiers in Veterinary Science 6. Available online: <https://www.frontiersin.org/journals/veterinary-science/articles/10.3389/fvets.2019.00412/full>. Accessed July 10, 2024.

Park, J., and Y. Do. 2022. Wind Turbine Noise Behaviorally and Physiologically Changes Male Frogs. Biology 11(4):516.

Parris, K. M. 2002. More bang for your buck: the effect of caller position, habitat and chorus noise on the efficiency of calling in the spring peeper. Ecological Modelling 156(2–3):213–224.

Powell, A. N., C. L. Fritz, B. L. Peterson, and J. M. Terp. 2002. Status of breeding and wintering snowy plovers in San Diego County, California, 1994–1999. Journal of Field Ornithology 73(2):156–165.

Purcell, K. L., E. L. McGregor, and K. Calderala. 2017. Effects of drought on western pond turtle survival and movement patterns. Journal of Fish and Wildlife Management 8(1):15–27.

Radle, A. L. 2007. The effect of noise on wildlife: A literature review. World Forum for Acoustic Ecology Online Reader. 16 pp.

Rathbun, G. B., M. R. Jennings, T. G. Murphey, and N. R. Siepel. 1993. Status and ecology of

sensitive aquatic vertebrates in lower San Simeon and Pico Creek, San Luis Obispo County, California. Final Report under Cooperative Agreement 14-16-0009-91-1909 between U.S. Fish and Wildlife Service and California Department of Par. 103 pp.
Rathbun, G. B., and J. Schneider. 2001. Translocation of California red-legged frogs (*Rana aurora draytonii*). Wildlife Society Bulletin 29:1300–1303.
Rathbun, G. B., N. J. Scott, and T. G. Murphey. 2002. Terrestrial habitat use by pacific pond turtles in a mediterranean climate. Southwestern Association of Naturalists. The Southwestern Naturalist 47(2):225–235.
[RCC] Western Pond Turtle Range-wide Conservation Coalition. 2020. Western pond turtle range-wide management strategy.
Reese, D. A., and H. H. Welsh Jr. 1998a. Habitat use by western pond turtles in the Trinity River, California. JSTOR. The Journal of wildlife management :842–853.
Reese, D. A., and H. H. Welsh Jr. 1998b. Comparative demography of *Clemmys marmorata* populations in the Trinity River of California in the context of dam-induced alterations. JSTOR. Journal of Herpetology :505–515.
Riensche, D. L., S. K. Riensche, and R. E. Riensche. 2019. Habitat use, movement patterns, and nest site selection by western pond turtles (*Actinemys marmorata*) in a managed central California rangeland pond. BioOne. Northwestern Naturalist 100(2):90–101.
Robinette, D. P., and E. Rice. 2019. Monitoring of California least terns and western snowy plovers on Vandenberg Air Force Base during the 12 June 2019 SpaceX Falcon 9 Launch with “boost-back”. Unpublished Report, Point Blue Conservation Science, Petaluma, California. 17 pp.
Robinette, D., and E. Rice. 2022. Monitoring of California least terns and western snowy plovers on Vandenberg Space Force Base during the 18 June 2022 SpaceX Falcon 9 launch and first stage landing at SLC-4. Vandenberg Field Station. 15 pp.
Rodgers, E. M. 2020. Rest and relaxation may be the key to more effective sea turtle conservation. J. L. Rummer, editor. Conservation Physiology 8(1):coaa006.
Rosenberg, D. K., J. Gervais, D. Vesely, S. Barnes, L. Holts, R. Horn, R. Swift, L. Todd, and C. Yee. 2009. Conservation assessment for western pond turtles in Oregon. Unpublished Report, Oregon Wildlife Institute, Corvallis, OR. <https://www.fs.usda.gov/r6/issssp/downloads/xvertebrates/ca-hr-actinemys-marmorata-200911.pdf>.
Rosenberg, D. K., and R. Swift. 2013. Post-emergence behavior of hatchling western pond turtles (*Actinemys marmorata*) in western Oregon. The University of Notre Dame. American Midland Naturalist 169(1):111–121.
Ryals, B. M., R. J. Dooling, E. Westbrook, M. L. Dent, A. MacKenzie, and O. N. Larsen. 1999. Avian species differences in susceptibility to noise exposure. Hearing Research 131(1–2):71–88.
Ryals, B. M., and E. W. Rubel. 1988. Hair Cell Regeneration After Acoustic Trauma in Adult Coturnix Quail. Science 240(4860):1774–1776.
Ryan, R. G., E. A. Marais, C. J. Balhatchet, and S. D. Eastham. 2022. Impact of Rocket Launch and Space Debris Air Pollutant Emissions on Stratospheric Ozone and Global Climate. Earth’s Future 10(6).
Salas, A. K., A. M. Capuano, C. A. Harms, W. E. D. Piniak, and T. A. Mooney. 2023.

Temporary noise-induced underwater hearing loss in an aquatic turtle (*Trachemys scripta elegans*). The Journal of the Acoustical Society of America 154(2):1003–1017.
Sapolsky, R. M., L. M. Romero, and A. U. Munck. 2000. How Do Glucocorticoids Influence Stress Responses? Integrating Permissive, Suppressive, Stimulatory, and Preparative Actions. Endocrine Reviews 21(1):55–89.
Schwartz, J., B. Buchanan, and G. H. 2002. Acoustic interactions among male gray treefrogs, *Hyla versicolor*, in a chorus setting. Behavioral Ecology and Sociobiology 53(1):9–19.
Scott, N. 2002. Annual report, California red-legged frog, *Rana aurora draytonii*, Permit TE-036501-4. Unpublished report submitted to the Ventura Fish and Wildlife Office. 2 pp.
Seeliger, L. M. 1945. Variation in the pacific mud turtle. JSTOR. Copeia 1945(3):150–159.
[Service] U.S. Fish & Wildlife Service. In Prep. Draft Conservation Strategy for California red-legged frog. Ventura Field Office.
[Service] U.S. Fish and Wildlife Service. 1970. Conservation of endangered species and other fish or wildlife, Appendix A. Federal Register. Vol. 35, No. 106, pp. 8491–8498. 8 pp.
[Service] U.S. Fish and Wildlife Service. 1993. Endangered and threatened wildlife and plants: Determination of threated status for the Pacific Coast population of western snowy plover. Federal Register. Vol. 58, No. 42, pp. 12864–12874.
[Service] U.S. Fish and Wildlife Service. 1999. Endangered and threatened wildlife and plants: Designation of critical habitat for the Pacific Coast population of the western snowy plover. Federal Register. Vol. 64, No. 234, pp. 68508–68544.
[Service] U.S. Fish and Wildlife Service. 2002. Recovery plan for the California red-legged frog *(Rana aurora draytonii*). U.S. Fish and Wildlife Service, Portland, Oregon. 173 pp.
[Service] U.S. Fish and Wildlife Service. 2005. Endangered and Threatened Wildlife and Plants; Final Designation of Critical Habitat for Four Vernal Pool Crustaceans and Eleven Vernal Pool Plants in California and Southern Oregon; Evaluation of Economic Exclusions from August 2003 Final Designation; Federal Register 70:46924–46999.
[Service] U.S. Fish and Wildlife Service. 2006a. California least tern (*Sterna antillarum brownii*) 5-year review summary and evaluation. U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office, Carlsbad, California. 35 pp.
[Service] U.S. Fish and Wildlife Service. 2006b. 5-Year review for the Pacific coast population of the western snowy plover (*Charadrius alexandrinus nivosus*). Arcata Fish and Wildlife Office, Arcata, California. 5 pp.
[Service] U.S. Fish and Wildlife Service. 2007a. Recovery plan for the Pacific coast population of the western snowy plover (*Charadrius alexandrinus nivosus*). In 2 volumes. Sacramento, California. xiv + 751 pp.
[Service] U.S. Fish and Wildlife Service. 2012. Endangered and threatened wildlife and plants: Revised designation of critical habitat for the Pacific Coast population of the western snowy plover. Federal Register. Vol. 77, No. 118, pp. 36727–36869.
[Service] U.S. Fish and Wildlife Service. 2015. Biological opinion on the beach management plan and water rescue training at Vandenberg Air Force Base (2014–2018) (8-8-12-F-11R). U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. 84 pp.
[Service] U.S. Fish and Wildlife Service. 2017. Biological Opinion on the Launch, Boost-back and landing of the Falcon 9 First Stage at SLC-4 at Vandenberg Air Force Base, Santa

Barbara County (2017-F-0480). Ventura Fish and Wildlife Office, Ventura, California. December 12, 2017. 71 pp.
[Service] U.S. Fish and Wildlife Service. 2018. Biological opinion for the erosion protection system maintenance at the San Antonio Road West Bridge at Vandenberg Air Force Base (2016-F-0103). U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California. 135 pp.
[Service] U.S. Fish and Wildlife Service. 2019. 5-Year review for the Pacific coast population of the western snowy plover (*Charadrius nivosus nivosus*). Arcata Fish and Wildlife Office, Arcata, California. 11 pp.
[Service] U.S. Fish and Wildlife Service. 2020. California least tern (*Sterna antillarum brownii*) 5-year review summary and evaluation. U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office, Carlsbad, California. 118 pp.
[Service] U.S. Fish and Wildlife Service. 2022a. Unpublished data for the 2021 to 2022 winter window survey and 2022 breeding window survey for western snowy plovers on the U.S. Pacific Coast. Arcata Fish and Wildlife Office, Arcata, California.
[Service] U.S. Fish and Wildlife Service. 2022b. Unpublished data for the 2014–2022 breeding window surveys for western snowy plovers on U.S. Pacific Coast. Arcata Fish and Wildlife Office, Arcata, California.
[Service] U.S. Fish and Wildlife Service. 2023a. Reinitiation of the Biological Opinion on the Launch, Boost-back and landing of the Falcon 9 First Stage at SLC-4 at Vandenberg Air Force Base, Santa Barbara County (2022-0013990-S7-001; Reinitiation of 2017-F-0480). Ventura Fish and Wildlife Office, Ventura, California. March 21, 2023.
[Service] U.S. Fish and Wildlife Service. 2023b. Species status assessment report for the northwestern pond turtle (*Actinemys marmorata*) and southwestern pond turtle (*Actinemys pallida*), Version 1.1, April 2023. U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, Ventura, California.
[Service] U.S. Fish and Wildlife Service. 2023c. U.S. Fish and Wildlife Service Mitigation Policy and Endangered Species Act Compensatory Mitigation Policy (88 FR 31000). Federal Register 88(93):31000–31001.
[Service] U.S. Fish and Wildlife Service. 2024a. Unpublished Draft data; 2024 Rangewide Western Snowy Plover Window Survey Data (winter and breeding); Draft July 9, 2024. Sent to Sarah Termondt from Micah Ashford (Arcata USFWS Office).
[Service] U.S. Fish and Wildlife Service. 2024b. U.S. Fish and Wildlife Service - Western Snowy Plover Winter Window Survey Search results between 2018-2024; Accessed Online July 9, 2024. Available online: <https://www.fws.gov/search?$keywords=%22winter%20window%20survey%22>.
[Service] U.S. Fish and Wildlife Service. 2024c. Western Snowy Plover Draft 5-year review. U.S. Fish and Wildlife Service; Arcata Field Office. Draft Accessed July 9, 2024.
[Service] U.S. Fish and Wildlife Service. 2024d. Ventura Fish and Wildlife Office. Compiled Unpublished data for 2023 WSPL Breeding season compiled in addition to 2018-2023 Robinette and Rice Report Summaries for WSPL on Vandenberg Space Force Base. Excel spreadsheet titled: <VFWO_2024_Compiled 2023 RU5 Draft Breeding Season Data (003) From ChristieB and Robinette Reports back to 2018>.
Shaffer, B. H., and P. A. Scott. 2022. Summary of *Actinemys* population genetic results provided

to the USFWS.
Shaffer, H. B., G. M. Fellers, R. Voss, C. Oliver, and G. B. Pauly. 2004. Species boundaries, phylogeography and conservation genetics of the red-legged frog (*Rana aurora/draytonii*) complex. Molecular Ecology 13:2667–2677.
Simons, A. L., K. L. M. Martin, and T. Longcore. 2021. Determining the Effects of Artificial Light at Night on the Distributions of Western Snowy Plovers (C*haradrius nivosus nivosus*) and California Grunion (*Leuresthes tenuis*) in Southern California. Journal of Coastal Research 38(2). Available online: <https://bioone.org/journals/journal-of-coastal-research/volume-38/issue-2/JCOASTRES-D-21-00107.1/Determining-the-Effects-of-Artificial-Light-at-Night-on-the/10.2112/JCOASTRES-D-21-00107.1.full>. Accessed June 18, 2024.
[SLD 30] Space Launch Delta 30. 2024. Space Launch Delta 30 Response to California Coastal Commission Request for Information 28 June 2024. 51 pages.
Spinks, P. Q., G. B. Pauly, J. J. Crayon, and H. B. Shaffer. 2003. Survival of the western pond turtle (*Emys marmorata*) in an urban California environment. Elsevier. Biological Conservation 113(2):257–267.
Spinks, P. Q., R. C. Thomson, and H. B. Shaffer. 2014. The advantages of going large: genome-wide SNPS clarify the complex population history and systematics of the threatened western pond turtle. Molecular Ecology 23(9):2228–2241.
[SRS] SRS Technologies. 2004. Breeding Activities of the Western Snowy Plover (*Charadrius alexandrinus nivosus*) on Vandenberg Air Force Base, California. Dated December 15, 2004. 58pp + appendices.
Stebbins, R. C. 1972. Amphibians and reptiles of California. California Natural History Guides #31, University of California Press, Berkeley, CA.
Stebbins, R. C., and S. M. McGinnis. 2018. Peterson Field Guide to Western Reptiles & Amphibians, Fourth Edition. 4th edition. Mariner Books, Boston, MA. 576 pp.
Stenzel, L. E., B. R. Hudgens, G. W. Page, K. K. Neuman, A. L. Palkovic, J. L. Erbes, C. R. Eyster, B. A. Ramer, and D. E. George. 2023. Climate change consequences for differential adult survival and the mating system of a temperate breeding shorebird. Ecosphere 14(7):e4608.
Stone, J. S., and E. W. Rubel. 2000. Temporal, spatial, and morphologic features of hair cell regeneration in the avian basilar papilla. The Journal of Comparative Neurology 417(1):1–16.
Storer, T. I. 1925. A synopsis of the amphibia of California. University of California Publications in Zoology 27:1–342.
Strachan, G., M. McAllister, and C. J. Ralph. 1995. Ecology and Conservation of the Marbled Murrelet. USDA Forest Service Gen. Tech. Rep. PSW-152.
Swift, C. C. 1999. Special-Status Fish Species Survey Report for San Antonio Creek, Vandenberg Space Force Base, California. 30 pp.
Tatarian, P. J. 2008. Movement Patterns of California Red-Legged Frogs (*Rana draytonii*) in an Inland California Environment. Herpetological Conservation and Biology 3(2):155–169.
Tennessen, J. B., S. E. Parks, and T. Langkilde. 2014. Traffic noise causes physiological stress and impairs breeding migration behaviour in frogs. Conservation Physiology 2(1):8.
Thomson, R. C., A. N. Wright, and H. B. Shaffer. 2016. California amphibian and reptile species

of special concern. University of California Press, Oakland, CA. 407 pp. Google-Books-ID: cMLdCwAAQBAJ.

Troïanowski, M., N. Mondy, A. Dumet, C. Arcanjo, and T. Lengagne. 2017. Effects of traffic noise on tree frog stress levels, immunity, and color signaling. Conservation Biology 31(5):1132–1140.

Tush, D., and M. T. Meyer. 2016. Polyoxyethylene Tallow Amine, a Glyphosate Formulation Adjuvant: Soil Adsorption Characteristics, Degradation Profile, and Occurrence on Selected Soils from Agricultural Fields in Iowa, Illinois, Indiana, Kansas, Mississippi, and Missouri. Environmental Science and Technology. 50(11):5781–5789.

Tuttle, D. C., R. Stein, and G. Lester. 1997. Snowy plover nesting on Eel River gravel bars, Humboldt County. Western Birds 28:174–176.

Ultsch, G. R. 2006. The ecology of overwintering among turtles: where turtles overwinter and its consequences. Cambridge University Press. Biological reviews 81(3):339–367.

U.S. Air Force. 2014. Threatened and endangered species management plan [updated]. Tab D (51 pp.) in Integrated natural resources management plan; plan period 2011–2015. Vandenberg Air Force Base, California.

[USGS] United States Geological Survey. 2019. Potential effects of increased groundwater pumping at Vandenberg Space Force Base, Santa Barbara County, California. MIPR No. F4D3D39072G001. Restricted-File Federal Interagency Report. 12 pp.

[USSF] U.S. Space Force. 2022. Unpublished California red-legged frog survey data, Honda Creek, VSFB. Electronic mail from Samantha Kaisersatt, Vandenberg Space Force Base, California, to Sarah Termondt, U.S. Fish and Wildlife Service, Ventura, California. Dated 25 August, 2022.

[USSF] U.S. Space Force. 2024c. Annual report letter of authorization: Taking marine mammals incidental to space vehicle and missile launches and aircraft test flight and helicopter operations at Vandenberg Air Force Base, California 1 January to 31 December 2023. Report dated March 20, 2024. 32 pages.

Valdez-Villavicencio, J., A. Peralta-García, and J. Guillen-González. 2016. Nueva población de la tortuga de poza del suroeste *Emys pallida* en el Desierto Central de Baja California, México. Revista Mexicana de Biodiversidad 87.

Vandenberg, L. N., C. Stevenson, and M. Levin. 2012. Low Frequency Vibrations Induce Malformations in Two Aquatic Species in a Frequency-, Waveform-, and Direction-Specific Manner. Y. Gibert, editor. PLoS ONE 7(12):10.

Warriner, J. S., J. C. Warriner, G. W. Page, and L. E. Stenzel. 1986. Mating system and reproductive success of a small population of polygamous snowy plovers. Wilson Bulletin 98(1):15–37.

[WDFW] Washington Department of Fish and Wildlife. 1995. Washington State recovery plan for the snowy plover. Olympia, Washington. 87 pp.

Wilcox, J. T., M. L. Davis, K. D. Wellstone, and M. F. Keller. 2017. Traditional surveys may underestimate *Rana draytoni*i egg-mass counts in perennial stock ponds. California Fish and Game 103(2):66–71.

Williams, S. 2014. Sounds you can’t hear can still hurt your ears. Sept 30, 2014. Science. Accessed July 23, 2024. Available online: <https://www.science.org/content/article/sounds-you-cant-hear-can-still-hurt-your-ears>.

Wilson, R. A. 1980. Snowy Plover Nesting Ecology on the Oregon Coast. M.S. Thesis, Oregon State University, Corvallis, Oregon. 41 pp.
Wise, S. 2007. Studying the ecological impacts of light pollution on wildlife: Amphibians as models. In StarLight: A Common Heritage; Proceedings of the StarLight 2007 Conference; C. Marín and J. Jafari editors. La Palma, Canary Islands, Spain.
[WPTRWCC] Western Pond Turtle Range-wide Conservation Coalition. 2020. Western pond turtle range-wide management strategy. 24 pp.
Wright, A. H., and A. A. Wright. 1949. Handbook of frogs and toads of the United States and Canada. Comstock Publishing Company, Inc., Ithaca, New York. 640 pp.
Zembal, R., S. M. Hoffman, C. Gailband, and J. Konecny. 2016. Light-footed Ridgway's (Clapper) Rail Management, Study, and Zoological Breeding in California 2016 Season.

IN LITTERIS

Kephart, B. 2022. Chief, Installation Management Flight, USSF. Letter sent to Steve Henry, U.S. Fish and Wildlife Service, regarding response to Sept 26, 2022 monitoring plan comments for Phantom Launch project. Dated November 1, 2022.

PERSONAL COMMUNICATIONS

Brandt, J. 2024. Joseph Brandt, USFWS Biologist and California condor species expert, review comments on draft California condor NLAA section within SpaceX 2024 Biological Opinion. Draft dated July 18, 2024.
Carswell, L. 2024. Lilian Carswell, USFWS Biologist and SSO species lead; Microsoft Teams chat to Sarah Termondt, USFWS Biologist regarding pinniped hearing sensitivity in comparison with otter. Sent May 30, 2024, at 9:44 AM.
Dooling, R. J. 2024. Email from Dr. Robert Dooling, Professor Emeritus, University of Maryland to Sarah Termondt, Biologist, USFWS re: anticipated effects from launch noise to WSPL hearing, associated correspondence on USSF effects analysis. Email sent April 1, 2024.
Evans, R. 2022. Biologist, Environmental Conservation 30 CES VSFB, USSF. Electronic mail sent to Sarah Termondt, U.S. Fish and Wildlife Service, regarding response to supplemental questions #2 for Phantom Launch project. Dated November 1, 2022. 5 pp.
Faunt, C., and G. Cromwell. 2021. Supervisory hydrologist, U.S. Geological Survey and Geologist, U.S. Geological Survey. Microsoft Teams Meeting with Sarah Termondt, Biologist, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office, and Christopher Diel, Assistant Field Supervisor, U.S. Fish and Wildlife Service, Ventura Fish and Wildlife Office regarding additional clarifications on 7.7 acre-feet water extraction amount based on USGS 2019 and 2021 hydrological analysis/modeling for 921 acre-feet extraction within San Antonio Creek for the operation of the Vandenberg Dunes Golf Courses at Vandenberg Space Force Base. Dated June 24, 2021.
Kaisersatt, S. 2022. Chief, Environmental Conservation 30 CES VSFB, USSF. Electronic mail

sent to Sarah Termondt, USFWS Biologist, regarding clarification on Phantom Launch soot production. Dated August 26, 2022

Kaisersatt, S. 2023a. Chief, Environmental Conservation 30 CES VSFB, USSF. Electronic mail sent to Chris Diel, USFWS Assistant Field supervisor, regarding clarification on SpaceX Reinitiation. Dated January 17, 2023. 8 pp.

Kaisersatt, S. 2023b. Chief, Environmental Conservation, USSF. Email to Chris Diel, Assistant Field Supervisor, USFWS, regarding California red-legged frogs at the San Antonio Creek oxbow restoration site. Dated April 25, 2023. 1 pp.

Kaisersatt, S. 2024. Chief, Environmental Conservation 30 CES VSFB, USSF. Electronic mail) to Chris Diel (Assistant Field Supervisor, Ventura Field Office, USFWS) re: initial SpaceX response to additional information request attachment. Sent May 1, 2024.

Lieske, Patrick, Forest Wildlife Biologist, US Forest Service, Solvang, CA. 2021. Electronic mail to Dou-Shuan Yang, Biologist, US Fish and Wildlife Service, Sacramento, California. Subject: California red-legged frog data – Matilija Creek Watershed, dated October 1, 2021.

[Service] U.S. Fish and Wildlife Service. 2024e. Email from Micah Ashford, WSPL Range Species Lead, Arcata Field Office, to Christie Boser, WSPL species lead, Ventura Fish and Wildlife Office re: Vandenberg plover time spent at breeding sites declining, preliminary data analysis between 2020 to 2023. Email Sent July 17, 2024.

Seymoure, B. 2024 Assistant Professor of Biological Sciences and lighting specialist at University of Texas at El Paso. Email conversation and meetings with Sarah Termondt, USFWS biologist, regarding VIIRS data surrounding SLC-4, UV Filter BMPs; Email conversation and meetings between February 16 to 22, 2024.

Schwartz, C. 2023. Graduate Student, San Francisco State University, Department of Biology. Email conversation with Sarah Termondt, USFWS biologist, regarding recommended improvements to Space Force’s proposed bioacoustic monitoring design for amphibians. Email thread dated January 20 to July 17, 2023.

SpaceX. 2024a. Communication during July 2, 2024 In person meeting held at VSFB with Microsoft Teams virtual component between USFWS Region 8 Office, USFWS Ventura Field Office, SpaceX, and U.S. Space Force including Paul Souza (Regional Director) and Kiko Dontchev (SpaceX) and Col. Mark Shumaker (USSF) regarding agreement to bridge consult for 14 launches from SLC-4 between October to December 31, 2024.

SpaceX. 2024b. Communication during July 25, 2024 12:00pm Microsoft Teams Meeting with USFWS Region 8 Office, USFWS Ventura Field Office, SpaceX, and U.S. Space Force including Paul Souza (Regional Director) and Kiko Dontchev (SpaceX) regarding changes to proposed project description from 14 with 1 boost back to 16 launches with 2 boost backs from SLC-6 between October to December 31, 2024.

Tennessen, J. 2022. Jennifer Tennessen, NOAA Research Scientist, email to Sarah Termondt, USFWS Biologist regarding sensory pollutant effects monitoring techniques for California red-legged frog. August 9, 2022.

[USSF] U.S. Space Force. 2024a. Email from Tiffany Whitsitt-Odell, USSF, sent to Sarah Termondt USFWS via [DoD SAFE]; Re: Requested SpaceX Noise and Overpressure Shapefiles for 2024 Consultation. Unpublished project GIS data saved to VFWO internal Server. Email sent on July 11, 2024.

[USSF] U.S. Space Force. 2024b. Email from Tiffany Whitsitt-Odell, Biologist 30 CES USSF. VSFB Response to USFWS questions with launch schedule. Sent to Sarah Termondt, Biologist, USFWS. Email dated July 12, 2024.

[USSF] U.S. Space Force. 2024d. Email from Tiffany Whitsitt-Odell, Biologist, USSF, sent to Sarah Termondt, Biologist Ventura Fish and Wildlife Office, re: draft SpaceX NLAA comment responses. Comment from John LaBonte (Mantech Contractor) regarding SWPT habitat suitability in Bear creek. August 2, 2024.

York, D. 2024. Electronic email sent to Sarah Termondt, Biologist Ventura Fish and Wildlife Office, re: clarifications on State Water VSFB use and maintenance period. Sent July 23, 2024.

APPENDIX A – Figures

Launch Noise Effect Area

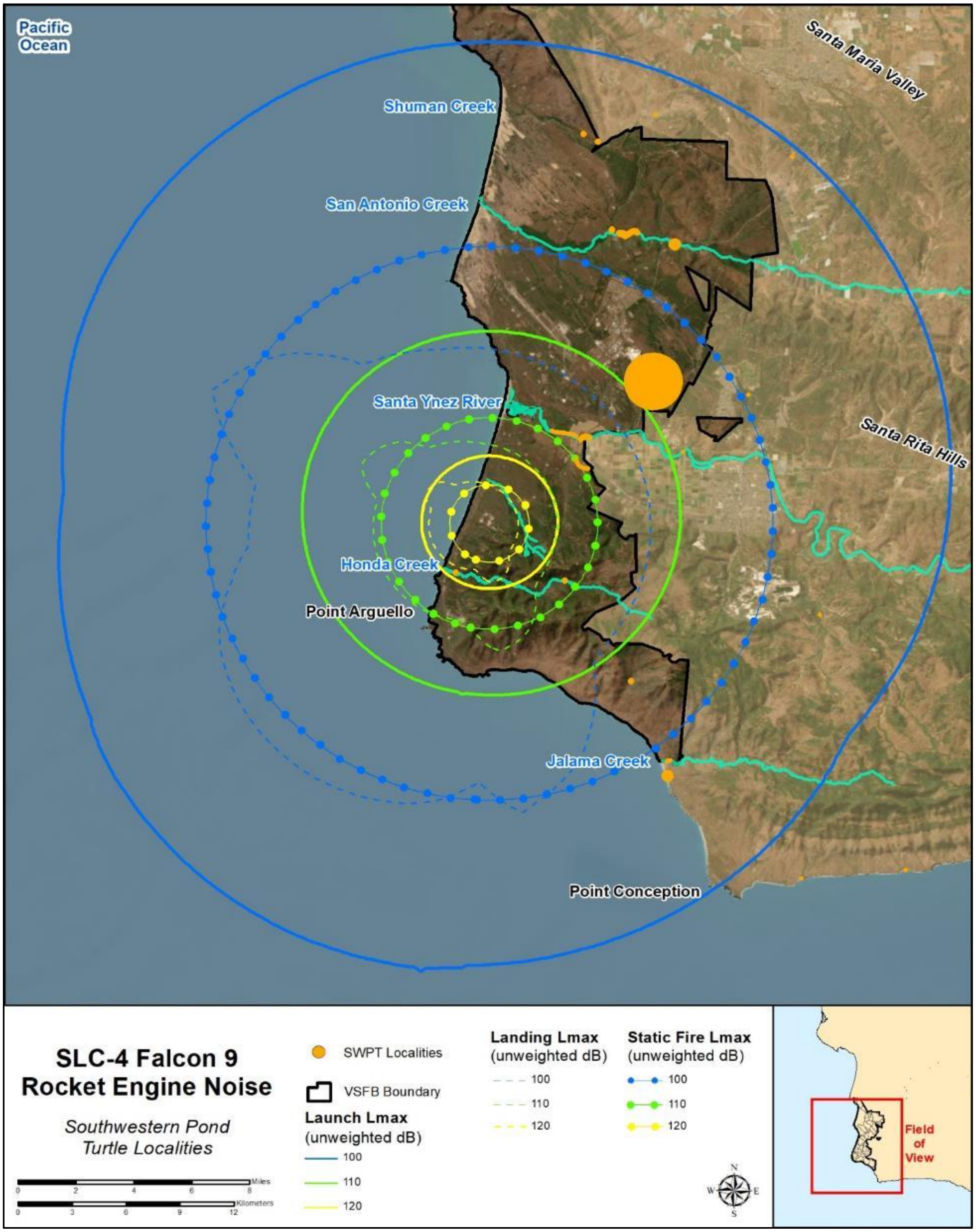

Figure 1A. Southwestern pond turtle occurrences and the projected Launch Noise Effect Area.

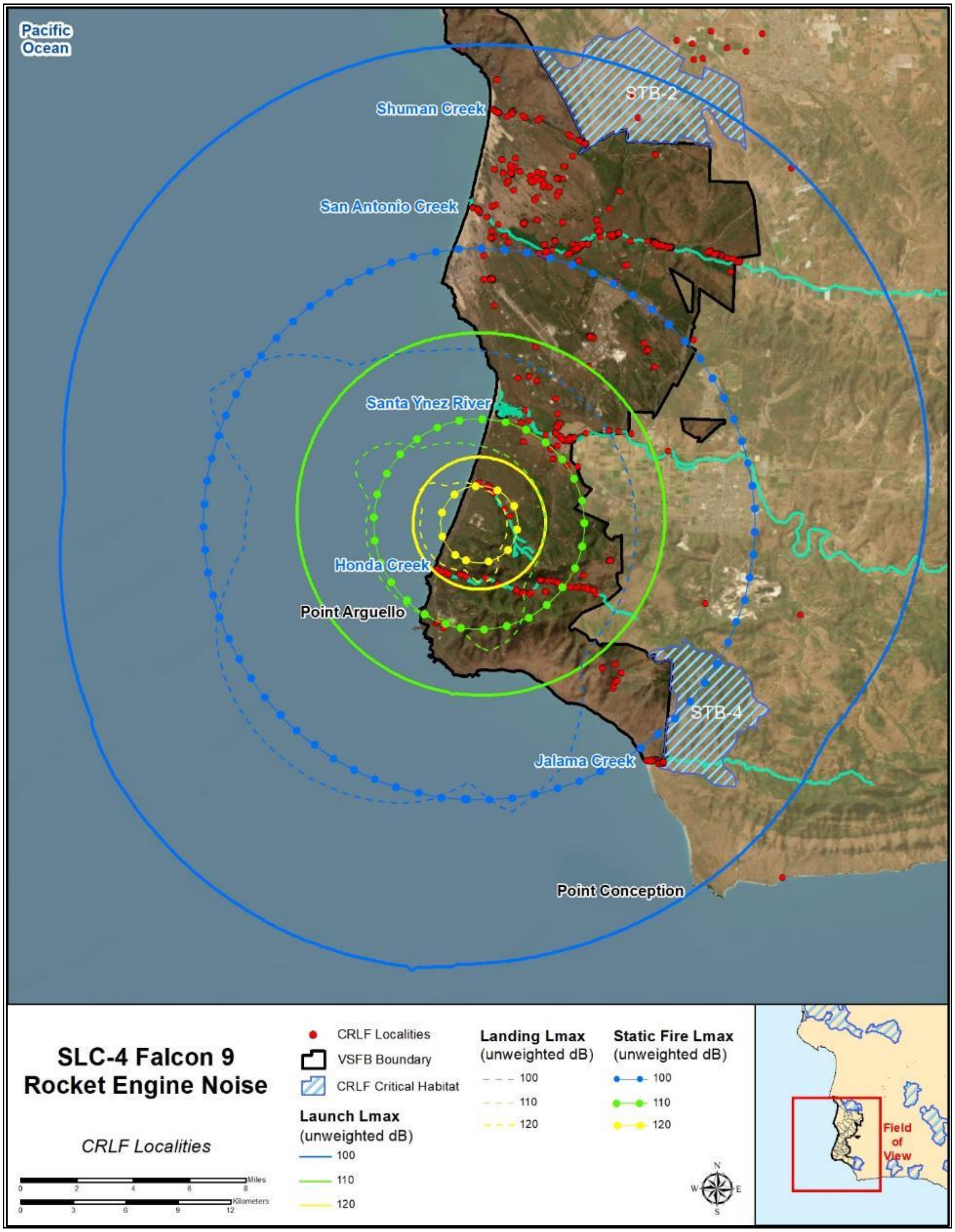

Figure 1B. California red-legged frog occurrences and the projected Launch Noise Effect Area.

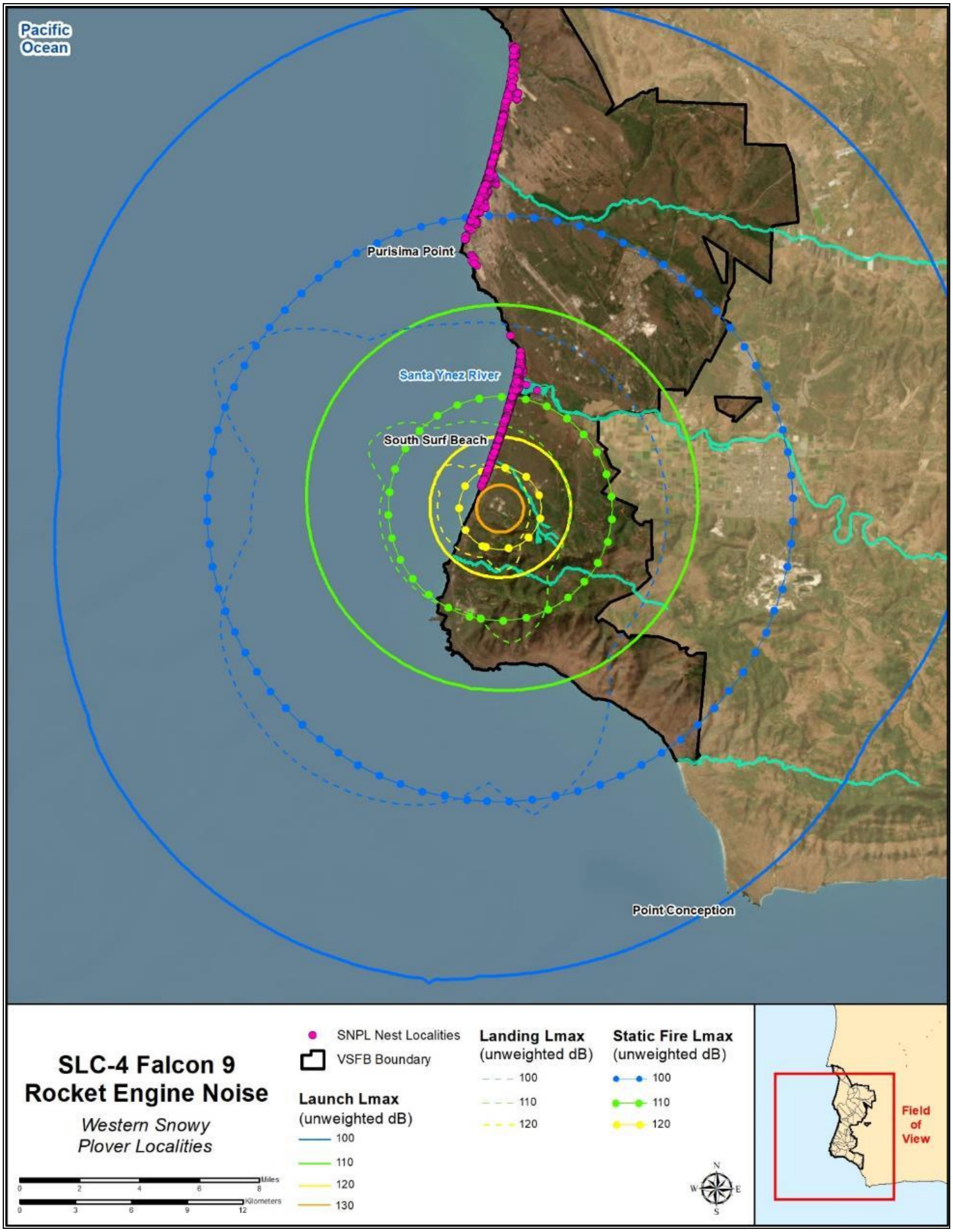

Figure 1C. Western snowy plover nesting occurrences and the projected Launch Noise Effect Area.

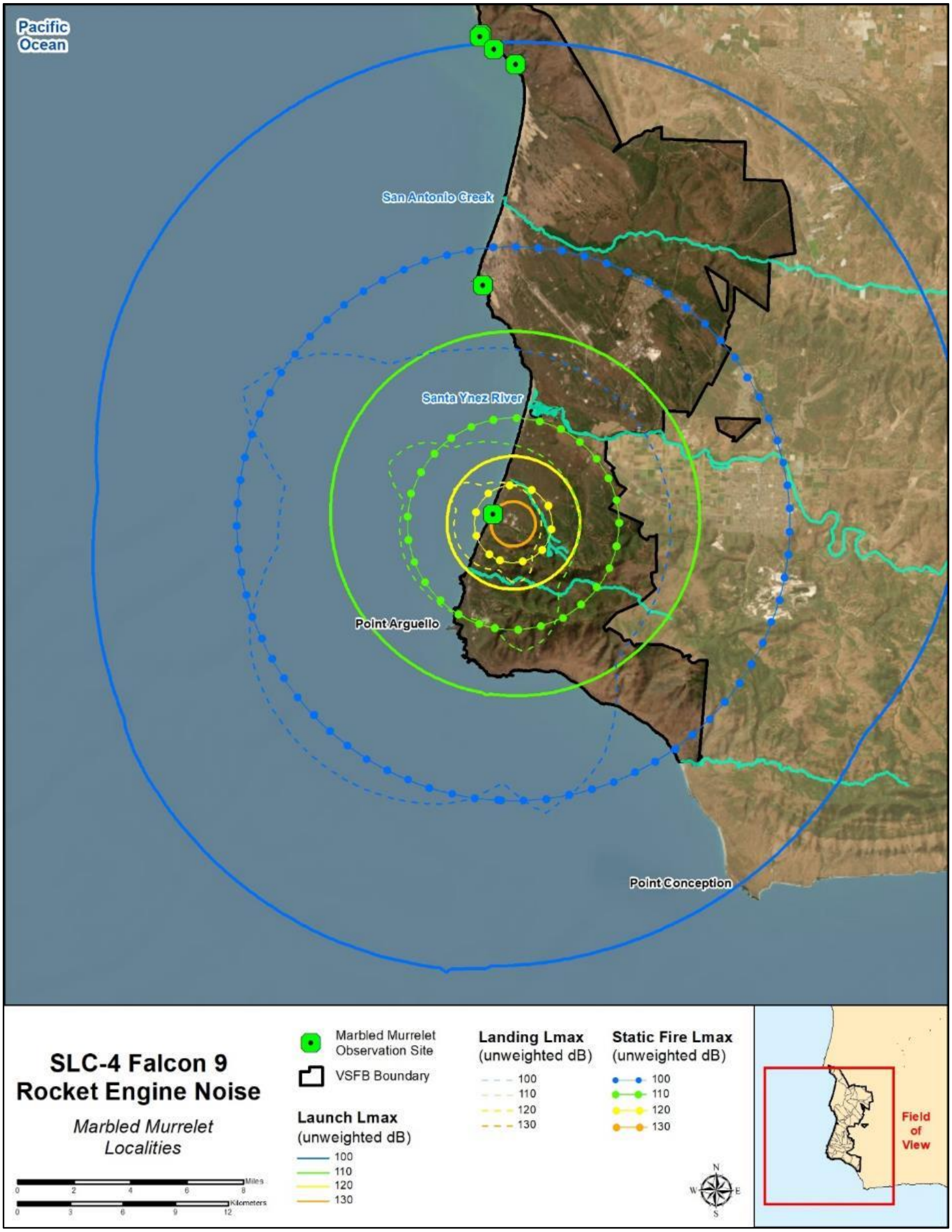

Figure 1D. Marbled Murrelet occurrence observation sites and the projected Launch Noise Effect Area.

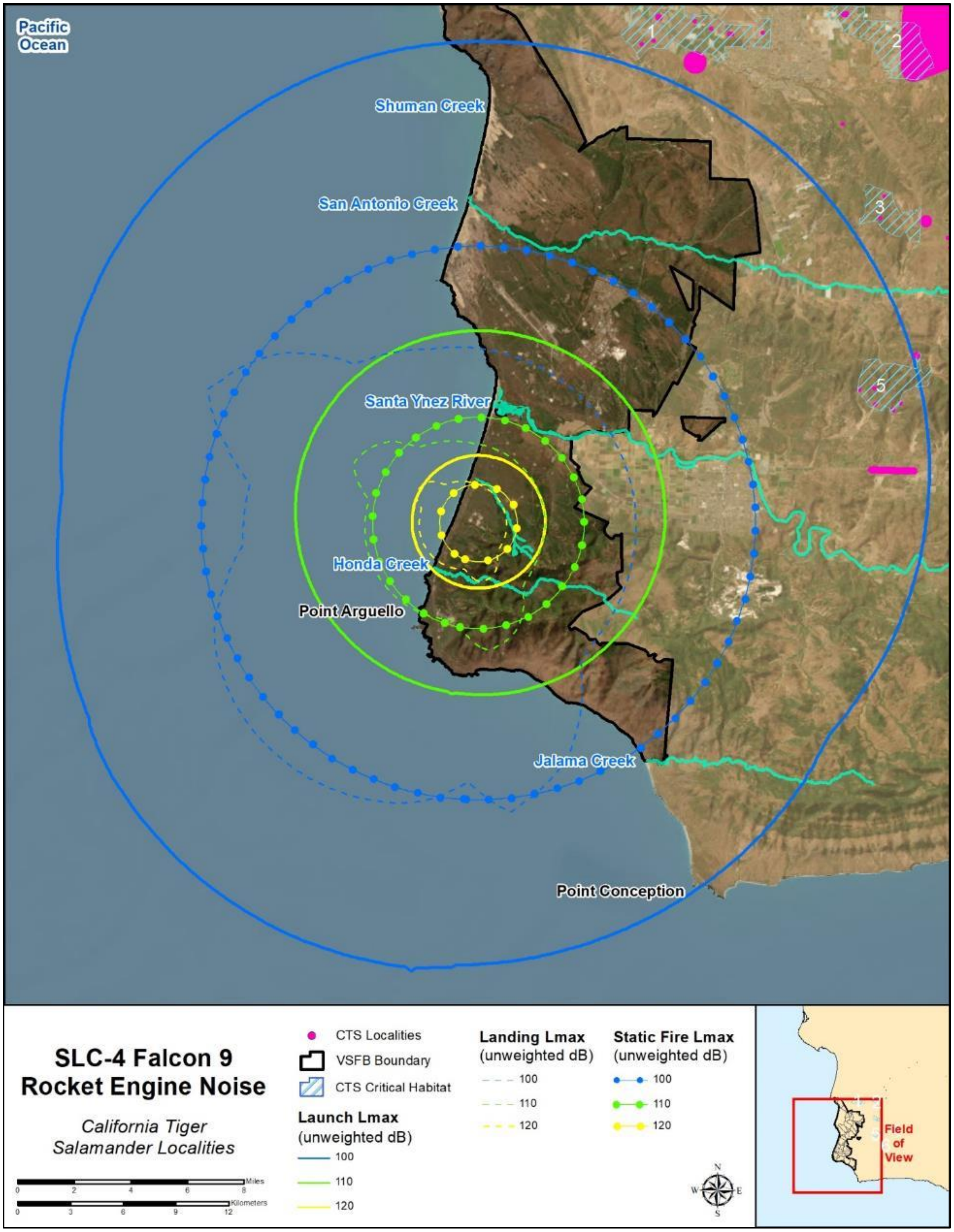

Figure 1E. California tiger salamander occurrences and the projected Launch Noise Effect Area.

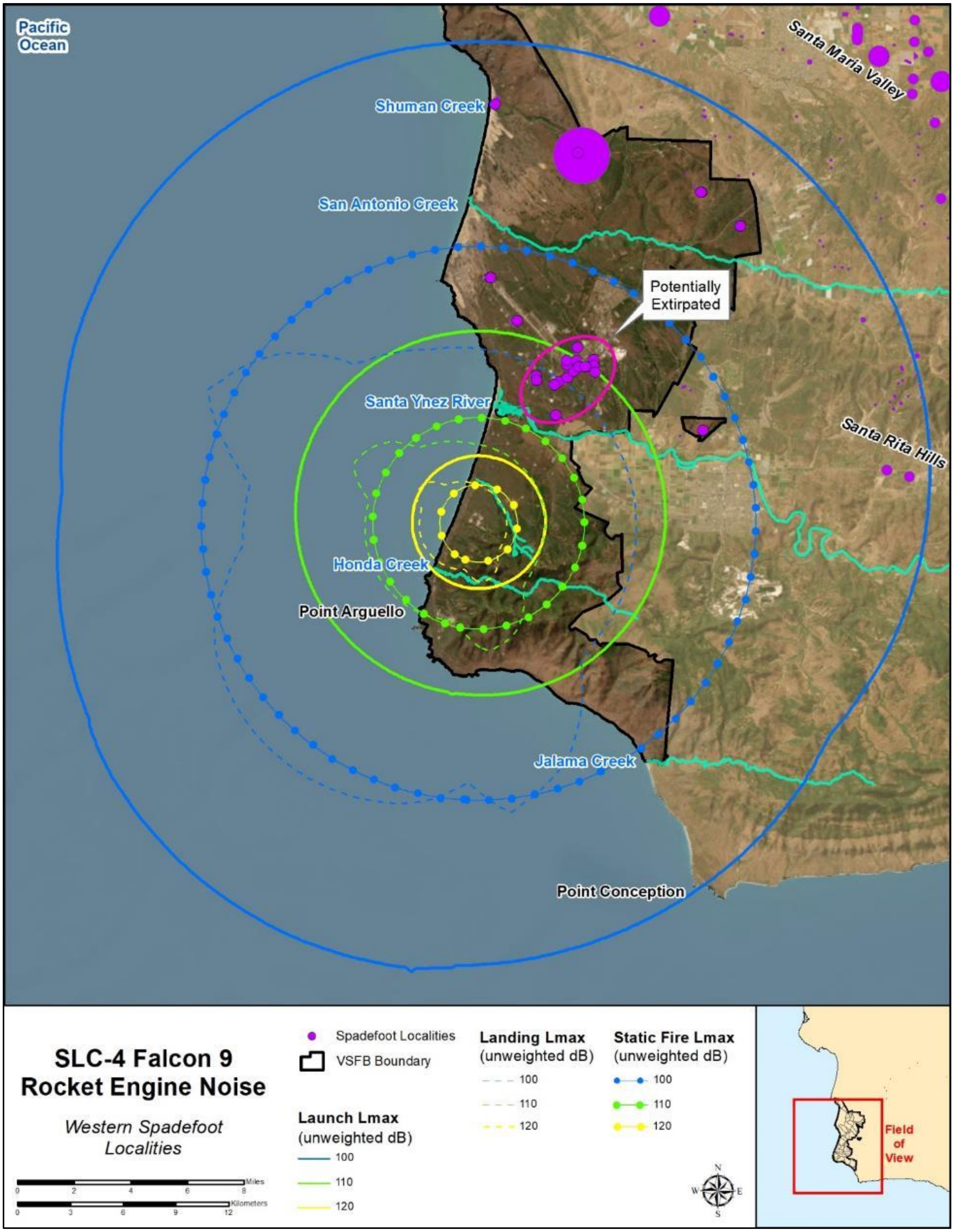

Figure 1F. Western spadefoot occurrences and the projected Launch Noise Effect Area.

Sonic Boom Overpressure Effect Area; Launch Descent (boost-back landing)

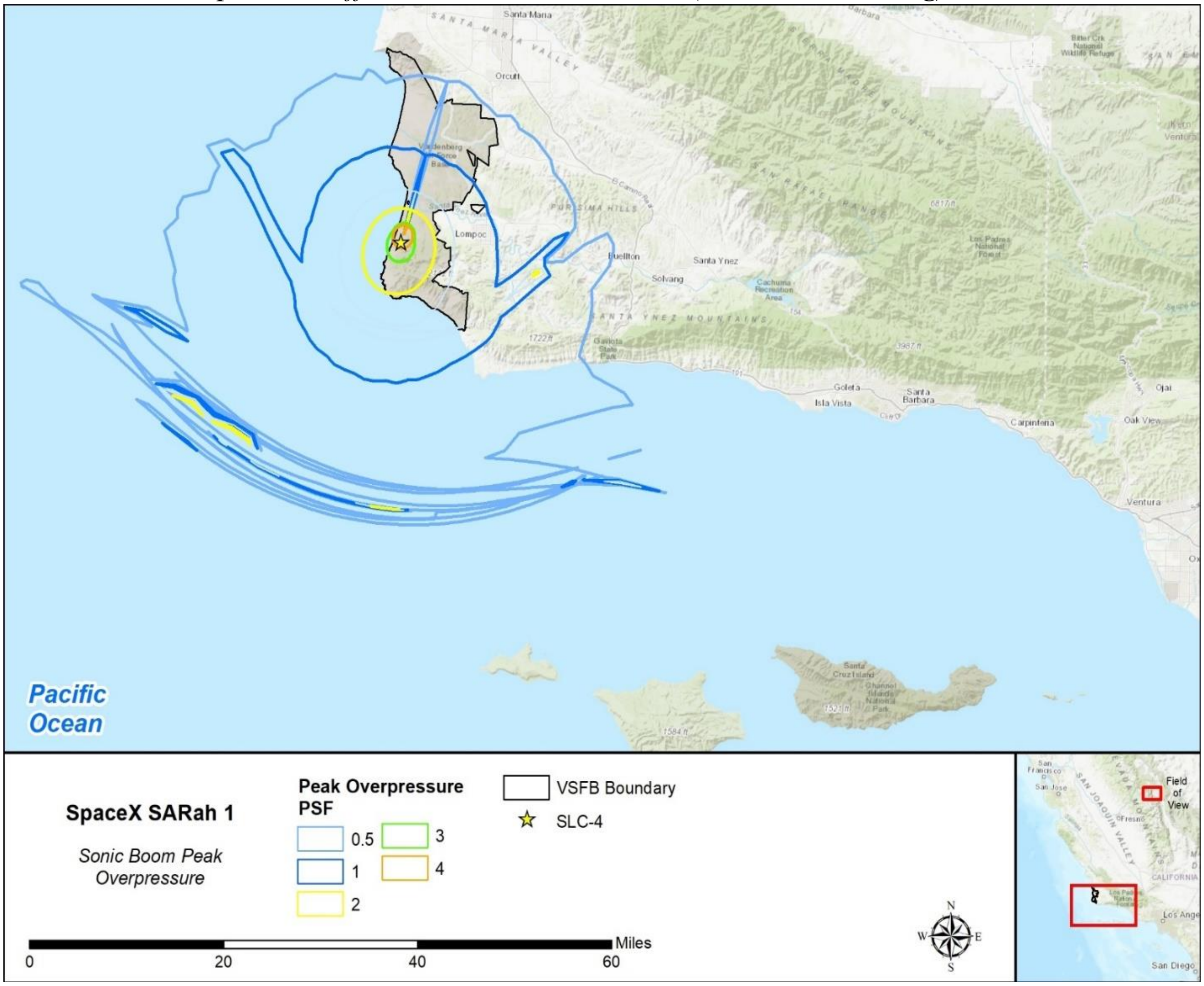

Figure 2A. The Sonic Boom Overpressure Effect Area impacting VSFB during launch descent to SLC-4.

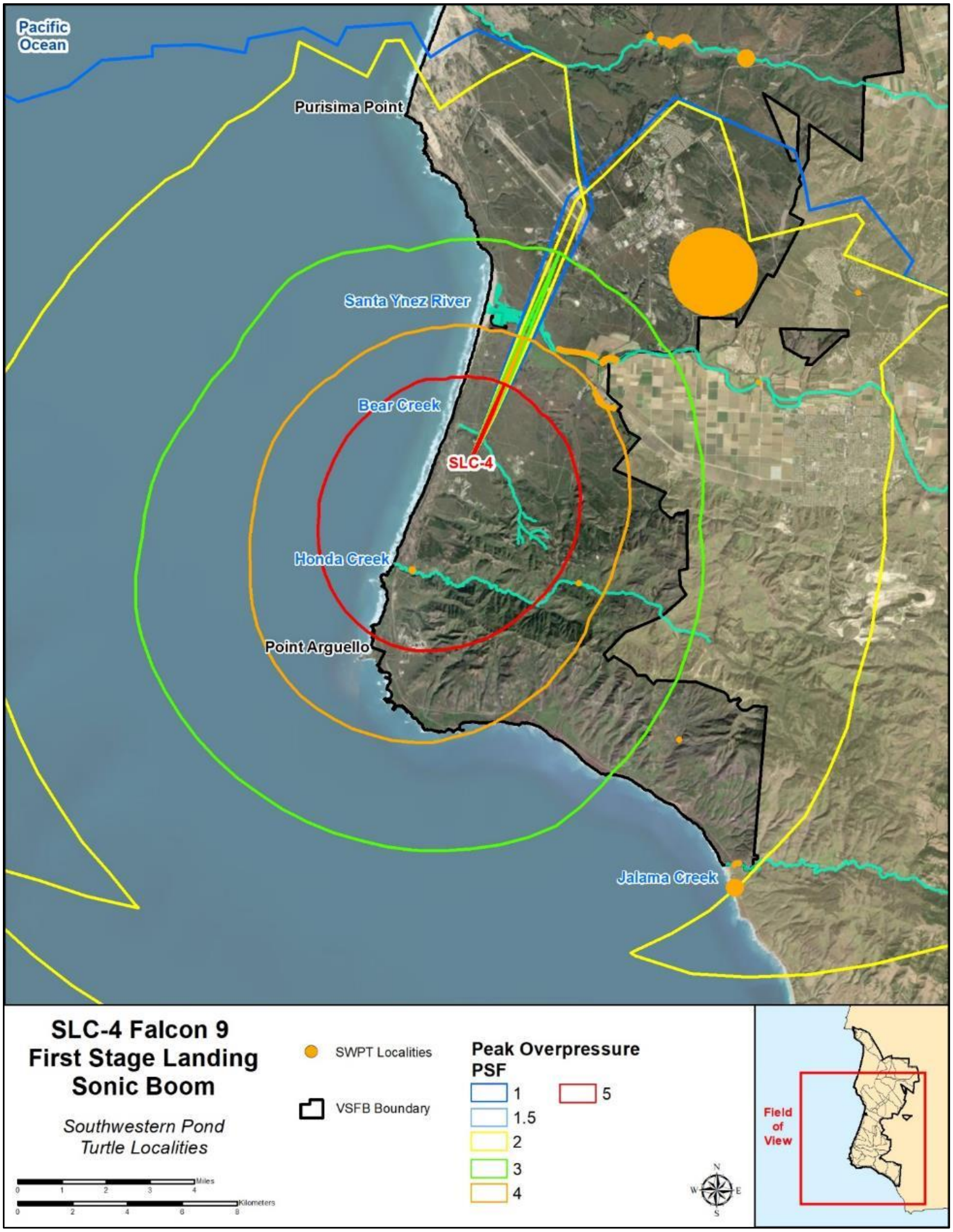

Figure 2B. Southwestern pond turtle occurrences and the projected Sonic Boom Overpressure Effect Area produced during vehicle landing at SLC-4.

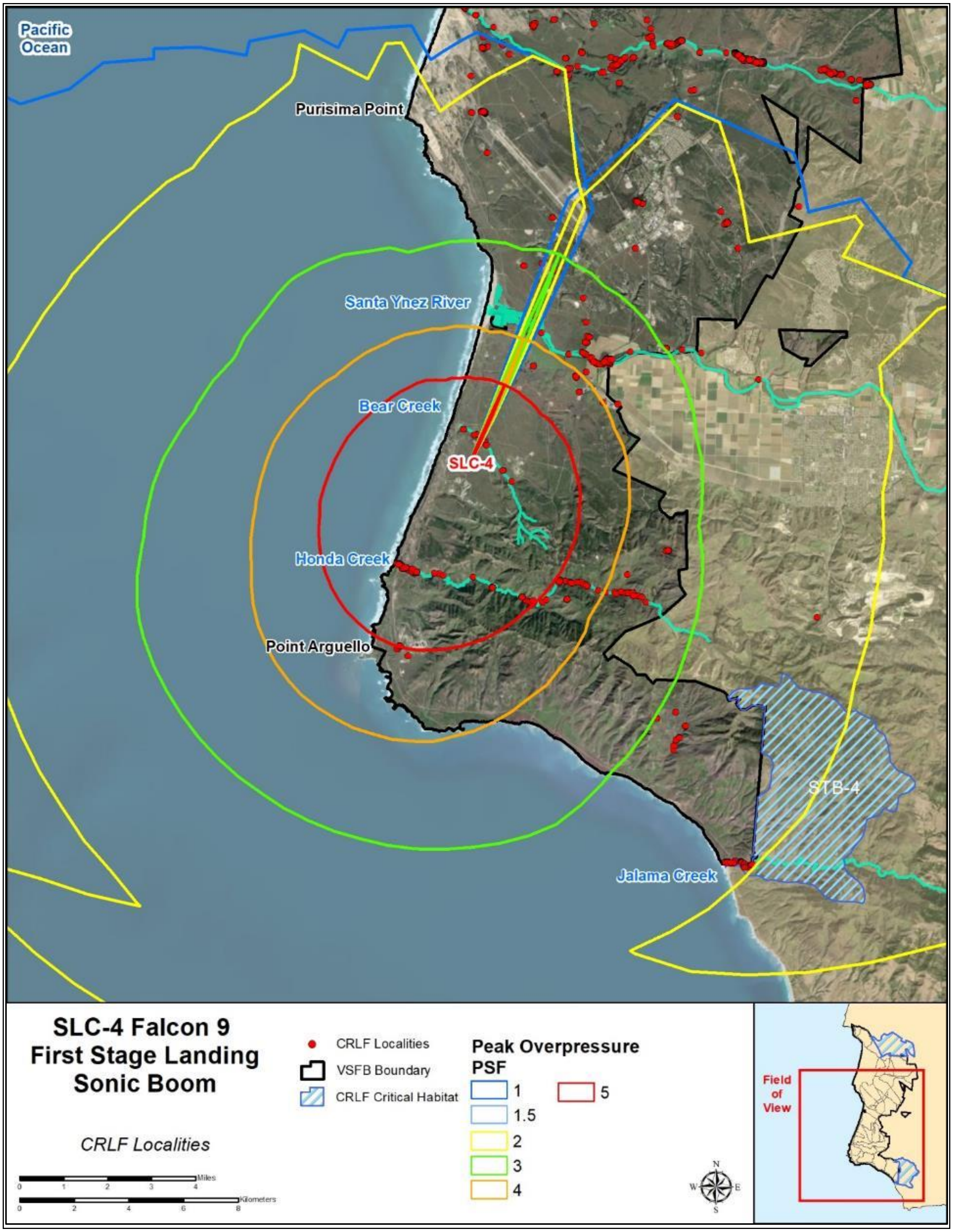

Figure 2C. California red-legged frog occurrences and the projected Sonic Boom Overpressure Effect Area produced during vehicle landing at SLC-4.

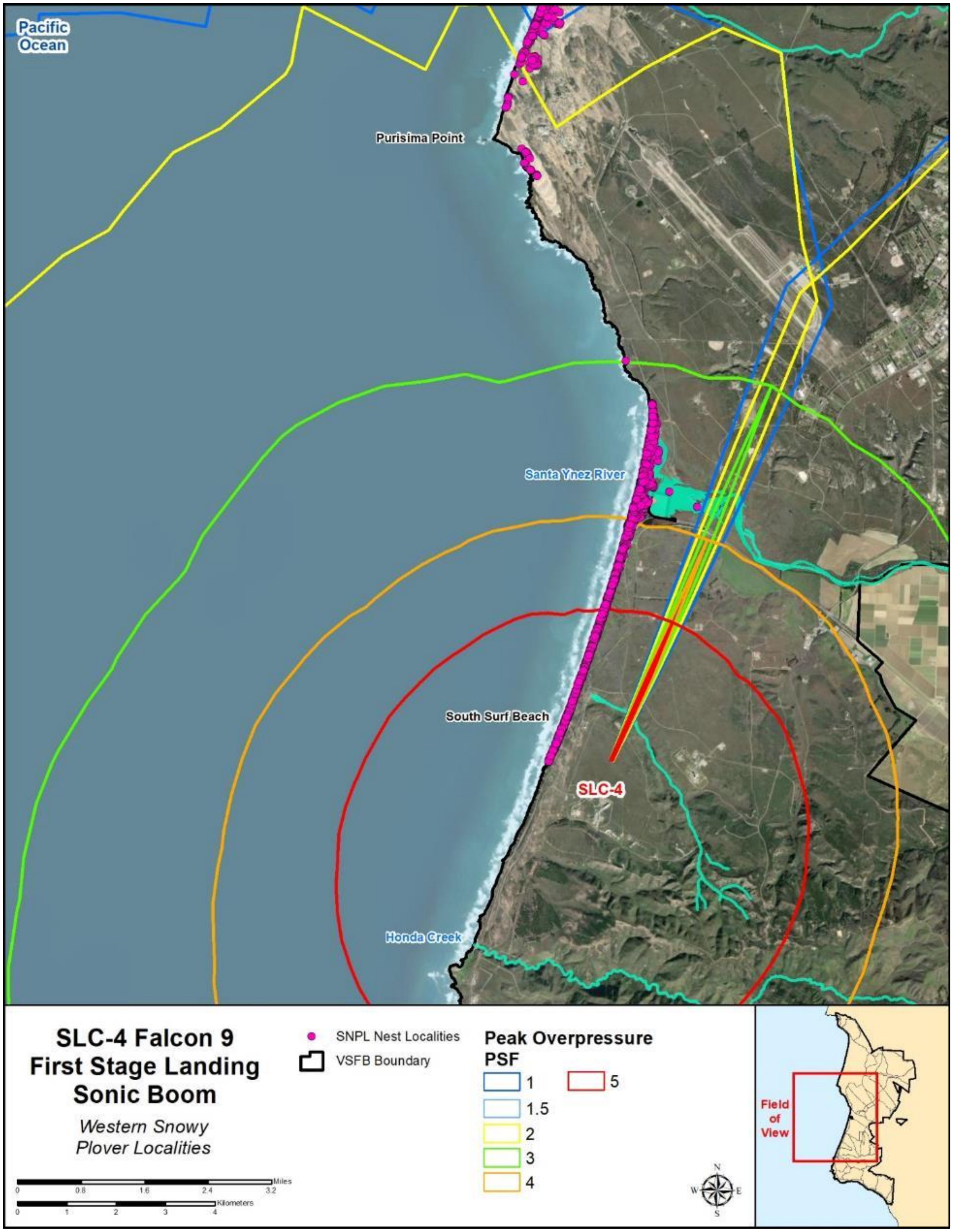

Figure 2D. Western snowy plover nesting occurrences and the projected Sonic Boom Overpressure Effect Area produced during vehicle landing at SLC-4.

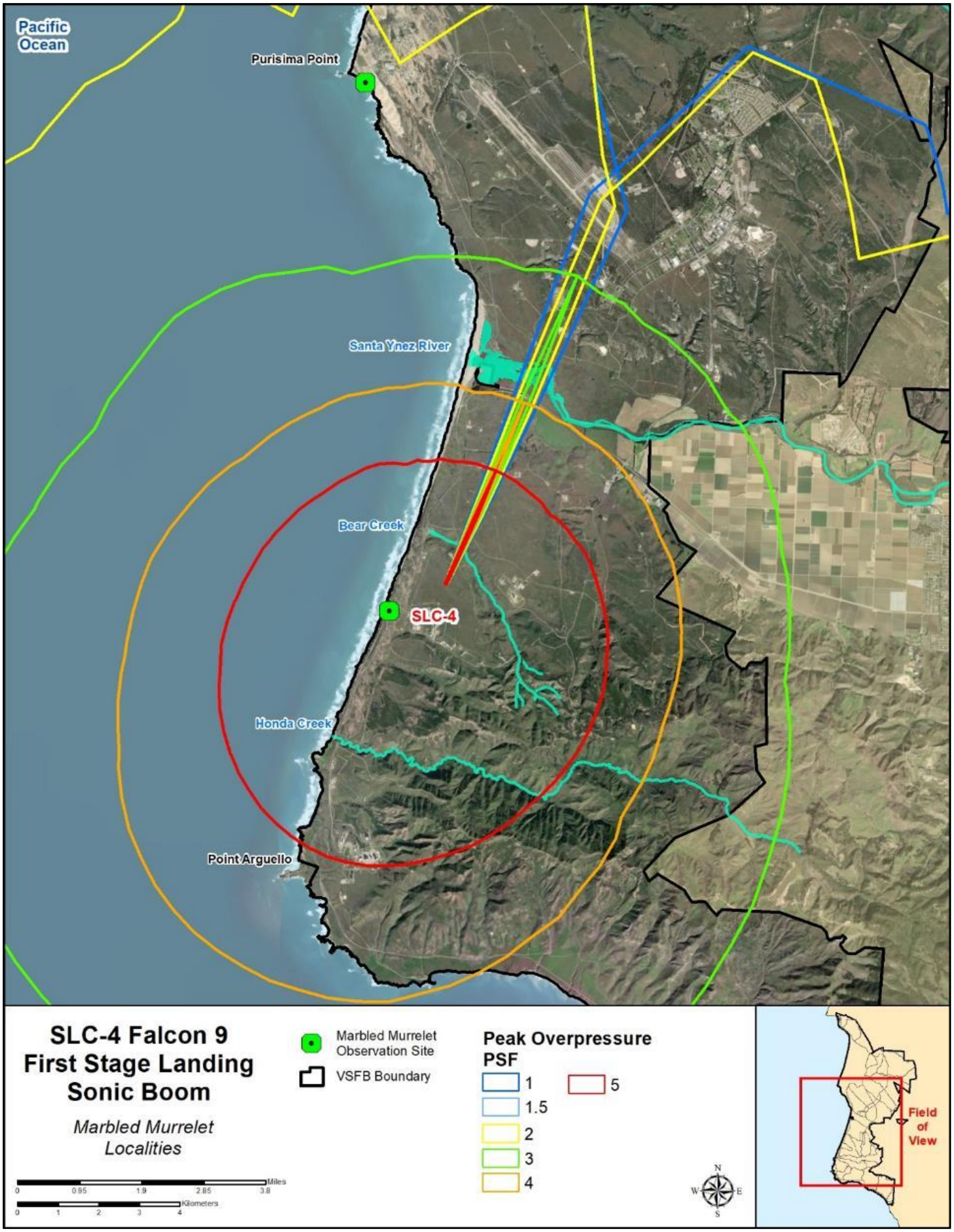

Figure 2E. Marbled murrelet occurrence observation sites and the projected Sonic Boom Overpressure Effect Area produced during vehicle landing at SLC-4.

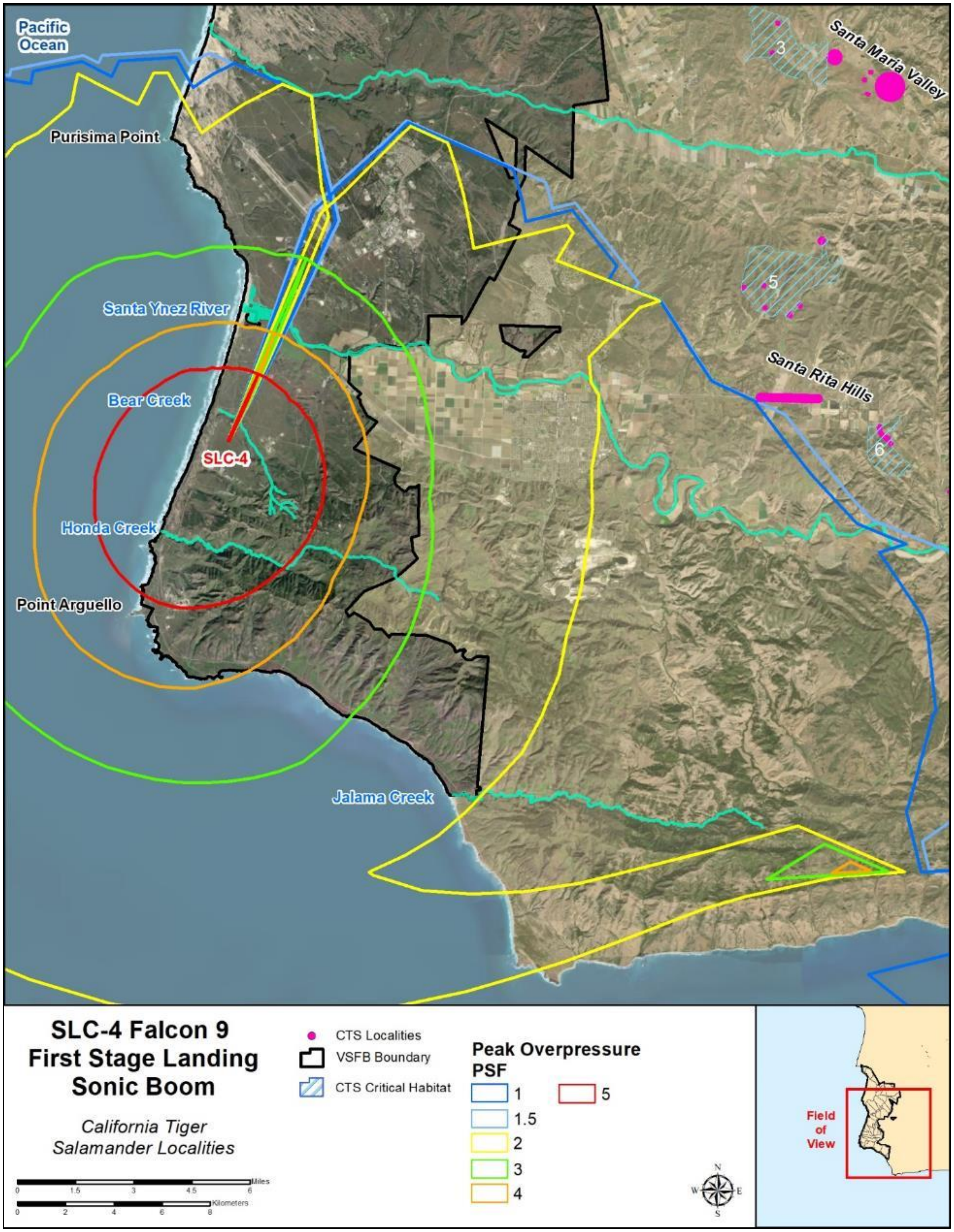

Figure 2F. California tiger salamander occurrences and the projected Sonic Boom Overpressure Effect Area produced during vehicle landing at SLC-4.

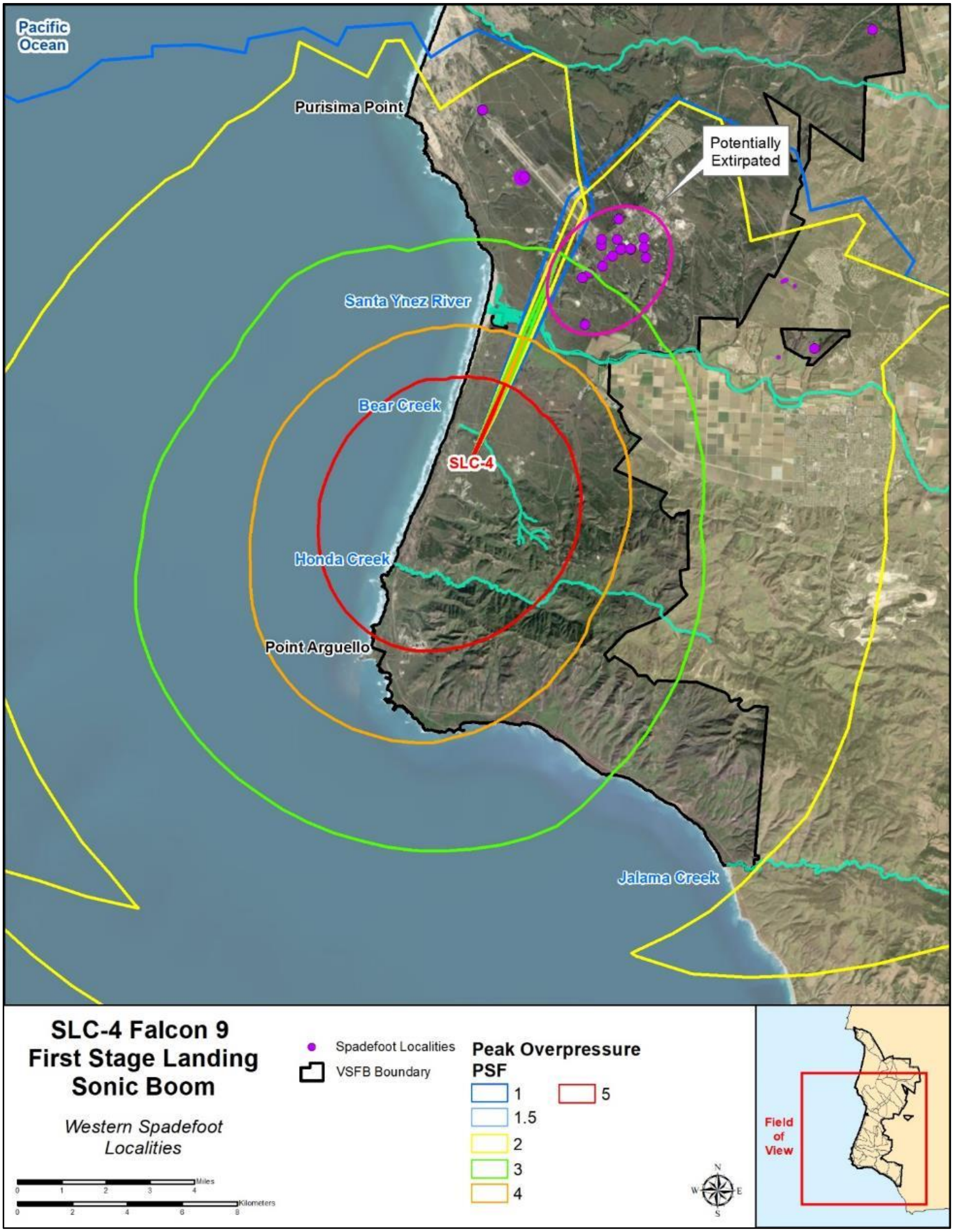

Figure 2G. Western spadefoot occurrences and the projected Sonic Boom Overpressure Effect Area produced during vehicle landing at SLC-4.

Sonic Boom Overpressure Effect Area; Launch Ascent

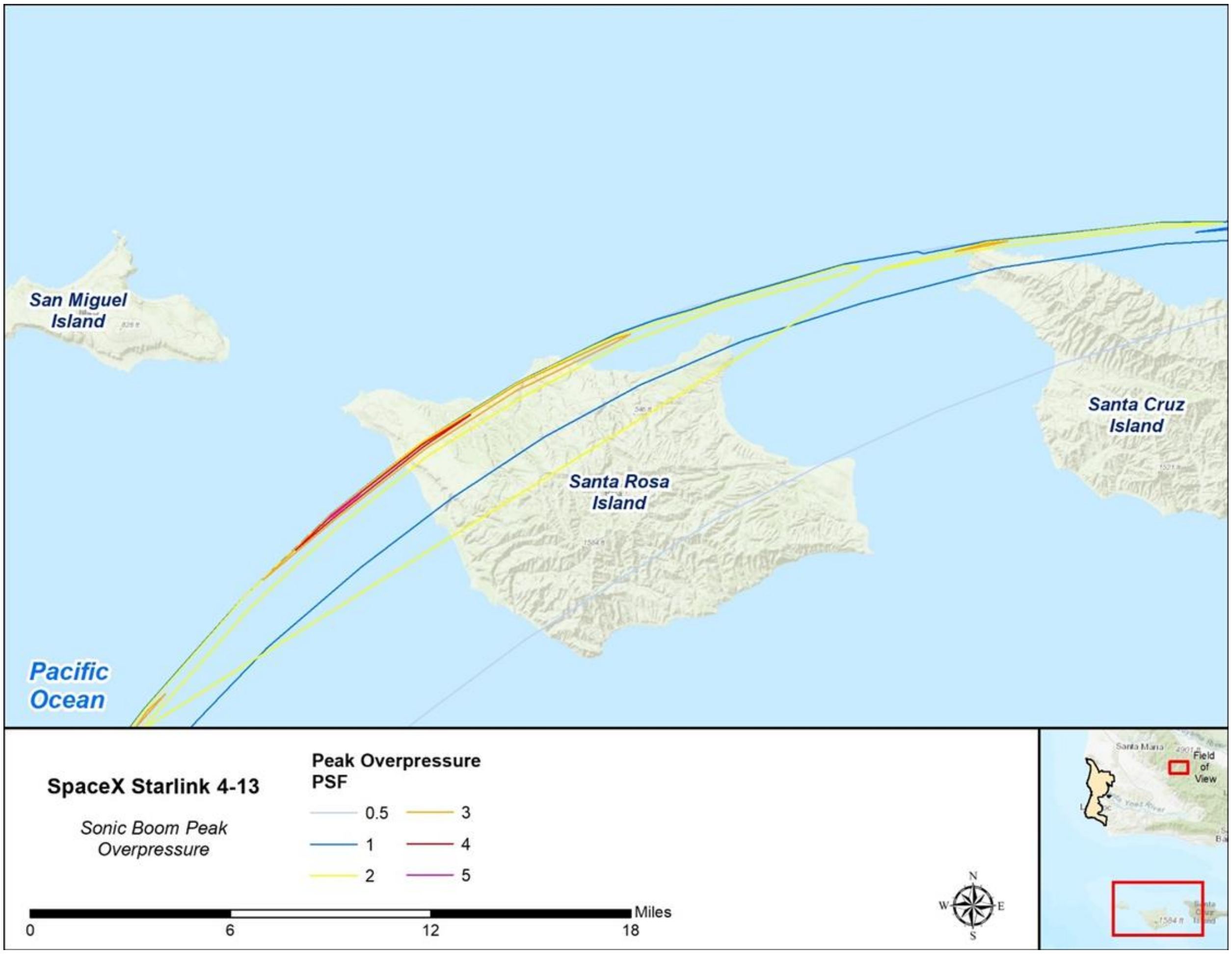

Figure 2H. Portion of the Sonic Boom Overpressure Effect Area impacting Northern Channel Islands during launch ascent.

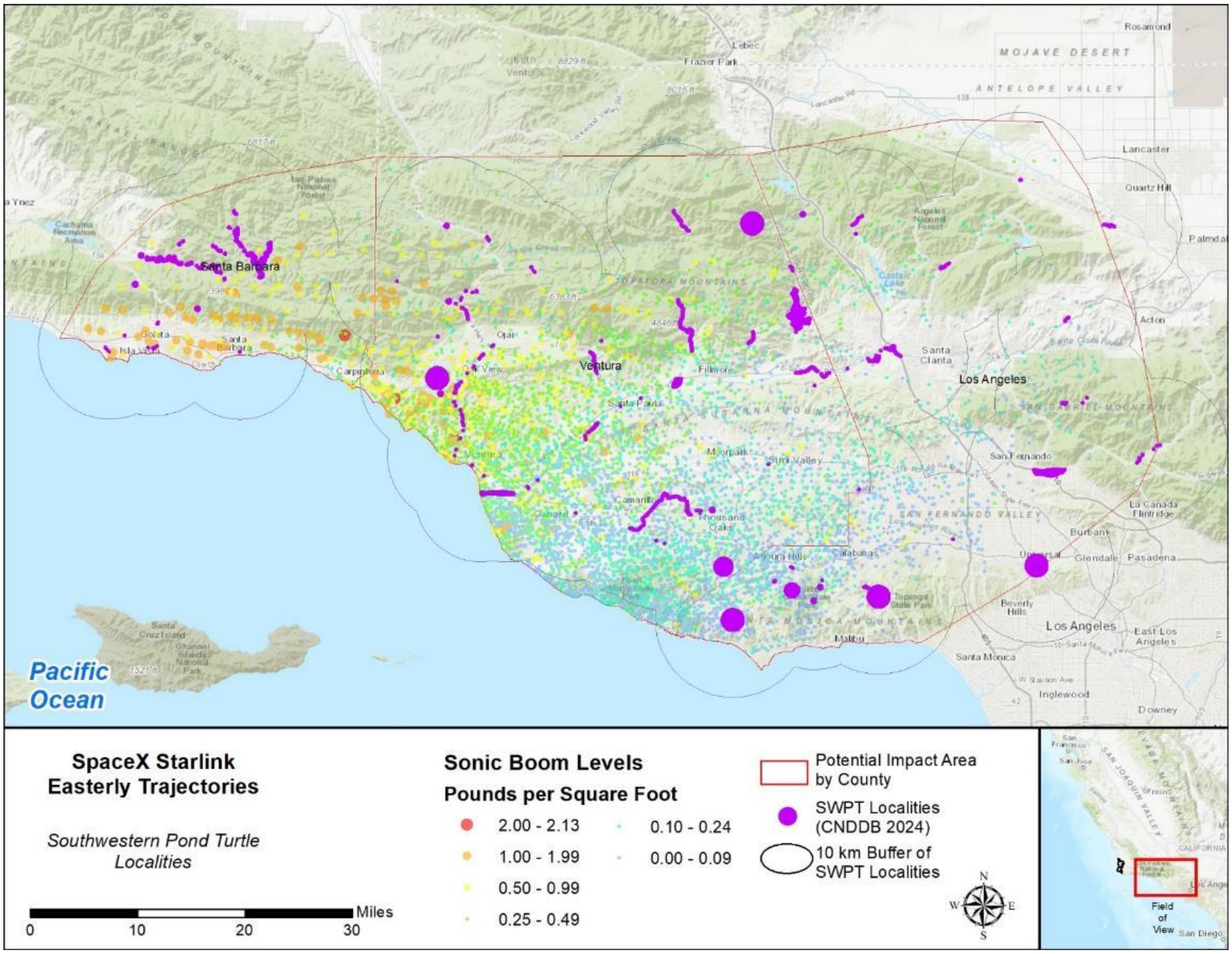

Figure 2I. Southwestern pond turtle occurrences and the Sonic Boom Overpressure Effect Area impacting Mainland California during launch ascent.

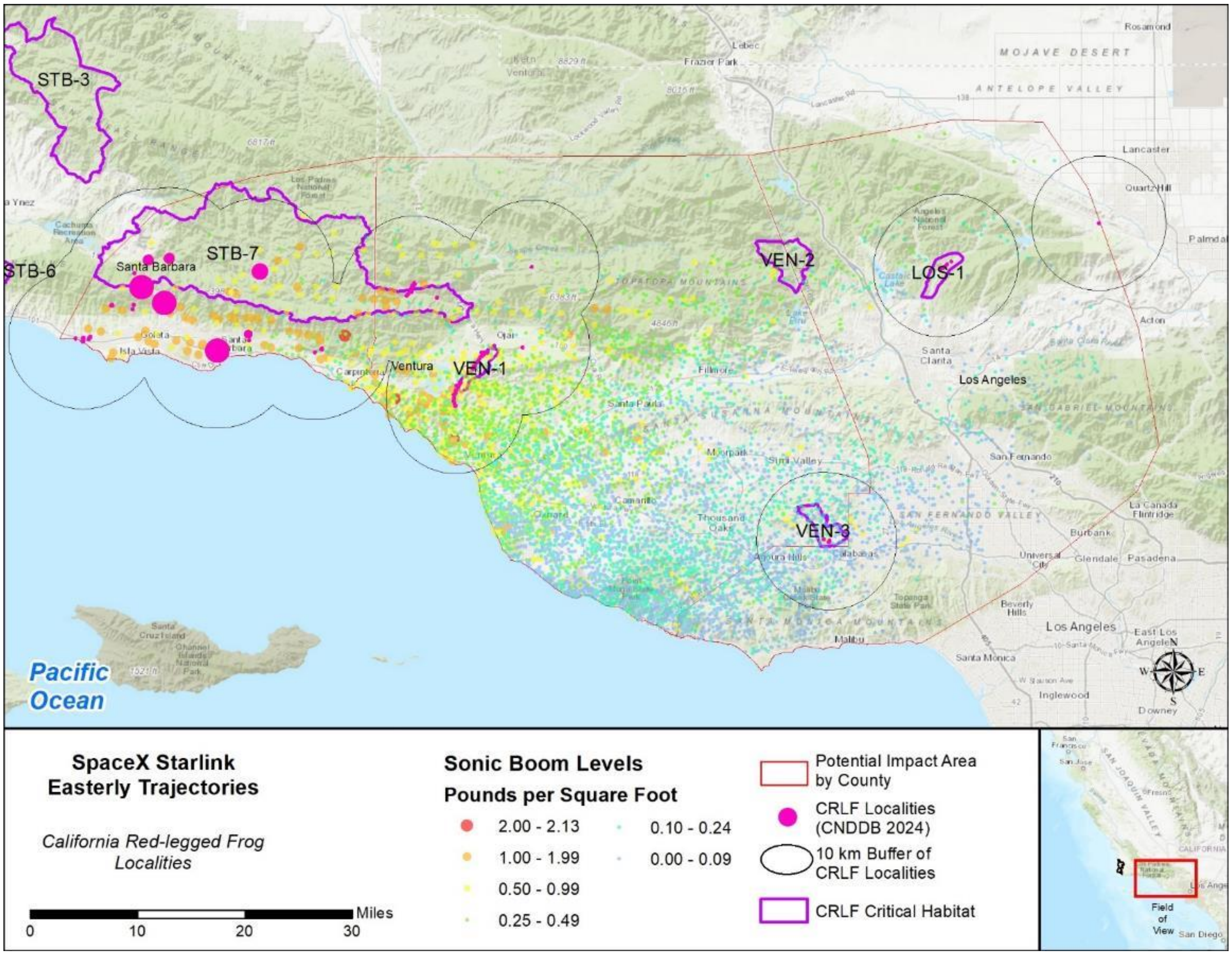

Figure 2J. California red-legged frog occurrences and the Sonic Boom Overpressure Effect Area impacting Mainland California during launch ascent.

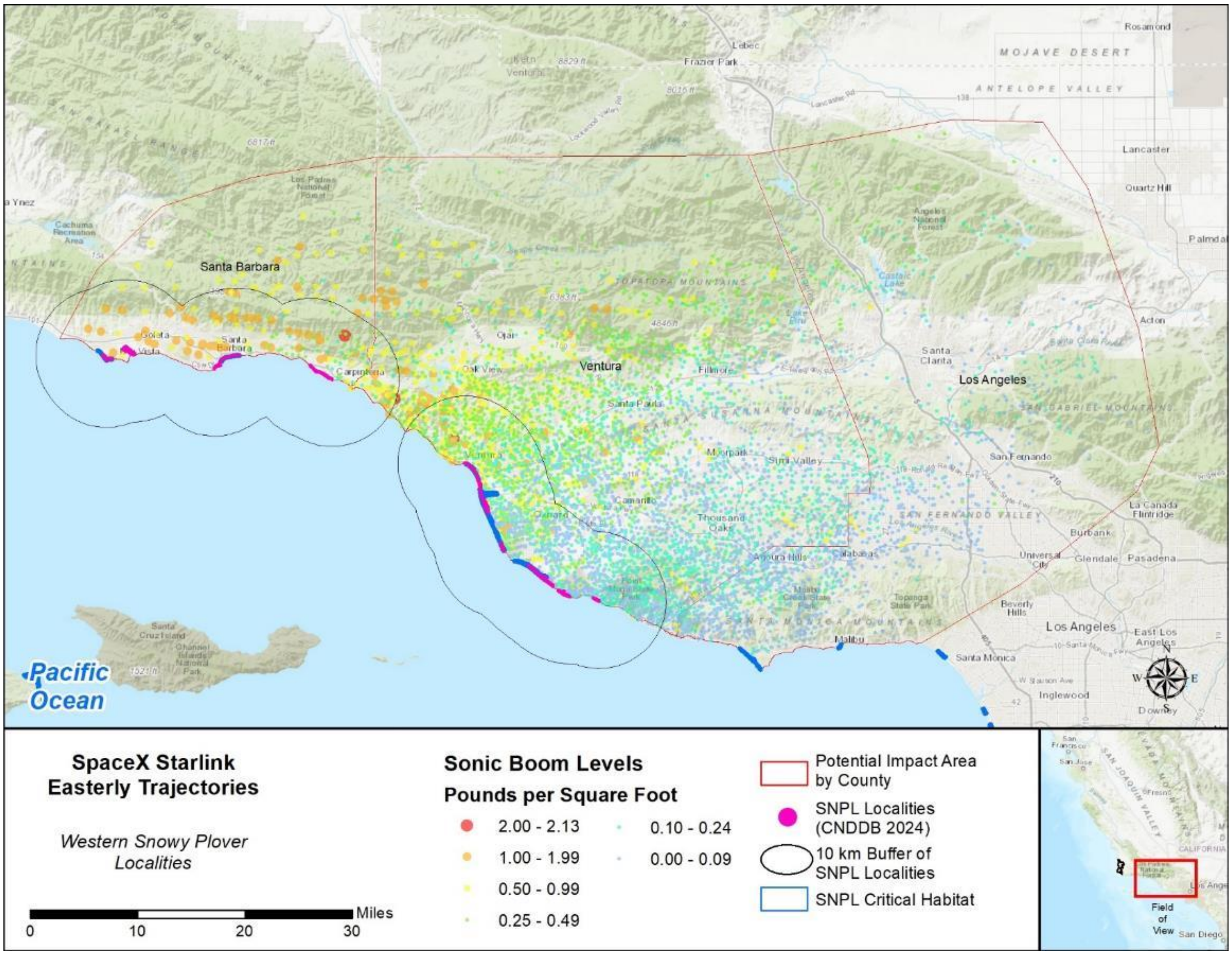

Figure 2K. Western snowy plover occurrences and the Sonic Boom Overpressure Effect Area impacting Mainland California during launch ascent.

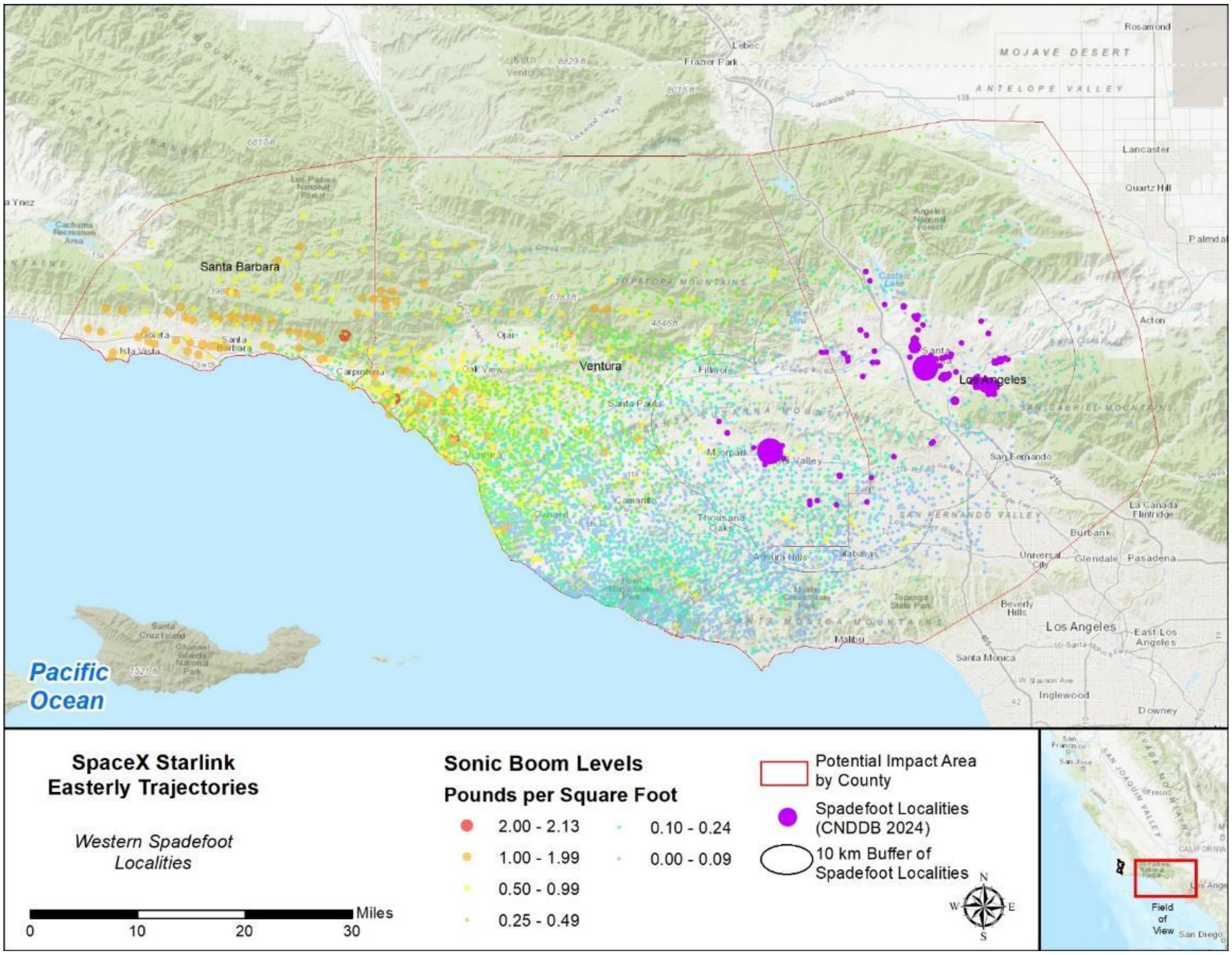

Figure 2L. Western spadefoot occurrences and the Sonic Boom Overpressure Effect Area impacting Mainland California during launch ascent.

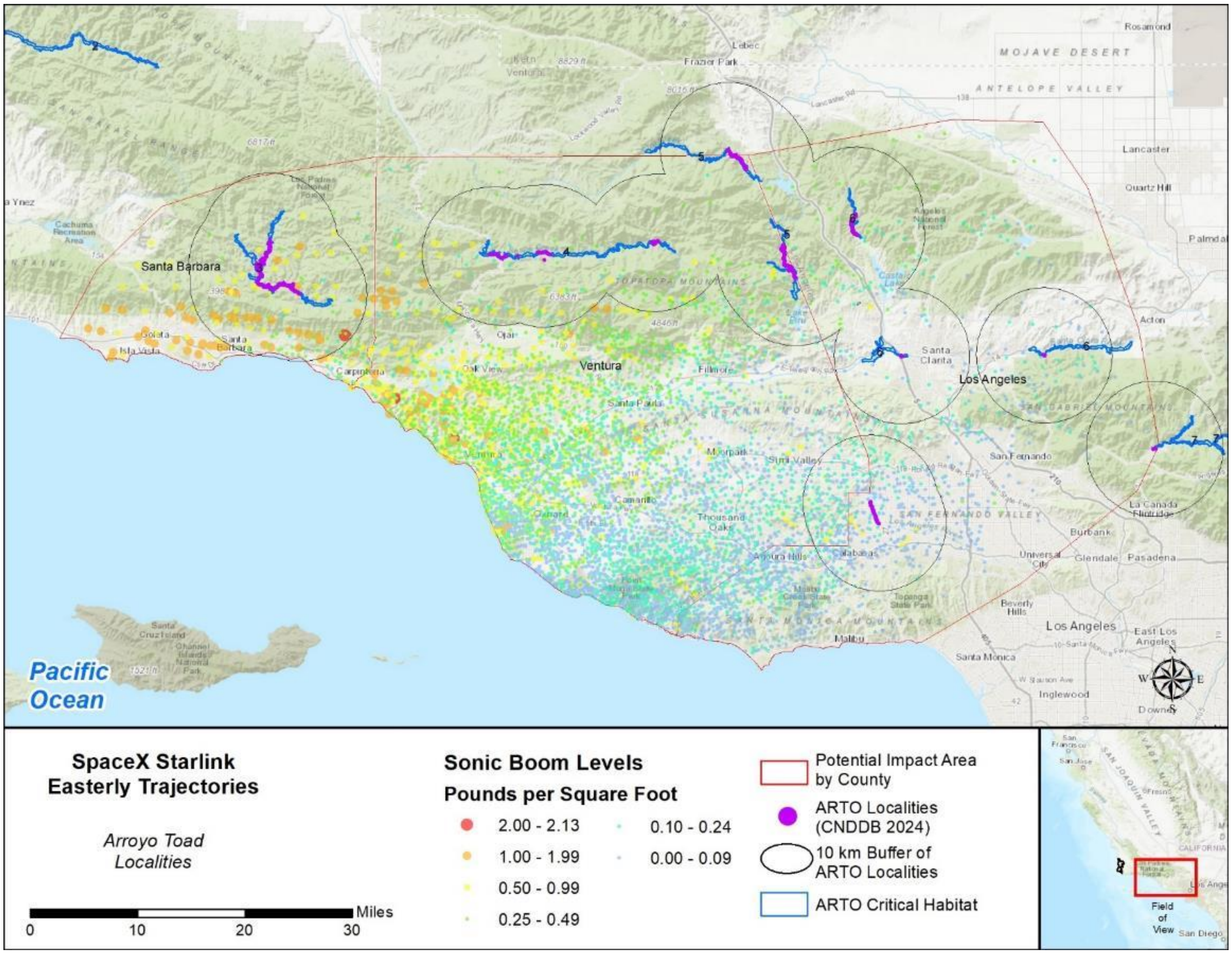

Figure 2M. Arroyo toad occurrences and the Sonic Boom Overpressure Effect Area impacting Mainland California during launch ascent.

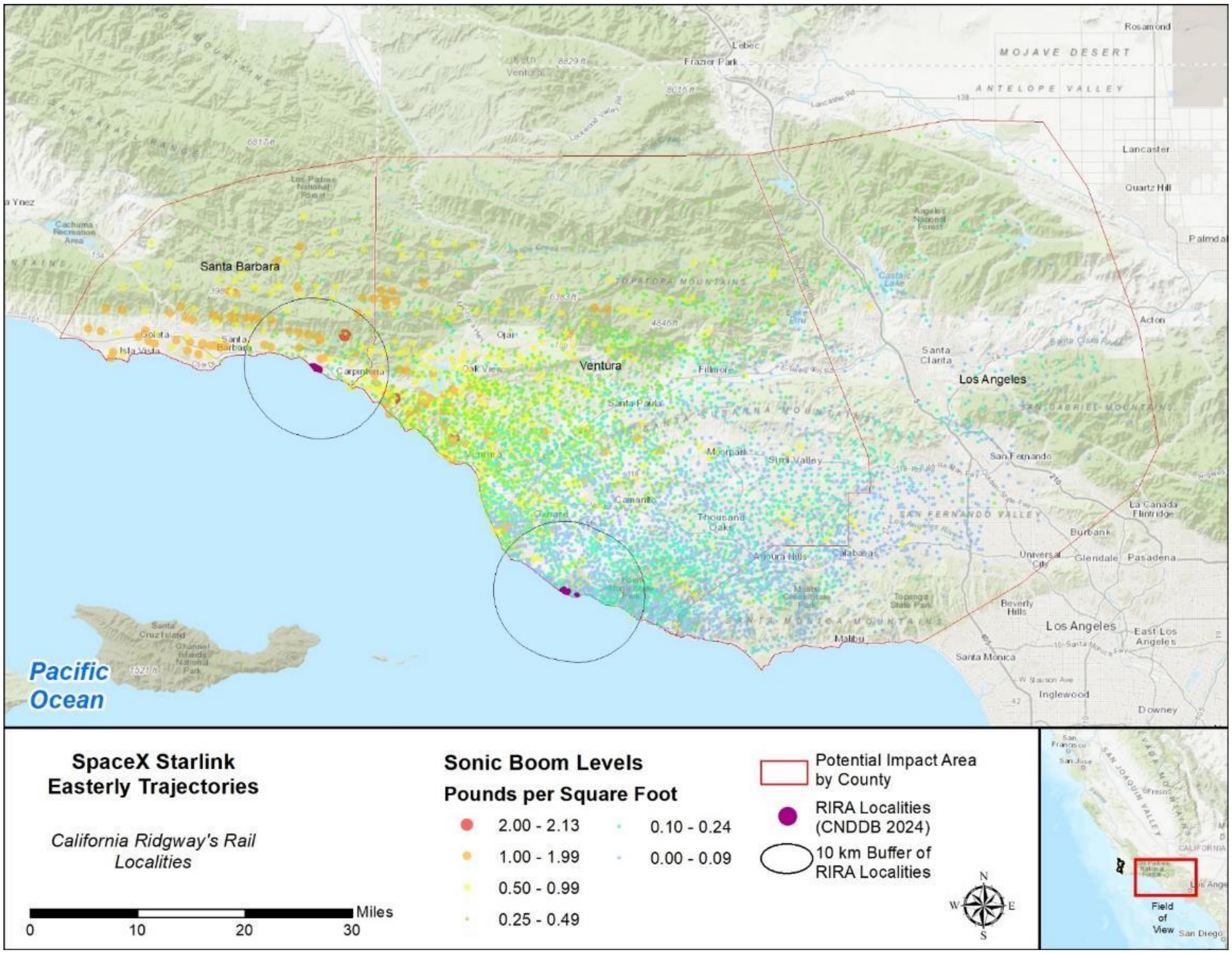

Figure 2N. Light-footed ridgway's rail occurrences and the Sonic Boom Overpressure Effect Area impacting Mainland California during launch ascent.

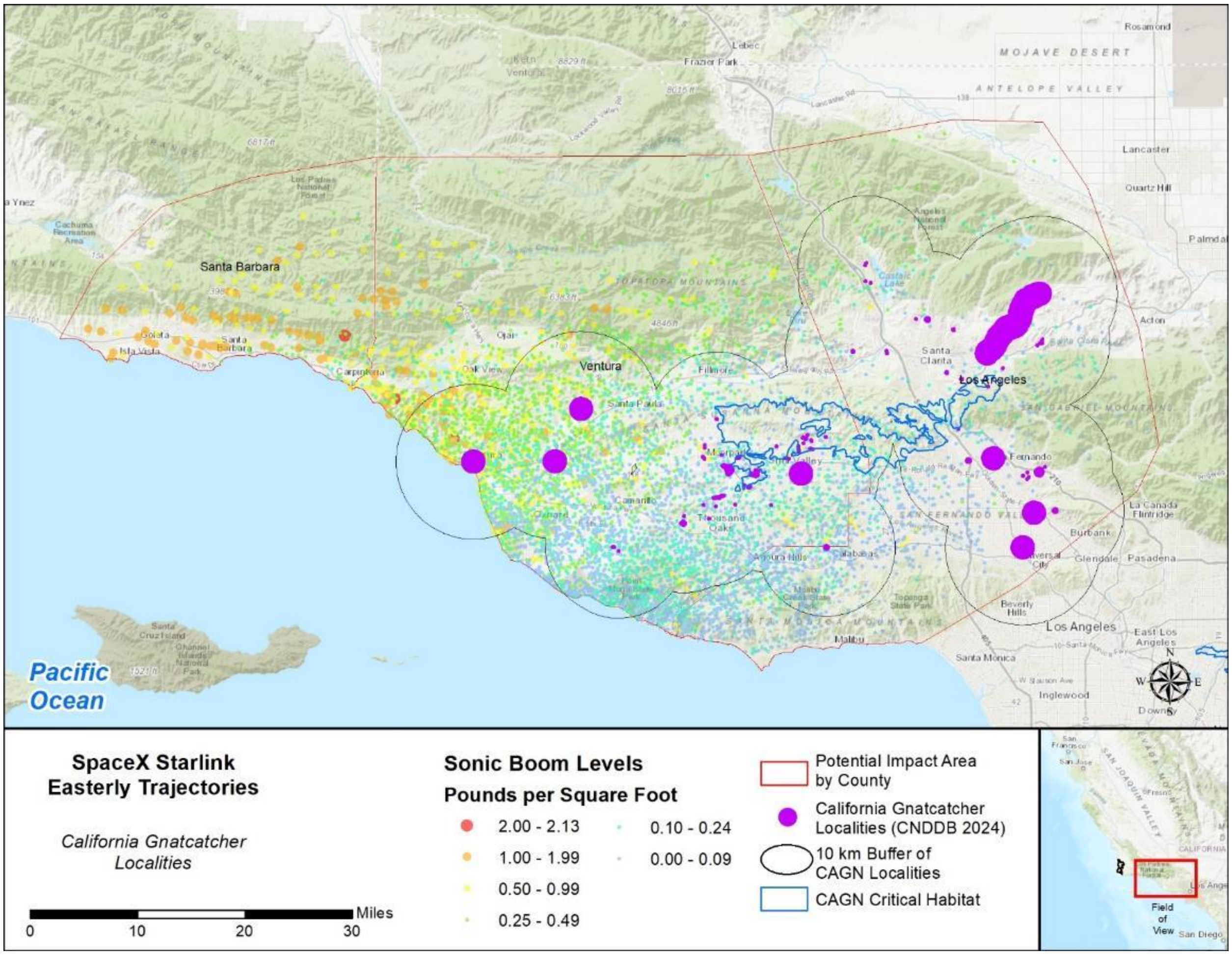

Figure 2O. Coastal California gnatcatcher occurrences and the Sonic Boom Overpressure Effect Area impacting Mainland California during launch ascent.

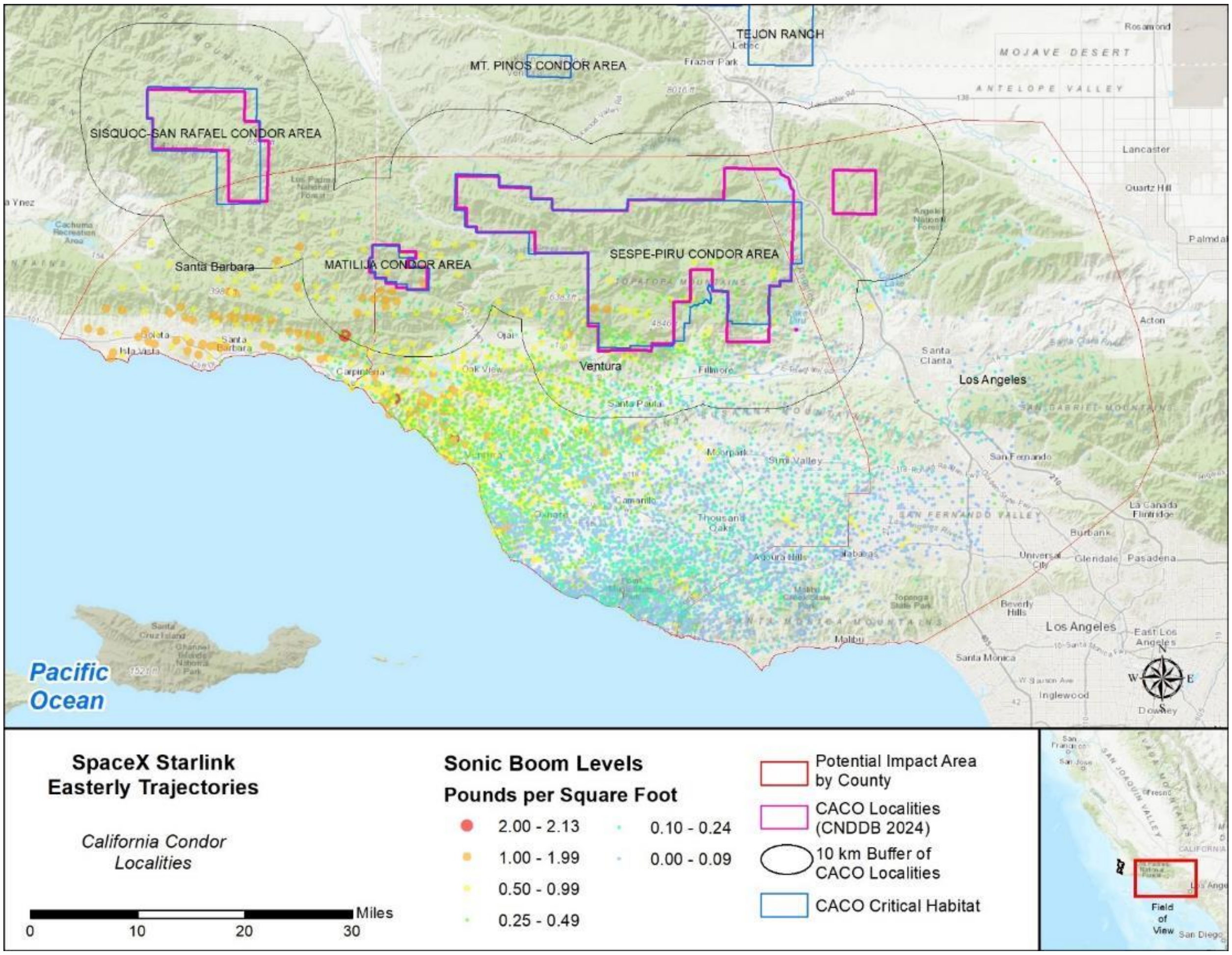

Figure 2P. California condor occurrences and the Sonic Boom Overpressure Effect Area impacting Mainland California during launch ascent.

Vehicle Landing Effect Area

Pacific Ocean and SLC-4E

Figure 3. Vehicle Landing Effect Area within the Pacific Ocean on a mobile barge ship and at SLC-4E.

Space Force proposed Potential Mitigation Areas

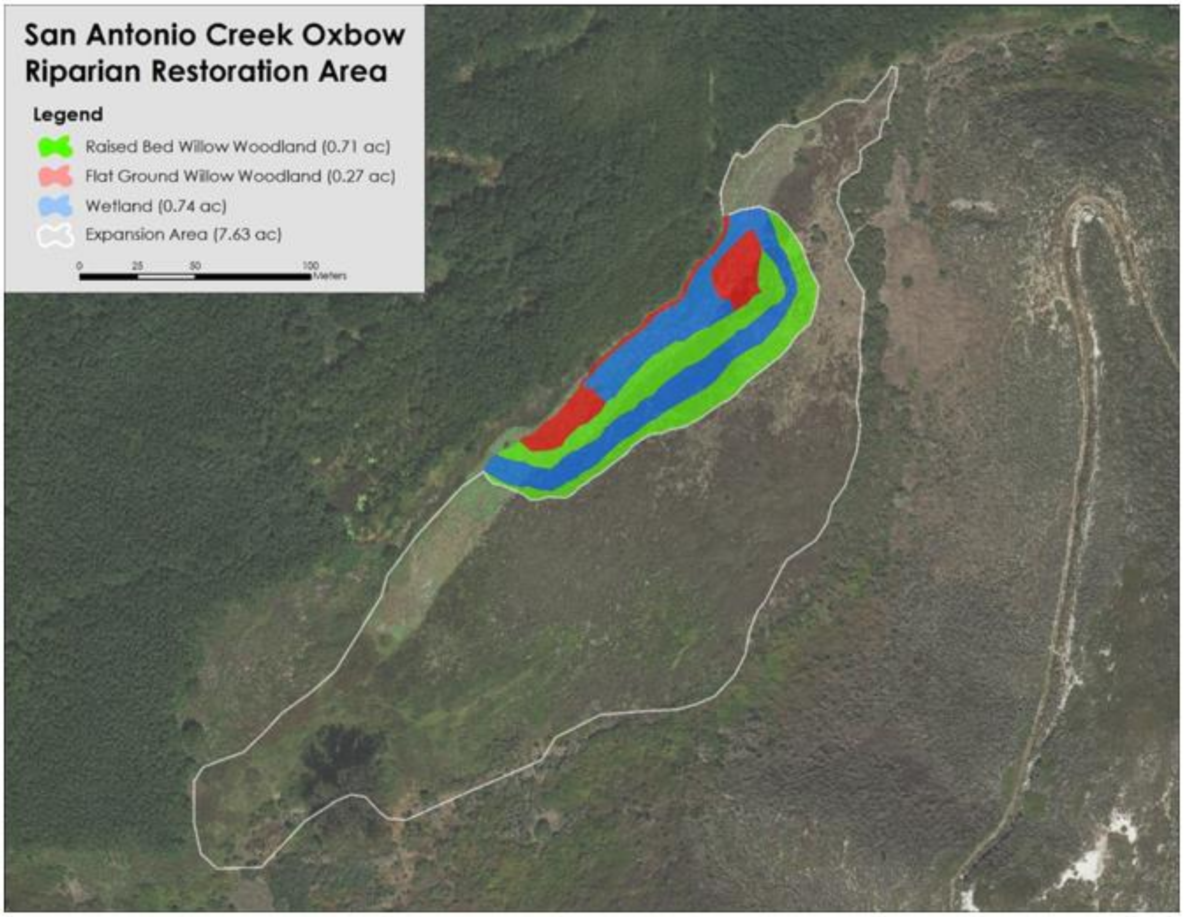

Figure 4A. Space Force proposed potential mitigation area (San Antonio Creek Oxbow Restoration Area) for California red-legged frog and southwestern pond turtle. Current restoration efforts depicted in green, red, and blue.

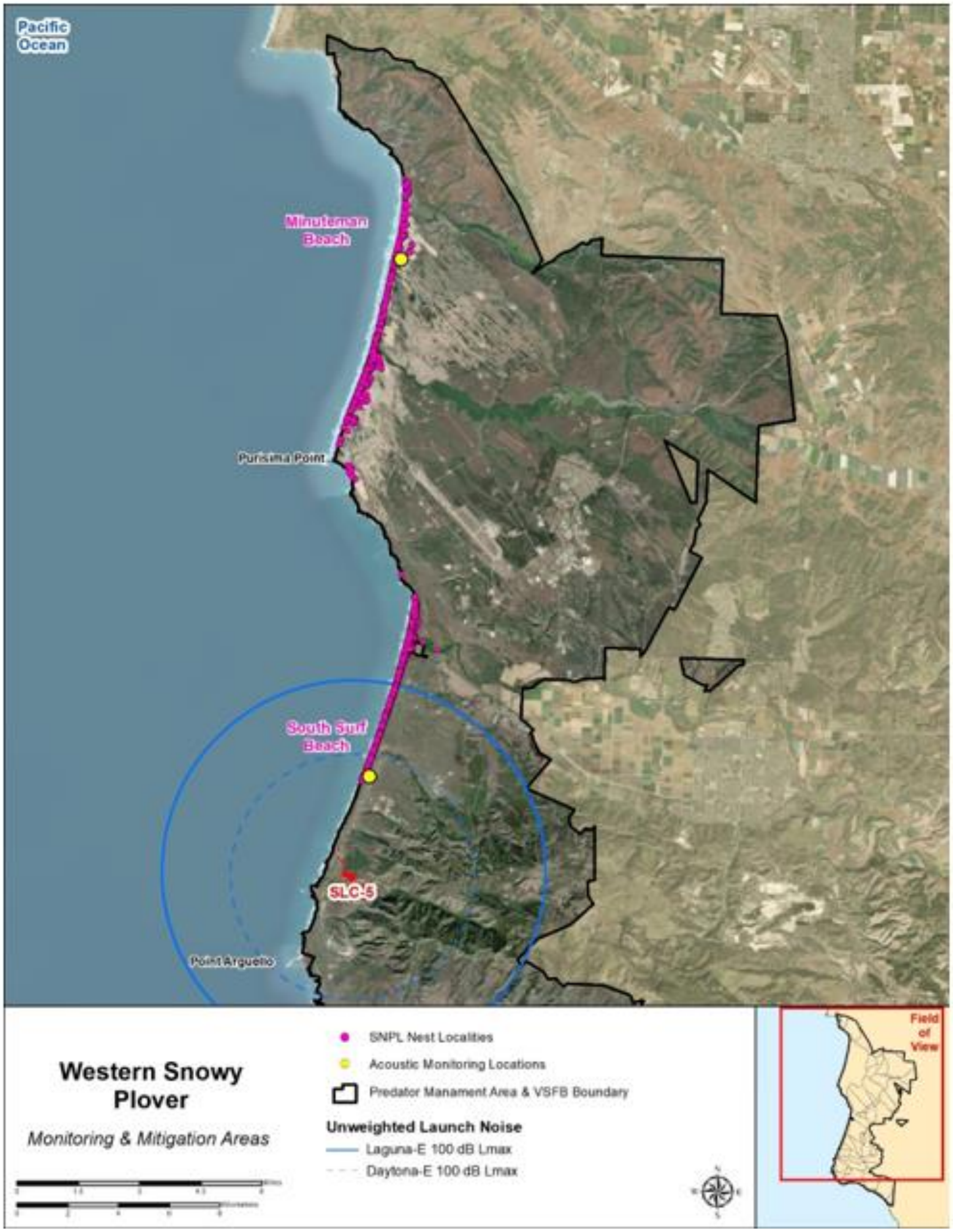

Figure 4B. Space Force proposed potential mitigation area (Predator Management Area) for western snowy plover. Note that the figure references a separate project's (Phantom) launch noise effect area to be disregarded (Kaisersatt, pers. comm, 2023c; MSRS 2022d).

APPENDIX B – Biologist Authorization Request, Field Experience Tracking Form

Biologist Authorization Request

Field Experience Tracking Form

Please be as detailed as possible when submitting your qualifications with your resume. The Service must determine, based on the verifiable information you provide, that you have the expertise to conduct the requested activity with the target species under the applicable Biological Opinion. This field experience tracking document is provided to assist you in providing detailed information to support your overall qualifications.

Basic Information (to be filled in by the Action Agency)

Biologist Name

Activity Authorization Request Type (For Each Species Requested)

e.g., California red-legged frog relocation, Western snowy plover surveys and monitoring, etc.

Project Name and Biological Opinion #

Relevant Experience

Please Enter Recovery Permit:

OR populate table below as necessary to demonstrate adequate experience.

Project Name, approximate dates, and Survey or Activity Type	# of Hrs.	# of Individuals detected, handled, etc. (Please include lifestage as applicable)

Other pertinent notes or experience acquired. Include work under supervision by authorized individuals.

Service Assessment (to be completed by the Service)

- ☐ **Individual is authorized to conduct requested activity**
- ☐ **Individual is authorized to conduct requested activity under direct supervision**
- ☐ **Individual is not authorized to conduct requested activity**
- ☐ **More information is needed**
- ☐ **Remarks (attach additional information)**

Description of additional information needed and/or clarifying remarks

Electronic Signatures and Authorizations

Vandenberg SFB Official's Title and Office	Date	VFWO Title USFWS	Date

APPENDIX C - Western Monarch Butterfly Conservation Recommendations

Western Monarch Butterfly Conservation Recommendations:

Purpose: Section 7(a)(1) of the Endangered Species Act of 1973 (ESA), directs federal agencies to use their authorities to further the purpose of the ESA, by conducting conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary activities that an action agency may undertake to avoid and minimize the adverse effects of a proposed action, implement recovery plans, or to develop information that is useful for the conservation of listed species. The purpose of the following conservation recommendations is to encourage federal agencies to incorporate monarch butterflies as applicable into their Environmental Assessments and Biological Assessments associated with Section 7 Biological Opinions, when in consultation with the U.S. Fish & Wildlife Service.

Background: The western migratory monarch butterfly population has declined by more than 99 percent since the 1980s. An estimated 4.5 million monarchs overwintered on the California coast in the 1980s, whereas in 2020, the population estimate for overwintering monarchs was less than 2,000 butterflies. This extreme population decline is likely due to multiple stressors across the monarch's range, including the loss and degradation of overwintering groves; pesticide use, particularly insecticides; loss of breeding and migratory habitat; climate change; parasites and disease. Historically, the majority of western monarchs spent the winter in forested groves near the coast from Mendocino County, California, south into northern Baja California, Mexico. In recent years, monarchs have not clustered in the southern-most or northern-most parts of their overwintering range, and there are year-round residents in some areas of the coast. This resident phenomenon is likely due to a combination of climate change and an abundance of residential-planted non-native, tropical milkweed that is available for monarchs year-round. Migratory western monarchs depart the overwintering groves in mid-winter to early-spring. Throughout the spring and summer, monarchs breed, lay their eggs on milkweed, and migrate across multiple generations within California and other states west of the Rocky Mountains. In an attempt to reverse the severe population decline of western monarch butterflies, and to protect other pollinators as well, we encourage implementation of the conservation recommendations listed below. Please see Figure 1 for suggested areas to focus voluntary conservation actions in California. Western monarch conservation actions outside of California are also important, especially for the larger pollinator community. Recommendations for other western states are addressed in the "All Breeding and Migratory Zones" section of this document.

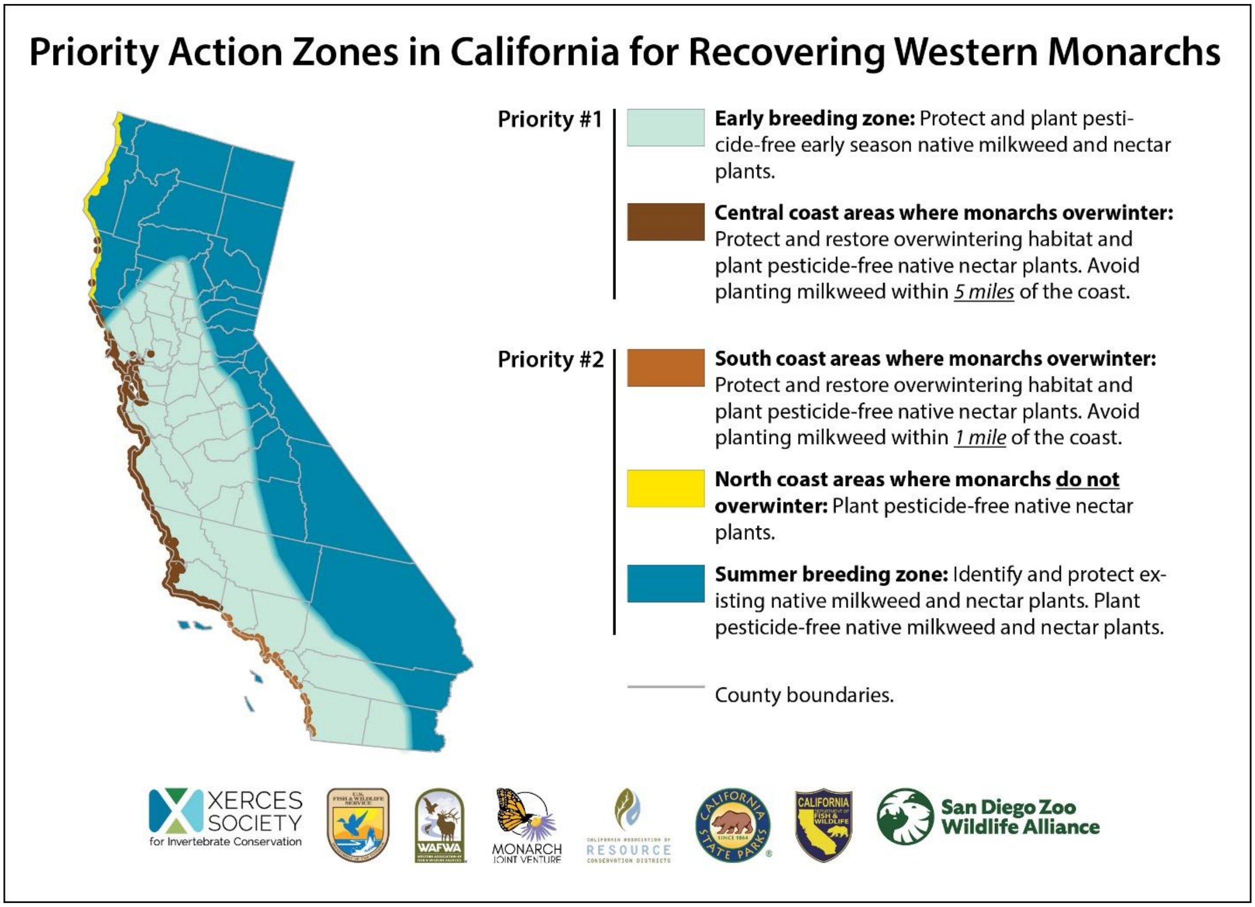

Figure 1. Priority Monarch Habitat Restoration Areas in California.

Coastal California Overwintering Habitat: Western monarchs migrate to the California coast, and cluster in a specific set of forested tree groves during the fall and winter each year. Overwintering groves provide protection from inclement weather and possess suitable vegetation and microclimate conditions for monarchs (e.g., roosting trees, wind protection, dappled sunlight, nectar sources, water and/or dew for hydration, high humidity, and an absence of freezing temperatures). In the overwintering zone of the coast (i.e., within five miles of the coast from Mendocino County south through Santa Barbara County, and within one mile of the coast from Ventura County south through San Diego County), we recommend the following:

0. Protect, manage, enhance and restore monarch butterfly overwintering groves (Find An Overwintering Site).
1. Use only native, insecticide-free plants for habitat restoration and enhancement actions.
2. Conduct overwintering grove habitat assessment(s), and develop and implement long-term grove management plans, as applicable. Management plan actions for groves may include, but are not limited to:
    a. Enhance roosting trees within overwintering groves and within 1/2 mile of groves by planting trees (e.g., Monterey pine (Pinus radiata), Monterey cypress

(Cupressus macrocarpa), Coast redwood (Sequoia sempervirens), coast live oak (Quercus agrifolia), Douglas fir (Pseudotsuga menzesii), Torrey pine (Pinus torreyana), western sycamore (Platanus racemosa), bishop pine (Pinus muricata) and others, as appropriate for location).

b. Avoid the removal of trees or shrubs within 1/2 mile of overwintering groves, except for specific grove management purposes, and/or for human health and safety concerns. The maintenance of trees and shrubs within a 1/2 mile of these sites provides a buffer to preserve the microclimate conditions of the winter habitat.

c. Conduct management activities (e.g., tree trimming, mowing, burning and grazing) in monarch overwintering groves from March 16-September 14 (outside of estimated timeframe when monarchs are likely present), in coordination with a monarch biologist and arborist.

d. Enhance nectar sources by planting fall/winter blooming forbs or shrubs within overwintering groves and within one mile of the groves (Nectar Planting Lists).

e. Provide a minimum 125-foot buffer zone for new development from the outermost trees identified as a monarch butterfly roost site, unless larger buffer zones are necessary.

3. Protect monarchs, other pollinators, and their habitats from pesticides (i.e., insecticides and herbicides). Specific recommendations may vary by site.

a. Avoid the use pesticides within one mile of overwintering groves, particularly when monarchs may be present. If pesticides are used, then conduct applications from March 16-September 14, when possible.

b. Screen all classes of pesticides for pollinator risk to avoid harmful applications, including biological pesticides such as Bacillus thuringiensis (UC Integrated Pest Management).

c. Avoid the use of neonicotinoids or other systemic insecticides, including coated seeds, any time of the year in monarch habitat due to their ecosystem persistence, systemic nature, and toxicity.

d. Consider non-chemical weed control techniques, when possible (Cal-IPC Non-chemical BMPs).

e. Avoid herbicide application on blooming flowers. Apply herbicides during young plant phases, when plants are more responsive to treatment, and when monarchs and other pollinators are less likely to be nectaring on the plants.

f. Whenever possible, use targeted application herbicide methods, avoid large-scale broadcast applications, and take precautions to limit off-site movement of herbicides (e.g., drift from wind and discharge from surface water flows).

g. Separate habitat areas from areas receiving chemical treatments with a pesticide-free spatial buffer and/or evergreen vegetative buffer of coniferous, non-flowering trees to capture chemical drift. The appropriate monarch and pollinator habitat spatial buffer size depends on several factors, including weather and wind conditions, but at a minimum, the habitat should be at least 40 feet from ground-based pesticide applications, 60 feet from air-blast sprayers, and 125 feet from any systemic insecticide applications or seed-treated plants.

4. To minimize the spread of the pathogen Ophryocystis elektroscirrha (OE), and to encourage natural monarch migration, do not plant non-native tropical milkweed (Asclepias curassavica). OE is able to build up on tropical milkweed, because these plants are evergreen, and they do not die back in the winter. OE can be debilitating and/or lethal to monarchs.

5. Remove tropical milkweed that is detected, and replace it with nectar plants suitable for the location (Nectar Planting Lists).

6. To assist in maintaining normal migration behavior, do not plant any type of milkweed within five miles of the coast from Mendocino County south through Santa Barbara County, and within one mile of the coast south of Santa Barbara County.

7. After appropriate training, conduct grove monitoring for butterflies during the Western Monarch Counts each fall and winter. When possible, report when monarchs arrive and depart the groves each year (Western Monarch Count).

8. To provide benefits for monarchs and other pollinators anywhere on the landscape within the overwintering zone, install a mosaic of nectar plants that bloom throughout the year, as is feasible (Nectar Planting Lists).

Breeding and Migratory Habitat: Monarch butterflies breed and migrate across multiple generations each year throughout the western U.S. The early breeding zone (i.e., Priority 1) is an estimated area in California where monarchs are likely to breed and/or lay their eggs on milkweed after departing the overwintering groves in mid-winter to early spring each year (See Figure 1, above). Early emerging milkweed species are likely a limiting factor on the landscape in the early breeding zone and may be associated with the severe population decline of western monarchs, and these plants are essential to successfully create the next generation of migratory butterflies. For monarch breeding and migratory habitat, we recommend the following:

Priority 1 Zone:

1. Enhance and maintain habitat in the Priority 1 early breeding zone of California, (Figure 1, above), by identifying and protecting existing habitat, and planting native, insecticide-free early-emerging milkweed species (e.g., Asclepias vestita, A. californica, A. eriocarpa, A. cordifolia, A. erosa), and flowering plants that are available to monarchs from January-April, as appropriate for the project location (Nectar Planting Lists; Milkweed Seed Finder).

For All Breeding and Migratory Zones:

2. Use only native, insecticide-free plants for habitat restoration and enhancement actions.

3. Enhance and maintain habitat in the Priority 2 zone of California (Figure 1, above) and in other western States, by identifying and protecting existing habitat, and planting milkweed species and flowering plants that are appropriate for the location (Nectar Planting Lists; Milkweed Seed Finder).

4. Conduct management activities such as mowing, burning and grazing in monarch breeding and migratory habitat outside of the estimated timeframe when monarchs are likely present (Figure 2, Recommended Management Timing Map, below).

5. Protect monarchs, other pollinators, and their habitats from pesticides (i.e., insecticides and herbicides).

    a. Avoid the use of pesticides when monarchs may be present, when feasible (Figure 2, Recommended Management Timing Map, below).

    b. Screen all classes of pesticides for pollinator risk to avoid harmful applications, including biological pesticides such as Bacillus thuringiensis (UC Integrated Pest Management).

    c. Avoid the use of neonicotinoids or other systemic insecticides, including coated seeds, any time of the year in monarch habitat due to their ecosystem persistence, systemic nature, and toxicity.

    d. Consider non-chemical weed control techniques, when feasible (Cal-IPC Non-chemical BMPs).

    e. Avoid herbicide application on blooming flowers. Apply herbicides during young plant phases, when plants are more responsive to treatment, and when monarchs and other pollinators are less likely to be nectaring on the plants.

f. Whenever possible, use targeted application herbicide methods, avoid large-scale broadcast applications, and take precautions to limit off-site movement of herbicides (e.g., drift from wind and discharge from surface water flows).

g. Separate habitat areas from areas receiving treatment with a pesticide-free spatial buffer and/or evergreen vegetative buffer of coniferous, non-flowering trees to capture chemical drift. The appropriate monarch and pollinator habitat spatial buffer size depends on several factors, including weather and wind conditions, but at a minimum, the habitat should be at least 40 feet from ground-based pesticide applications, 60 feet from air-blast sprayers, and 125 feet from any systemic insecticide applications or seed-treated plants.

6. To minimize the spread of the pathogen Ophryocystis elektroscirrha (OE), do not plant non-native tropical milkweed (Asclepias curassavica). OE can build up on tropical milkweed and infect monarchs, because these plants are evergreen and do not die back in the winter. OE can be lethal to monarchs.

7. Remove tropical milkweed that is detected, and replace it with milkweed and nectar plants appropriate for the location (Nectar Planting Lists; Milkweed Seed Finder).

8. Report milkweed and monarch observations from all life stages, including breeding butterflies, to the Monarch Milkweed Mapper or via the project portal in the iNaturalist smartphone app.

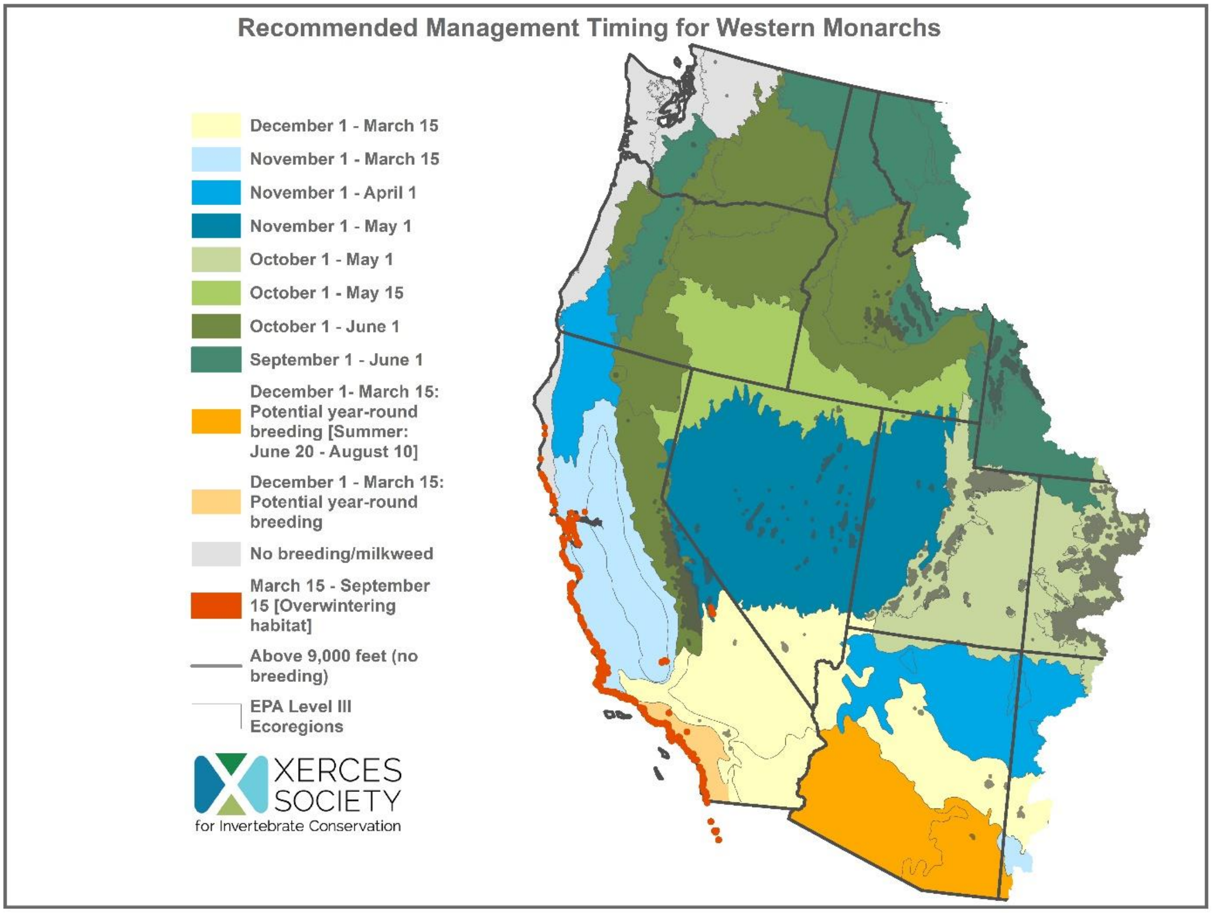

Figure 2. Recommended Management (i.e., mowing, burning, grazing, pesticide applications) Timing Window in the western U.S. by Zone.

Notes: The management timing windows illustrated in Figure 2 represent approximate recommendations of timeframes to conduct management actions. These timeframes are based upon the best available current information and may be updated in the future. Each year and site is different, so when possible, please consider surveying milkweed plants for the early life stages of monarchs prior to burning, mowing, grazing or applying pesticides.

APPENDIX B
National Marine Fisheries Service Consultations

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
501 West Ocean Boulevard, Suite 4200
Long Beach, California 90802-4213

January 20, 2023

Refer to NMFS No: WCRO-2023-00002

Beatrice L. Kephart
Chief, Installation Management Flight
30 CES/CEI
1028 Iceland Avenue
Vandenberg AFC, California 93437

Re: Endangered Species Act Section 7(a)(2) Concurrence Letter for increasing number of launches at the Vandenberg Space Force Base

Dear Mr. Kephart:

This letter responds to your December 19, 2022, request for concurrence from the National Marine Fisheries Service (NMFS) pursuant to Section 7 of the Endangered Species Act (ESA) for the subject action. Your request qualified for our expedited review and concurrence because it contained all required information on your proposed action and its potential effects to listed species and designated critical habitat.

We reviewed United States Space Force's consultation request document and related materials. Based on our knowledge, expertise, and your action agency's materials, we concur with the action agency's conclusions that the proposed action is not likely to adversely affect the NMFS ESA-listed species and/or designated critical habitat.

This letter underwent pre-dissemination review using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The concurrence letter will be available through NMFS' Environmental Consultation Organizer [https://appscloud.fisheries.noaa.gov]. A complete record of this consultation is on file at the NMFS Long Beach office.

Reinitiation of consultation is required and shall be requested by the United States Space Force or by NMFS, where discretionary Federal involvement or control over the action has been retained or is authorized by law and (1) the proposed action causes take; (2) new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the written concurrence; or (4) a new species is listed or critical habitat designated that may be affected by the identified action (50 CFR 402.16).

This concludes the ESA consultation.

Please direct questions regarding this letter to Chiharu Mori at Chiharu.Mori@noaa.gov.

Sincerely,

Dan Lawson
Long Beach Branch Chief
Protected Resource Division

cc: Rhys Evans, VAFB, rhys.evans@spaceforce.mil

Administrative Record Number: 151422WCR2023PR00013

Draft Biological Assessment for

Increase Cadence of Space Launch Vehicle First Stage Recovery Actions and Expanded Landing Areas in the Pacific Ocean at Vandenberg Space Force Base, California

21 March 2024

Prepared for

Space Launch Delta 30, Installation Management Flight Environmental Assets
1028 Iceland Avenue, Bldg. 11146
Vandenberg Space Force Base, California 93437

Prepared by

ManTech SRS Technologies, Inc.
300 North G Street
Lompoc, CA 93436

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ACRONYMS AND ABBREVIATIONS

BA	Biological Assessment
C.F.R.	Code of Federal Regulations
DAF	Department of the Air Force
DPS	Distinct Population Segment
EPM	Environmental Protection Measure
ESA	Endangered Species Act
ESU	Evolutionary Significant Unit
°F	degrees Fahrenheit
FE	federally endangered
ft	foot or feet
FT	federally threatened
LOC	Letter of Concurrence
mi	mile(s)
NCI	Northern Channel Islands
NLAA	not likely to adversely affect
nm	nautical mile(s)
NMFS	National Marine Fisheries Service
psf	pounds per square foot
SLC	Space Launch Complex
USFWS	United States Fish and Wildlife Service
VSFB	Vandenberg Space Force Base

1 Introduction

1.1 Background & Consultation History

The purpose of this Biological Assessment (BA) is to address the effects of the addition of Falcon Heavy at Vandenberg Space Force Base (VSFB), increasing Falcon 9 and Falcon Heavy launch, and first stage and booster recoveries to 100 times per year, and expanding the first stage/booster and fairing recovery area in the Pacific Ocean on species listed under the Endangered Species Act (ESA) and designated critical habitat under the jurisdiction of the National Marine Fisheries Service (NMFS). Although the current action also includes the modification and future use of existing Space Launch Complex 6 (SLC-6), there is no impact from that portion of the action on NMFS' resources.

Only those species and designated critical habitat that may be affected by the Proposed Action are discussed in this BA. Consistent with the NMFS requirements for ESA Section 7 analyses, the spatial and temporal overlap of activities with the presence of listed species is assessed in this BA. The definitions used by the Department of the Air Force (DAF) in making the determination of effect under Section 7 of the ESA are based on the United States Fish and Wildlife Service (USFWS) and NMFS Endangered Species Consultation Handbook (USFWS & NMFS 1998). The DAF is the lead agency for the purposes of this BA. The DAF and the project proponents have utilized the best available scientific and commercial data in the preparation of this BA.

The DAF previously completed informal Section 7 consultation with NMFS, which concurred potential impacts were *not likely to adversely affect* the ESA-listed species managed by NMFS, detailed in Table 1.1-1, through a Letter of Concurrence (LOC), issued on 20 January 2023 (hereafter "2023 LOC"; NMFS 2023). The Proposed Change has not modified the action in a manner that would result in different types of stressors or levels of stressors that were not considered in the 2023 LOC; nor would the Proposed Change affect the ESA-listed species previously consulted on or critical habitat in a manner or to an extent not previously considered. The addition of Falcon Heavy to VSFB would not result in new stressors that were not considered in the 2023 LOC. The DAF would not increase the number of first stage/booster landings at VSFB; however, would increase the number of downrange first stage/booster landings on droneships in the Pacific Ocean. This increase would not change the types or levels of stressors to ESA-listed species in the Pacific Ocean (discussed in Section 4). The proposed recovery area is larger than analyzed in the 2023 LOC and overlaps the range of the federally threatened Central North Pacific Distinct Population Segment (DPS) of the green sea turtle (*Chelonia mydas*), which was not included in the NMFS 2023 LOC. All other species, DPSs, and Evolutionary Significant Units (ESUs) considered in the prior BA (30th Space Wing 2022) and 2023 LOC remain the same.

Table 1.1-1. NMFS concurrence on effect determinations for species, DPSs, and ESUs covered under LOC 20 January 2023.

Common Name	Distinct Population Segment or Evolutionarily Significant Units	ESA Status	Effect Determination
Steelhead	Southern California Coast	FE	NLAA
Chinook salmon	4 ESUs[1]	FT	NLAA
Coho salmon	2 ESUs[2]~~[3]~~	FT	NLAA
Green sturgeon	Southern	FT	NLAA
Oceanic whitetip shark	-	FT	NLAA
Scalloped hammerhead shark	Eastern Pacific	FE	NLAA
Green sea turtle	East Pacific	FT	NLAA
Leatherback sea turtle	-	FE	NLAA
Olive ridley sea turtle	Mexico Pacific coast	FE	NLAA
Hawksbill sea turtle	-	FE	NLAA
Loggerhead turtle	North Pacific	FE	NLAA
Blue whale	-	FE	NLAA
Fin whale	-	FE	NLAA
Gray whale	Western North Pacific	FE	NLAA
Humpback whale	Mexico	FT	NLAA
	Central America	FE	
Humpback whale critical habitat	Mexico/Central America DPS	-	NLAA
Killer whale	Southern Resident	FE	NLAA
Sei whale	-	FE	NLAA
Sperm whale	-	FE	NLAA
Guadalupe fur seal	-	FT	NLAA

[1] Chinook salmon ESUs include California Coastal (FT), Central Valley Spring-Run (FT), Lower Columbia River (FT), and Sacramento River Winter-Run (FT)

[2] Coho salmon ESUs include Central California Coast (FT) and Southern Oregon and Northern California Coasts (FT).

FE = federally endangered; FT = federally threatened; NLAA = not likely to adversely affect.

2 Description of the Action and the Action Area

2.1 Action Area

The action area is defined in 50 Code of Federal Regulations (C.F.R.) § 402.02 as "all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action." In general, the action area includes the portions of the Pacific Ocean where launch, reentry, and recovery activities are anticipated (Figure 2.1-1). These activities occur in the marine environment in deep waters between approximately 46-400 nautical miles (nm) off Rockport, California at the northern limit, 575 nm off of southern Mexico at the southern limit, and 490 nm east of Hawaii at the western limit (Figure 1.1-1). No recovery activities would occur within 12 nm of islands. The only component of the Proposed Action that occurs less than 12 nm from the U.S. are marine vessels transiting to and from a port in support of first stage and fairing recovery activities. These nearshore vessel transit areas in the action area include marine waters that lead to the Port of Long Beach and the VSFB Harbor.

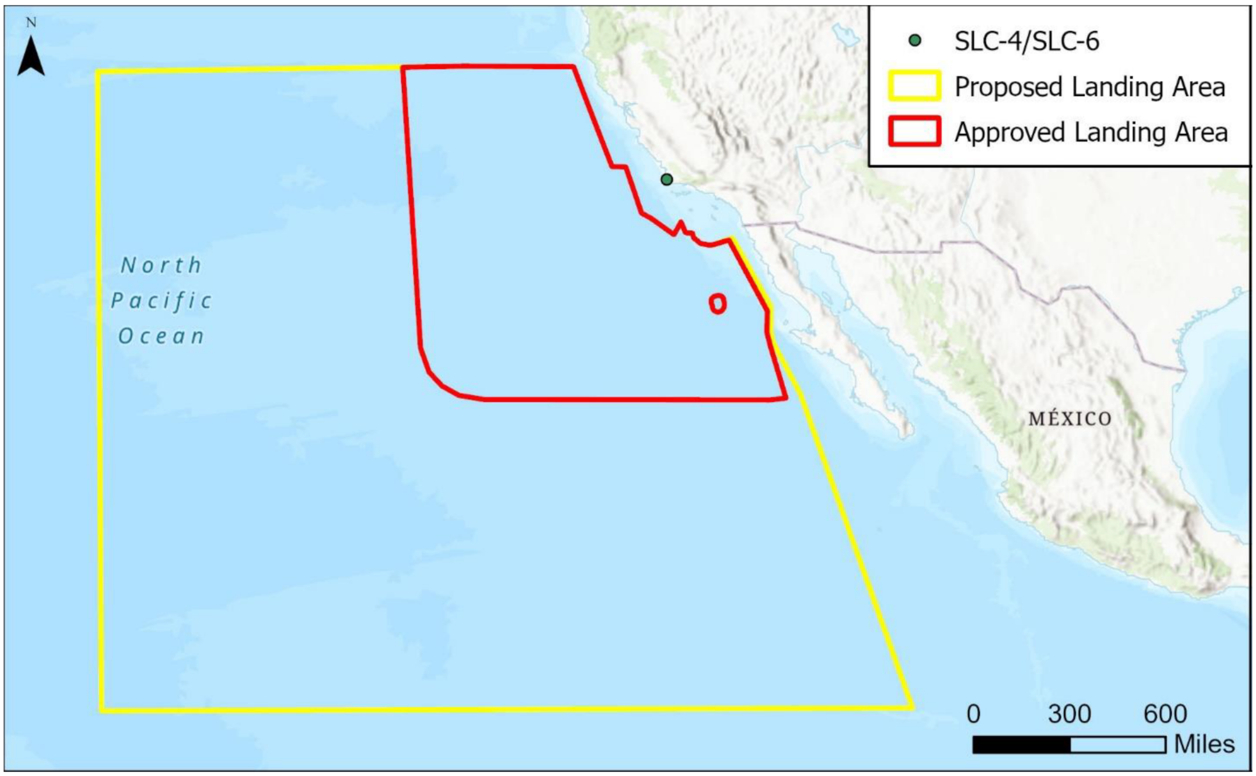

Figure 2.1-1. Proposed landing area. (Note: at this scale, SLC-4 and SLC-6 are in practically the same location)

2.2 Proposed Action

The Proposed Action will maintain the annual number of space launch activities from VSFB at 110 launches per year, as analyzed in the 2023 LOC. The DAF also proposes to increase the annual number of first stage recoveries from 36 per year, as approved in the 2023 LOC, to 100 either downrange on a droneship or at landing zones at VSFB, but not more than 36 per year at landing zones at VSFB, and expand potential downrange droneship landing and fairing recovery locations in the Pacific Ocean to accommodate new trajectories and the addition of Falcon Heavy (Figure 2.1-2). Launches and recovery operations would continue to occur day or night, at any time during the year.

2.2.1 Launch Operations

Launch operations would be performed in the same manner as analyzed in the 2023 LOC. Space launch vehicles (commonly termed rockets) at VSFB place a payload into space by vertical launch. For expendable launch vehicles, the first stage and fairing would fall into the Pacific Ocean after stage separation and sink to the ocean floor. The fairing consists of two halves which separate, allowing the deployment of the payload at the desired orbit. First stage boosters and fairings are composed of heavy-duty metal components but may also include some carbon composite components that may float for several days (10 days maximum) before becoming waterlogged and sinking. Both expendable and reusable rockets at VSFB use liquid oxygen and either kerosene or alcohol as propellants. Current and reasonably foreseeable launch vehicles at VSFB are listed in Table 2.2-1.

Table 2.2-1. Launch Vehicles that May Affect the Marine Environment.

Launch Vehicle	Operator	Type	Launch Site
Alpha	Firefly	Expendable	SLC-2
Daytona-E	Phantom	Expendable	SLC-5/SLC-8
Falcon 9	SpaceX	Reusable/Expendable	SLC-4/SLC-6
Falcon Heavy	SpaceX	Reusable/Expendable	SLC-6
Laguna-E	Phantom	Expendable	SLC-5
Minotaur IV/Peacekeeper	Northrop Grumman	Expendable	SLC-8
New Glenn	Blue Origin	Expendable	SLC-9
RSL	ABL	Expendable	LF-576E
Terran 1	Relativity	Expendable	SLC-11
Vulcan	ULA	Expendable	SLC-3

As analyzed previously, launches may occur from any launch facility on VSFB. Engine noise produced during launches would primarily impact VSFB and the surrounding area. During ascent, a sonic boom (overpressure of impulsive sound) with a peak generated over a relatively small area, typically between 3.0 to 5.0 pounds per square foot (psf), but potentially as high as 8.0 psf, would be generated. Depending on the launch trajectory, the sonic boom may or may not impact the surface of the earth. When sonic booms do impact the earth's surface, they primarily impact the Pacific Ocean, but may overlap the Northern Channel Islands (NCI). The levels and anticipated impact locations of sonic booms would not change from those previously analyzed in the 2023 LOC.

2.2.2 First Stage/Booster Recovery Operations

The Proposed Action would continue to conduct boost-back and landing of first stage/boosters downrange in the Pacific Ocean on a droneship within the proposed landing area (Figure 2.1-1) or at a landing complex on VSFB. Currently the only active landing complex on VSFB is at Space Launch Complex (SLC) 4; however, SpaceX will develop a second landing zone near SLC-6. The annual number of first stage/booster recoveries would increase from 36 (as analyzed in the 2023

LOC) to 100; however, the annual number of first stage/booster landings at landing complexes on VSFB would not increase from 36, which was analyzed in the 2023 LOC.

After the first stage engine cutoff and separation from the second stage, a subset of the first stage engines restart to conduct a reentry burn. Once the first stage is in position and approaching its landing target, the engines are cut off. A final burn is performed to slow the first stage to a velocity of zero for landing on the droneship or at VSFB. During descent, the first stage will produce engine noise and sonic booms. Engine noise during downrange droneship landing operations would only impact open ocean and would not impact mainland or islands. As analyzed in the 2023 LOC, engine noise produced during landing operations at VSFB would primarily impact areas on VSFB. Landing engine noise follows launch and associated launch engine noise by approximately 5 to 7 minutes and typically occurs slightly before the sonic boom impacts land. During descent, when a first stage/booster is supersonic, a sonic boom (overpressure of high-energy impulsive sound) would be generated, as analyzed in the 2023 LOC. Overpressure levels for the Falcon Heavy booster landings at SLC-6 would be similar to those for Falcon 9 first stage landings, except higher overpressure levels are expected centered on the landing pad, due to the vehicle transitioning from supersonic to subsonic at a lower altitude (Figure 2.2-1). While Figure 2.2-1 shows two sonic boom footprints, each for one Falcon Heavy booster landing, each recovery operation may involve two nearly simultaneous booster landings at SLC-6, such that multiple booms are expected to occur at nearly the same time from both vehicles. (Figure 2.2-3). During landing events at VSFB or in offshore areas near VSFB, sonic booms may continue to impact the NCI at the same levels and geographic locations as analyzed in the 2023 LOC.

The Proposed Action includes expanding the potential landing area in the Pacific Ocean to accommodate new trajectories; first stage/booster landing locations would be no closer than 12 nm from either mainland or islands anywhere within the Proposed Landing Area (Figure 1.1-2). The proposed landing area is also no closer than 26 nm to the Davidson Seamount and no closer than 12 nm to Guadalupe Island (Figure 1.1-2).

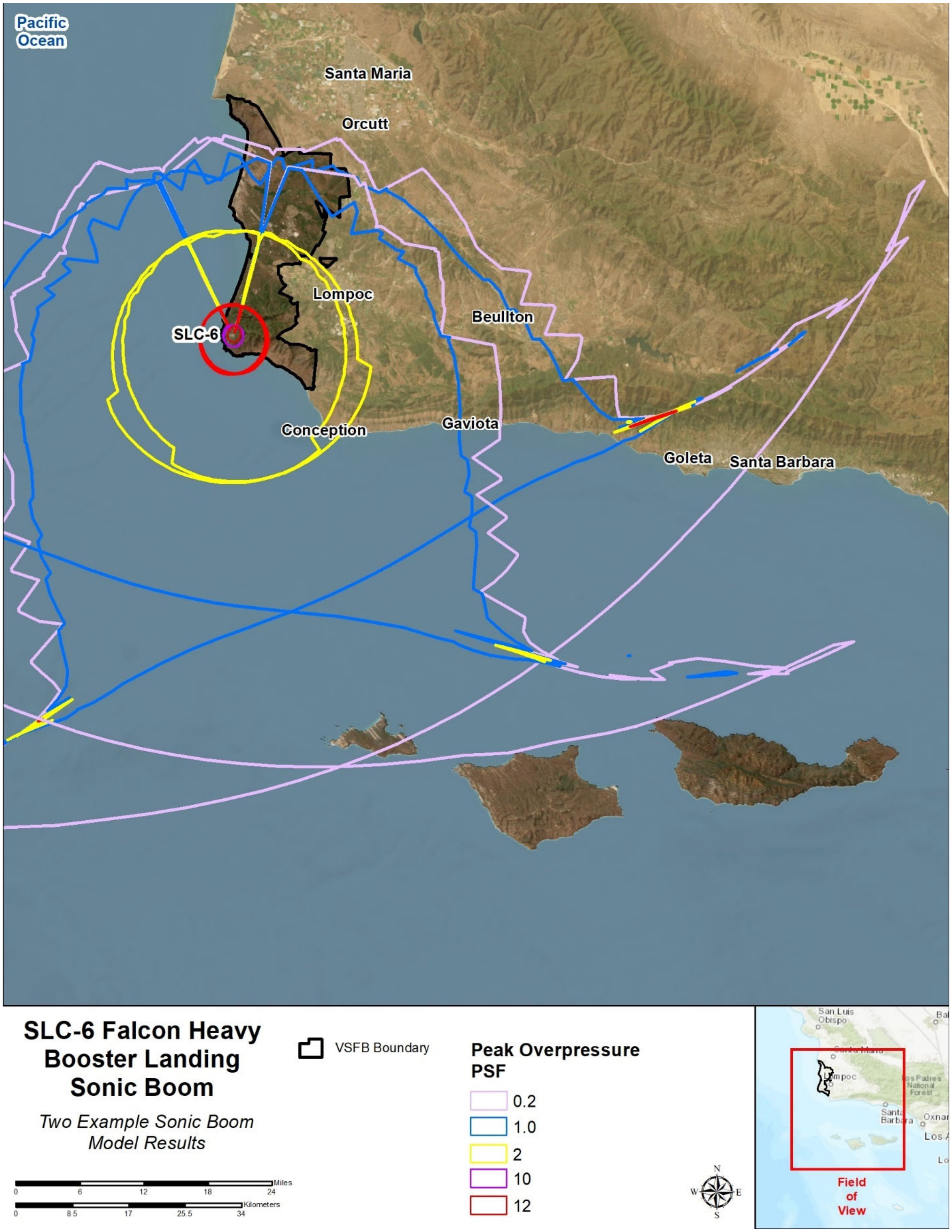

Figure 2.2-1. Examples of two sonic boom model results for Falcon Heavy boost landing at SLC-6.

2.2.3 Fairing Recovery Operations

Fairing recovery operations would increase from 36 to up to 100 per year. Up to 200 parachutes and 200 parafoils would land in the ocean annually. All parachutes and parafoils are meant to be recovered and they have been recovered during the majority of operations, but it is possible that some of the parafoils would not be recovered due to sea or weather conditions at the time of recovery. Parafoils are made of nylon and are expected to sink at a rate of approximately 1,000 feet (ft) in 145.5 minutes (NMFS 2022). Recovery of the parachute assembly would be attempted if the recovery team can get a visual fix on the splashdown location. Because the parachute assembly is deployed at a high altitude, it is difficult to locate. In addition, based on the size of the assembly and the density of the material, the parachute assembly would saturate and begin to sink upon impact. This would make recovering the parachute assembly difficult and unlikely. Parachutes are made of nylon and Kevlar and are expected to sink at a rate of approximately 1,000 ft in 46 minutes (NMFS 2022).

The fairing and parafoil would be recovered by a salvage ship stationed in the Proposed Landing Area near the anticipated splashdown site, but no closer than 12 nm offshore (Figure 2.1-1). The salvage ship would be able to locate the fairing using GPS data from mission control and strobe lights on the fairing data recorders. Upon locating the fairing, a rigid hulled inflatable boat would be launched. Crew members would hook rig lines to the fairing and connect a buoy to the parafoil. Then the crew would release the parafoil riser lines and secure the canopy by placing it into a storage drum. If sea or weather conditions are poor, recovery of the fairing and parafoil may be unsuccessful.

2.2.4 Environmental Protection Measures

The DAF will continue to ensure the following Environmental Protection Measures (EPMs) are implemented to reduce the risk of injury or mortality of ESA-listed species:

- The DAF will ensure that all personnel associated with vessel support operations are instructed about marine species and any critical habitat protected under the ESA that could be present in the proposed landing area. Personnel will be advised of the civil and criminal penalties for harming, harassing, or killing ESA-listed species.
- Support vessels will maintain a minimum distance of 150 ft from sea turtles and a minimum distance of 300 ft from all other ESA-listed species. If the distance ever becomes less, the vessel will reduce speed and shift the engine to neutral. Engines would not be re-engaged until the animal(s) are clear of the area.
- Support vessels will maintain an average speed of 10 knots or less.
- Support vessels will attempt to remain parallel to an ESA-listed species' course when sighted while the watercraft is underway (e.g., bow-riding) and avoid excessive speed or abrupt changes in direction until the animal(s) has left the area.
- The DAF will immediately report any collision(s), injuries, or mortalities to ESA-listed species to the appropriate NMFS contact.

3 Description of the Species

The list of ESA-listed endangered and threatened species that may be affected by the Proposed Change were obtained from the NMFS endangered species web sites, species experts, and a review of available literature. Table 1.1-1 lists the ESA-listed species under NMFS jurisdiction that may be affected by the Proposed Change that were previously analyzed in the 2023 LOC. The Proposed Change has not modified the action in a manner that would result in different types of stressors or levels of stressors that were not considered in the 2023 LOC; nor would the Proposed Change affect ESA-listed species or critical habitat in a manner or to an extent not previously considered. The proposed recovery area is larger than analyzed in the 2023 LOC and overlaps the range of the federally threatened Central North Pacific DPS of the green sea turtle which was not included in the 2023 LOC. All other species, DPSs, and ESUs considered in the prior BA and 2023 LOC remain the same. As a result, a description is only provided for the Central North Pacific DPS of the green sea turtle.

3.1 Green Sea Turtle (*Chelonia mydas*)

3.1.1 Distribution

The green sea turtle is found in tropical and subtropical coastal and open ocean waters, between 30° North and 30° South. Green sea turtles are widely distributed in the subtropical coastal waters of southern Baja California, Mexico, and Central America (Cliffton et al. 1995; NMFS and USFWS 1998). The range of the Central North Pacific DPS includes the Hawaiian Archipelago and Johnston Atoll, bound by 41° North 169° East in the northwest corner, 41° North 143° West in the northeast, 9° North 125° West in southeast, and 9° North 175° West in the southwest. Balazs et al. (2015) estimated the total nester abundance at 4,000 females, with 96 percent of nesting occurring at one atoll at the French Frigate Shoals.

3.1.2 Critical Habitat

Critical habitat has not been designated in the Action Area.

4 Analysis of Effects of the Proposed Action

As discussed in the prior BA and analyzed in the 2023 LOC, acoustic impacts as a result of the Proposed Action are limited to in-air noise as a result of sonic boom or rocket engine noise. Exceptionally little sound is transmitted between the air-water interface; thus, in-air sound would not have a significant effect on submerged animals (Godin 2008). Therefore, increasing the number of downrange droneship recoveries to 100, and thus the number of noise events on the open ocean, would have no effect on ESA-listed fish species.

In addition, cetaceans and sea turtles spend most of their time (>90% for most species) entirely submerged below the surface. When at the surface, their bodies are almost entirely below the water's surface, with only the blowhole or turtle's head exposed briefly to allow breathing. This minimizes in-air noise exposure, both natural and anthropogenic, essentially 100 percent of the time because their ears are nearly always below the water's surface. As a result, increasing the number of downrange droneship recoveries to 100 per year, and thus the number of noise events on the open ocean, will not have an effect on ESA-listed sea turtles or cetacean species.

Similarly, when at-sea, pinnipeds spend varying amounts of time underwater and the potential for disruption from in-air noise within the limited area of potential exposure during the brief moment of the sonic boom or engine noise is extremely unlikely for animals that are at sea. As a result, increasing the number of downrange droneship recoveries to 100 per year, and thus the number of noise events on the open ocean, would have no effect on ESA-listed Guadalupe fur seals that are at-sea.

The proposed increase in the number of weather balloons and fairing recovery operations would not change the effects analysis in the prior BA and 2023 LOC. Unrecovered parafoils, parachutes, and weather balloons could potentially become entangled with ESA-listed species, causing injury or death. While these materials may pose a risk of entanglement, the likelihood of entanglement is extremely small because: (1) the encounter rate for these expended materials is low, (2) there is restricted overlap with susceptible species, and (3) the physical characteristics of the expended materials reduce entanglement risk to ESA-listed species compared to abandoned fishing gear. For example, latex weather balloons burst after reaching its elastic limit at an altitude of 12 to 19 miles (mi). The temperature at this altitude range can reach negative 40 Fahrenheit (°F) and even colder. Under these conditions of extreme elongation and low temperature, the balloon undergoes "brittle fracture" where the rubber shatters along grain boundaries of crystallized segments. The resultant pieces of rubber are small strands comparable to the size of a quarter (Burchette 1989). The balloon fragments would be positively buoyant, float on the surface, and begin to photo-oxidize due to UV light exposure. In addition, unrecovered parafoils and parachutes would sink quickly through the water column, at 7 ft and 22 ft per minute, respectively, and settle (NMFS 2022). These activities would typically occur far offshore in deep waters where they are not expected to be encountered by ESA-listed species potentially affected by the Proposed Action. Entanglement with parachutes, unrecovered parafoils, or weather balloons therefore remains extremely unlikely and therefore the risk of entanglement is very low, as analyzed in the prior BA and 2023 LOC.

Similarly, the risk of ingestion of expended materials remains very low and discountable, as analyzed in the prior BA and 2023 LOC. Pieces of weather balloons, parachutes, or parafoils may pose an ingestion stressor to ESA-listed species. Parachutes and parafoils would sink rapidly (discussed above) and settle on the ocean floor, typically far from shore at depths greater than the ESA-listed species are expected to occur and where ultraviolet light would not penetrate. Because the degradation of these materials would be very slow and the presence of the ESA-listed species at these depths is unlikely the risk of ingestion of parachute or parafoil materials by ESA-listed species would remain very low and discountable. As discussed above, weather balloons would undergo "brittle fracture", and shatter into pieces approximately the size of a quarter (Burchette 1989). These pieces would become dispersed over a broad area as they fall to the surface of the ocean. The balloon fragments would be positively buoyant, float on the surface, and degrade over approximately 6 weeks as they photo-oxidize due to UV light exposure (Burchette 1989). After several weeks, the pieces of latex would be smaller and become neutrally buoyant (Ye and Andrady 1991; Lobelle and Cunliffe 2011). Because of the small amount of latex material expended, the dispersion of fragments as they descend to the ocean, and their limited amount of time on the surface, and low densities of ESA-listed species in the action area, the risk of ingestion of weather balloon material remains very low and discountable, as analyzed in the prior BA and 2023 LOC.

The proposed recovery area is larger than analyzed in the 2023 LOC and overlaps the range of the federally threatened Central North Pacific DPS of the green sea turtle, which was not included in the NMFS 2023 LOC and is therefore analyzed below. The potential effects to all other species, DPSs, and ESUs considered in the prior BA and 2023 LOC remain the same.

4.1 Direct and Indirect Effects on the Central North Pacific Green Sea Turtle DPS

This section evaluates how, and to what degree, the activities described in Chapter 2 potentially impact the ESA-listed Central North Pacific DPS of the green sea turtle. The stressors and effects are the same as were determined in the prior BA and 2023 LOC since green sea turtles of the Central North Pacific DPS are physically, behaviorally, and functionally essentially the same as the green sea turtle DPSs analyzed in the prior BA. The stressors considered are:

- Physical disturbance and impacts by fallen objects
- Entanglement
- Ingestion
- Ship Strike
- Indirect Effects
- Cumulative Effects

The DAF has identified no interrelated or interdependent projects that would impact the Central North Pacific DPS of the green sea turtle within the Action Area.

4.1.1 Physical Disturbance and Impacts by Fallen Objects

If a fairing or radiosonde struck a green sea turtle, it could result in injury or death. Once within the water column, disturbance or strike from an item falling through the water is possible, but its velocity would be greatly reduced (reducing the potential for serious injury) and the falling object could potentially be avoided by marine species once detected. A low possibility exists that a green sea turtle would be at or just under the surface in the impact area at the time of splashdown, but population-level impacts would not occur. In addition, green sea turtles occur in very low densities throughout the proposed landing area (U.S. Department of the Navy 2017), therefore, the probability of a strike would be very unlikely and discountable.

Therefore, the DAF has determined physical disturbance and potential strike as a result of the Proposed Change would be discountable and may affect, but is not likely to adversely affect the Central North Pacific DPS of the green sea turtle.

4.1.1 Entanglement

Unrecovered parafoils, parachutes, and weather balloons can potentially become entangled with green sea turtles, causing injury or death. While individual turtles could encounter expended materials that may pose a risk of entanglement, the likelihood of entanglement is extremely small because: (1) the encounter rate for these expended materials is low, (2) there is restricted overlap with susceptible turtles, and (3) the physical characteristics of the expended materials reduce entanglement risk to green sea turtles compared to abandoned fishing gear. For example, latex weather balloons burst after reaching its elastic limit at an altitude of 12 to 19 mi. The temperature at this altitude range can reach negative 40 ^{o}F and even colder. Under these conditions of extreme elongation and low temperature, the balloon undergoes "brittle fracture" where the rubber shatters along grain boundaries of crystallized segments. The resultant pieces of rubber are small strands comparable to the size of a quarter (Burchette 1989). The balloon fragments would be positively buoyant, float on the surface, and begin to photo-oxidize due to UV light exposure. In addition, unrecovered parafoils and parachutes would sink quickly through the water column, at 7 ft and 22 ft per minute, respectively, and settle (NMFS 2022). These activities will typically occur far offshore in deep waters where they are not expected to be encountered by green sea turtles potentially affected by the Proposed Action. Entanglement with parachutes, unrecovered parafoils, or weather balloons is therefore extremely unlikely and therefore the risk of entanglement is very low.

As a result, the DAF has determined that entanglement stressors introduced into the marine environment as a result of the Proposed Action may affect, but is not likely to adversely affect the Central North Pacific DPS of the green sea turtle species because the potential impacts are discountable.

4.1.2 Ingestion Stressors

Pieces of weather balloons, parachutes, or parafoils may pose an ingestion stressor to green sea turtles. Ingestion of expended materials by turtles could occur at or just below the surface, in the water column, or at the seafloor depending on the size and buoyancy of the expended object and the feeding behavior of the turtle. Floating material is more likely to be eaten by a turtle that is feeding at or just under the water's surface.

Parachutes and parafoils are made of nylon and Kevlar and thus do not degrade quickly. Photooxidation would break down nylon, however, the parachutes and parafoils would sink rapidly (discussed above) and settle on the ocean floor, typically far from shore at depths greater than the green sea turtles discussed herein are expected to occur and where ultraviolet light would not penetrate. Because the degradation of these materials would be very slow and the presence of the green sea turtle species at these depths is unlikely the risk of ingestion of parachute or parafoil materials by green sea turtle would be very low and discountable.

Weather balloons would burst at an altitude of 12 to 19 mi where temperatures can reach negative 40 ^{o}F and even colder. As discussed above, the balloon would undergo "brittle fracture", and shatter into pieces approximately the size of a quarter (Burchette 1989). These pieces would become dispersed over a broad area as they fall to the surface of the ocean. The balloon fragments would be positively buoyant, float on the surface, and degrade over approximately 6 weeks as they photo-oxidize due to UV light exposure (Burchette 1989). After several weeks, the pieces of latex would be smaller and become neutrally buoyant (Ye and Andrady 1991; Lobelle and Cunliffe 2011). Because of the small amount of latex material expended, the dispersion of fragments as they descend to the ocean, and their limited amount of time on the surface, and low densities of green sea turtle in the action area, the risk of ingestion of weather balloon material is very low and discountable.

Therefore, the DAF has determined that ingestion stressors introduced into the marine environment as a result of the Proposed Action may affect, but is not likely to adversely affect the Central North Pacific DPS of the green sea turtle because the potential impacts are discountable.

4.1.3 Ship Strike

Support vessels which would be used during first stage and fairing recover activities have the potential to strike green sea turtles that are at or near the surface of the water. Any of the sea turtles found in the action area can occur at or near the surface in open ocean, whether feeding or periodically surfacing to breathe. However, green sea turtles spend a majority of their time submerged (Hochscheid et al. 1999; Rice & Balazs 2008). Green sea turtles forage along the sea floor and are more likely to forage nearshore shallow environments (Hochscheid et al. 1999; Rice & Balazs 2008), outside of the proposed landing area. Green sea turtles occur in low densities in the action area and are widespread and scattered at sea. Therefore, ship strikes of green sea turtles would be very unlikely. Additionally, the probability of a strike would be further reduced by implementation of the EPMs, discussed in Section 2.2.4. As a result, the DAF has determined that strike stressors as a result of the Proposed Action may affect, but is not likely to adversely affect the Central North Pacific DPS of the green sea turtle because the potential impacts are discountable.

4.1.4 Indirect Effects

Indirect effects (secondary stressors) on green sea turtles would mainly be associated with the occurrence and availability of prey species and impacts on habitat. For example, the impact of expended materials on the ocean surface might cause injury or induce startle reactions and temporary dispersal of schooling fishes if they are within close proximity of the activity. The abundance of prey species could be diminished for a brief period of time before being repopulated by animals from adjacent waters. Secondary impacts such as these would be temporary, and no lasting impact on prey availability or the pelagic food web would be expected. Indirect impacts under the Proposed Action would not result in a decrease in the quantity or quality of prey species populations or sea turtle habitats in the Action Area.

Therefore, the DAF has determined that indirect effects of the Proposed Action may affect, but is not likely to adversely affect the Central North Pacific DPS of the green sea turtle because the potential impacts are insignificant.

4.2 Cumulative Effects on the Central North Pacific Green Sea Turtle DPS

Cumulative effects on green sea turtle species are those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the Action Area (50 C.F.R. Section 402.02). For the purposes of this BA and cumulative effects analysis for the Central North Pacific DPS of the green sea turtle, the DAF identified broad categories of activities including commercial fishing and harvest, maritime traffic and vessel strikes, coastal land development, ocean pollution, ocean noise, and offshore energy development. Any impacts that might occur could be additive to behavioral disturbance, injury and mortality associated with other actions within the Action Area. Therefore, this section evaluates risks posed by non-federal activities in the Action Area that could result in cumulative adverse effects on sea turtles.

Based on the listing status of the Central North Pacific DPS of the green sea turtle within the Action Area, there is a clear indication that the current aggregate impacts of past human activities are significant for green sea turtles. Bycatch, vessel strikes, coastal land development, and ocean pollution are the leading causes of mortality and population decline for green sea turtles. Paoching and illegal harvest of eggs within nesting areas are also impactful. Any incidence of injury and mortality that might occur under the Proposed Action, though unlikely and would affect a relatively small number of individuals, could be additive to injury and mortality associated with other actions in the region of influence.

As discussed above, the Central North Pacific DPS of the green sea turtle could be affected by physical disturbance, strike stressors, entanglement stressors, and ingestion stressors. Some stressors could also result in injury or mortality to a relatively small number of individuals but the likelihood of these effects is discountable. It is anticipated that the Proposed Action may affect, but is not likely to adversely affect the Central North Pacific DPS of the green sea turtle within the Action Area. Effects from the Proposed Action to green sea turtle food sources would be insignificant. Likewise, the stressors under the Proposed Action generally would not overlap other stressors in space and time as they occur as dispersed, infrequent, and isolated events that do not last for extended periods.

It is possible that the response of a previously stressed animal to impacts associated with the Proposed Action could be more severe than the response of an unstressed animal, or impacts from the Proposed Action could make an individual more susceptible to other stressors. Likewise, the Proposed Action could contribute incremental stressors to individuals, which would both compound effects on a given individual already experiencing stress which may further stress populations in significant decline. Although the aggregate impacts of past, present, and other reasonably foreseeable future actions continue to have significant impacts on the Central North Pacific DPS of the green sea turtle in the Action Area, the Proposed Action is not likely to incrementally contribute to declines in populations of the Central North Pacific DPS of the green sea turtle within the Action Area.

In summary, the aggregate impacts of past, present, and other reasonably foreseeable future actions continue to have significant impacts on the Central North Pacific DPS of the green sea turtle in the Action Area. The Proposed Action could contribute incremental stressors to individuals, which may further stress populations in significant decline. However, the incremental stressors anticipated from the Proposed Action would be insignificant in light of the relative contribution from the Proposed Action in comparison to other actions and because the Proposed Action generally will not overlap in space and time with other stressors. Therefore, it is anticipated that the Proposed Action may affect, but is not likely to adversely affect the Central North Pacific DPS of the green sea turtle within the Action Area.

5 Conclusion

The DAF proposes to add Falcon Heavy, increase first stage and booster recoveries to 100 times per year, and expand the first stage/booster and fairing recovery area in the Pacific Ocean. The Proposed Change would not modify the action in a manner that would result in different types of stressors or levels of stressors that were not considered in the 2023 LOC; nor would the Proposed Change affect the ESA-listed species previously consulted on or critical habitat in a manner or to an extent not previously considered. The proposed recovery area is larger than analyzed in the 2023 LOC and overlaps the range of the federally threatened Central North Pacific DPS of the green sea turtle, which was not included in the NMFS 2023 LOC. All other species, DPSs, and ESUs considered in the prior BA and 2023 LOC remain the same. After reviewing the Proposed Change, including the EPMs (Section 2.2.4), the DAF has determined that the Proposed Change *may affect, but is not likely to adversely affect* the Central North Pacific DPS of the green sea turtle.

6 Literature Cited

30th Space Wing. 2022. Biological Assessment of Launch Cadence Increase at Vandenberg Space Force Base, California, and Offshore Landing Locations to Support Endangered Species Act Section 7 Consultation with the National Marine Fisheries Service. Prepared by ManTech SRS Technologies, Inc. for 30th Space Wing, Installation Management Flight, Vandenberg Space Force Base, California. 16 December 2022.

Balazs, G.H., K.S. Van Houtan, S.A. Hargrove, S.M. Brunson, and S.K.K., Murakawa. 2015. A Review of the Demographic Features of Hawaiian Green Turtles (*Chelonia mydas*). Chelonian Conservation and Biologiy 14(2): 119-129.

Burchette, D.K. 1989. A Study of the Effect of Balloon Releases on the Environment. Latex Rubber Institute of Malaysia: Environmental Committee of the National Association of Balloon Artists.

Cliffton, K., D.O. Cornejo, and R.S. Felger. 1995. Sea turtles of the Pacific coast of Mexico. In K. A. Bjorndal (Ed.), Biology and Conservation of Sea Turtles (Revised ed., pp. 199-209). Washington, DC: Smithsonian Institution Press.

Godin, O. 2008. Sound transmission through water–air interfaces: new insights into an old problem. Contemporary Physics 49(2): 105-123.

Hochscheid, S., B.J. Godley, A.C. Broderick, and R.P. Wilson. 1999. Reptilian diving: highly variable dive patters in the green turtle *Chelonia mydas*. Marine Ecology Progress Series 185: 101-112.

Lobelle, D., and M. Cunliffe. 2011. Early microbial biofilm formation on marine plastic debris. Marine Pollution Bulletin 62(1): 197–200.

National Marine Fisheries Service. 2022. Programmatic Concurrence Letter for Launch and Reentry Vehicle Operations in the Marine Environment and Starship/Super Heavy Launch Vehicle Operations at SpaceX's Boca Chica Launch Site, Cameron County, TX. Office of Protected Resources, Silver Spring, MD.

National Marine Fisheries Service. 2023. Endangered Species Act Section 7(a)(2) Concurrence Letter for increasing number of launches at the Vandenberg Space Force Base. Reference No: WCRO-2023-00002. 20 January 2023.

Rice, M.R., and G.H. Balazs. 2008. Diving behavior of the Hawaiian green turtle (*Chelonia mydas*) during oceanic migrations. Journal of Experimental Marine Biology and Ecology 356(1-2): 121-127.

U.S. Department of the Navy. 2017. U.S. Navy Marine Species Density Database Phase III for the Hawaii-Southern California Training and Testing Study Area (Naval Facilities Engineering Command Pacific Technical Report). Pearl Harbor, HI: Naval Facilities Engineering Command Pacific.

U.S. Fish and Wildlife Service and National Marine Fisheries Service. 1998. Endangered Species Consultation Handbook Procedures for Conducting Consultation and Conference Activities Under Section 7 of the ESA. U.S. Fish and Wildlife Service and National Marine Fisheries Service.

Ye, S., and A.L. Andrady. 1991. Fouling of floating plastic debris under Biscayne Bay exposure conditions. Marine Pollution Bulletin 22(12): 608–613.

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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
501 West Ocean Boulevard, Suite 4200
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April 17, 2024

Refer to NMFS No: WCRO-2024-00812

Beatrice L. Kephart
Chief, Installation Management Flight
30 CES/CEI
1028 Iceland Avenue
Vandenberg AFC, California 93437

Re: Endangered Species Act Section 7(a)(2) Concurrence Letter for the Increase Cadence of Space Launch Vehicle First Stage Recovery Actions and Expanded Landing Areas in the Pacific Ocean

Dear Ms. Kephart,

This letter responds to your March 21, 2024, request for concurrence from the National Marine Fisheries Service (NMFS) pursuant to Section 7 of the Endangered Species Act (ESA) for the subject action. Your request qualified for our expedited review and concurrence because it contained all required information on your proposed action and its potential effects to listed species and designated critical habitat.

This response to your request was prepared by NMFS pursuant to section 7(a)(2) of the ESA and implementing regulations at 50 CFR 402. On July 5, 2022, the U.S. District Court for the Northern District of California issued an order vacating the 2019 regulations that were revised or added to 50 CFR part 402 in 2019 ("2019 Regulations," see 84 FR 44976, August 27, 2019) without making a finding on the merits. On September 21, 2022, the U.S. Court of Appeals for the Ninth Circuit granted a temporary stay of the district court's July 5 order. On November 14, 2022, the Northern District of California issued an order granting the government's request for voluntary remand without vacating the 2019 regulations. The District Court issued a slightly amended order two days later on November 16, 2022. As a result, the 2019 regulations remain in effect, and we are applying the 2019 regulations here. For purposes of this consultation and in an abundance of caution, we considered whether the substantive analysis and conclusions articulated in the letter of concurrence would be any different under the pre-2019 regulations. We have determined that our analysis and conclusions would not be any different.

We reviewed the Department of Air Force's (DAF) consultation request document and related materials. After a brief exchange in clarification regarding the proposed action and effects determination, and reference to their most recent 2023 consultation, we believe there was adequate consideration and mitigation measures to address the, minimal but present, threat of entanglement, ingestion of debris, strike by falling object, vessel strike, exposure to sonic boom, and other indirect effects. Based on our knowledge, expertise, and your action agency's materials, we concur with the action agency's conclusions that the proposed action is not likely to adversely affect the NMFS ESA-listed species and/or proposed critical habitat.

This letter underwent pre-dissemination review using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The concurrence letter will be available through NMFS' Environmental Consultation Organizer (https://www.fisheries.noaa.gov/resource/tool-app/environmental-consultation-organizer-eco)A complete record of this consultation is on file at NMFS Long Beach, CA office.

Reinitiation of consultation is required and shall be requested by DAF or by NMFS, where discretionary Federal involvement or control over the action has been retained or is authorized by law and (1) the proposed action causes take; (2) new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the written concurrence; or (4) a new species is listed or critical habitat designated that may be affected by the identified action (50 CFR 402.16). This concludes the ESA consultation.

Please direct questions regarding this letter to Dan Lawson, NMFS Long Beach, CA office at Dan.Lawson@noaa.gov.

Sincerely,

Dan Lawson
Long Beach Office Branch Chief
Protected Resources Division

bcc: Administrative File: 151422WCR2024PR00078

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
1315 East-West Highway
Silver Spring, Maryland 20910

DEPARTMENT OF COMMERCE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

NATIONAL MARINE FISHERIES SERVICE

Letter of Authorization

The U.S. Space Force (USSF), is hereby authorized to take marine mammals incidental to those activities at Vandenberg Space Force Base (VSFB), California, in accordance with 50 CFR 217, Subpart G--Taking Marine Mammals Incidental to U.S. Space Force Launches and Operations at Vandenberg Space Force Base (VSFB), California subject to the provisions of the Marine Mammal Protection Act (16 U.S.C. 1361 *et seq.*; MMPA) and the following conditions:

1. This Letter of Authorization (LOA) is valid April 10, 2024, through April 9, 2029.

2. This Authorization is valid only for the unintentional taking of the species and stocks of marine mammals identified in Condition 4 incidental to rocket and missile launches and supporting operations originating at VSFB.

3. This Authorization is valid only if USSF or any person(s) operating under its authority implements the mitigation, monitoring, and reporting required pursuant to 50 CFR §§ 217.64 and 217.65 and implements the Terms and Conditions of this Authorization.

4. General Conditions

   (a) A copy of this LOA must be in the possession of USSF, its designees, and personnel operating under the authority of this LOA.

   (b) The incidental take of marine mammals under the activities identified in Condition 2 and 50 CFR § 217.60 of the regulations, by Level B harassment only, is limited to the species and stocks and number of takes shown in Table 1.

Species	**Stock**	**Annual Take by Level B harassment**	**5-Year Total Take by Level B harassment**
Harbor seal	California	11,135	38,591
California sea lion	United States	84,870	281,021
Northern elephant seal	California Breeding	9,438	29,590
Steller sea lion	Eastern	550	1,900
Northern fur seal	California	5,909	18,383
Guadalupe fur seal	Mexico	23	71

(c) The taking by injury (Level A harassment), serious injury, or death of any of the species listed in condition 3(b) of the Authorization or any taking of any other species of marine mammal is prohibited and may result in the modification, suspension, or revocation of this LOA.

5. Mitigation

USSF, and any persons operating under its authority, must implement the following mitigation measures when conducting the activities identified in Condition 2 of this Authorization.

(a) USSF must provide pupping information to launch proponents at the earliest possible stage in the launch planning process and direct launch proponents to, if practicable, avoid scheduling launches during pupping seasons on VSFB from 1 March to 30 April and on the Northern Channel Islands from 1 June- 31 July. If practicable, rocket launches predicted to produce a sonic boom on the Northern Channel Islands >3 pounds per square foot (psf) from 1 June – 31 July will be scheduled to coincide with tides in excess of +1.0 ft (0.3 m), with an objective to do so at least 50 percent of the time.

(b) For manned flight operations, aircraft must use approved routes for testing and evaluation. Manned aircraft must also remain outside of a 1,000-ft (305 m) buffer around pinniped rookeries and haul-out sites (except in emergencies such as law enforcement response or Search and Rescue operations, and with a reduced, 500-ft (152 m) buffer at Small Haul-out 1).

(c) UAS classes 0-2 must maintain a minimum altitude of 300 ft (91 m) over all known marine mammal haulouts when marine mammals are present, except at take-off and landing. Class 3 must maintain a minimum altitude of 500 ft (152 m), except at take-off and landing. UAS classes 4 and 5 only operate from the VSFB airfield and must maintain a minimum altitude of 1,000 ft (305 m) over marine mammal haulouts except at take-off and landing. USSF must not fly class 4 or 5 UAS below 1,000 ft (305 m) over haulouts.

6. Monitoring

USSF is required to conduct marine mammal and acoustic monitoring as described below:

(a) Monitoring at VSFB and NCI must be conducted by at least one NMFS-approved Protected Species Observer (PSO) trained in marine mammal science. PSOs must have demonstrated proficiency in the identification of all age and sex classes of all marine mammal species that occur at VSFB and on NCI. They must be knowledgeable of approved count methodology and have experience in observing pinniped behavior, especially that due to human disturbances.

(b) In the event that the PSO requirements described in paragraph (a) of this section cannot be met (*e.g.*, access is prohibited due to safety concerns), daylight or nighttime video monitoring must be used in lieu of PSO monitoring. In certain circumstances where the daylight or nighttime video monitoring is also not possible (*e.g.*, USSF is unable to access a monitoring site due to road conditions or human safety concerns), USSF must notify NMFS.

(c) At VSFB, USSF must conduct marine mammal monitoring and take acoustic measurements for all new rockets, for rockets (existing and new) launched from new facilities, and for larger or louder rockets (including those with new launch proponents) than those that have been previously launched from VSFB during their first three launches and for the first three launches from any new facilities during March through July.

i. For launches that occur during the harbor seal pupping season (March 1 through June 30) or when higher numbers of California sea lions are present (June 1 through July 31), monitoring must be conducted. At least one NMFS-approved PSO trained in marine mammal science must conduct the monitoring.

ii. When launch monitoring is required, monitoring must begin at least 72 hours prior to the launch and continue through at least 48 hours after the launch. Monitoring must include multiple surveys each day, with a minimum of four surveys per day.

iii. For launches within the harbor seal pupping season, USSF must conduct a follow-up survey of pups.

iv. For launches that occur during daylight, USSF must make time-lapse video recordings to capture the reactions of pinnipeds to each launch. For launches that occur at night, USSF must employ night video monitoring, when feasible.

v. When possible, PSOs must record: species, number, general behavior, presence and number of pups, age class, gender, and reaction to launch noise, or to natural or other human-caused disturbances. PSOs must also record environmental conditions, including visibility, air temperature, clouds, wind speed and direction, tides, and swell height and direction.

(d) USSF must conduct sonic boom modeling prior to the first three small or medium rocket launches from new launch proponents or at new launch facilities, and all heavy or super-heavy rocket launches.

(e) USSF must conduct marine mammal monitoring and take acoustic measurements at the NCI if the sonic boom model indicates that pressures from a boom will reach or exceed 7 psf from 1 January through 28 February, 5 psf from 1 March through 31

July, or 7 psf from 1 August through 30 September. No monitoring is required on NCI from 1 October through 31 December.

i. The monitoring site must be selected based upon the model results, prioritizing a significant haulout site on one of the islands where the maximum sound pressures are expected to occur.

ii. USSF must estimate the number of animals on the monitored beach and record their reactions to the launch noise and conduct more focused monitoring on a smaller subset or focal group.

iii. Monitoring must commence at least 72 hours prior to the launch, during the launch and at least 48 hours after the launch, unless no sonic boom is detected by the monitors and/or by the acoustic recording equipment, at which time monitoring may be stopped.

iv. For launches that occur in darkness, USSF must use night vision equipment.

v. Monitoring for each launch must include multiple surveys each day that record, when possible: species, number, general behavior, presence of pups, age class, gender, and reaction to sonic booms or natural or human-caused disturbances.

vi. USSF must collect photo and/or video recordings for daylight launches when feasible, and if the launch occurs in darkness night vision equipment will be used.

vii. USSF must record environmental conditions, including visibility, air temperature, clouds, wind speed and direction, tides, and swell height and direction.

(f) USSF must continue to test equipment and emerging technologies, including but not limited to night vision cameras, newer models of remote video cameras and other means of remote monitoring at both VSFB and on the NCI.

(g) USSF must evaluate UAS based or space-based technologies that become available for suitability, practicability, and for any advantage that remote sensing may provide to existing monitoring approaches.

(h) USSF must monitor marine mammals during the first three launches of the missiles for the new Ground Based Strategic Defense program during the months of March through July across the 5-year duration of this LOA.

i. When launch monitoring is required, monitoring must include multiple surveys each day, with a minimum of four surveys per day.

ii. When possible, PSOs must record: species, number, general behavior, presence and number of pups, age class, gender, and reaction to launch noise, or to natural or other human-caused disturbances. PSOs must also record environmental conditions, including visibility, air temperature, clouds, wind speed and direction, tides, and swell height and direction.

(i) USSF must conduct semi-monthly surveys (two surveys per month) to monitor the abundance, distribution, and status of pinnipeds at VSFB. Whenever possible, these surveys will be timed to coincide with the lowest afternoon tides of each month when the greatest numbers of animals are usually hauled out. If a VSFB or area closure precludes monitoring on a given day, USSF must monitor on the next best day.

i. PSOs must gather the following data at each site: species, number, general behavior, presence and number of pups, age class, gender, and any reactions to natural or human-caused disturbances. PSOs must also record environmental conditions, including visibility, air temperature, clouds, wind speed and direction, tides, and swell height and direction.

7. <u>Reporting</u>

(a) USSF must submit an annual report each year to NMFS Office of Protected Resources and West Coast Region on March 1st of each year that describes all activities and monitoring for the specified activities during that year. This includes launch monitoring information in Condition 7(a)(i) through (iii) for each launch where monitoring is required or conducted. The annual reports must also include a summary of the documented numbers of instances of harassment incidental to the specified activities, including non-launch activities (*e.g.*, takes incidental to aircraft or helicopter operations observed during the semi-monthly surveys). Annual reports must also include the results of the semi-monthly sentinel marine mammal monitoring described in Condition 6(i), results of tests of equipment and emerging technologies described in condition 6(f), and results of evaluation of UAS based or space-based technologies described in condition 6(g).

i. Launch information, including:

1) Date(s) and time(s) of the launch (and sonic boom, if applicable);

2) Number(s), type(s), and location(s) of rockets or missiles launched;

ii. Monitoring program design; and

iii. Results of the launch-specific monitoring program, including:

1) Date(s) and location(s) of marine mammal monitoring;

2) Number of animals observed, by species, on the haulout prior to commencement of the launch or recovery;

3) General behavior and, if possible, age (including presence and number of pups) and sex class of pinnipeds hauled out prior to the launch or recovery;

4) Number of animals, by species, age, and sex class that responded at a level indicative of harassment. Harassment is characterized by:

A. Movements in response to the source of disturbance, ranging from short withdrawals at least twice the animal's body length to longer retreats over the beach, or if already moving a change of direction of greater than 90 degrees; or

B. All retreats (flushes) to the water.

5) Number of animals, by species, age, and sex class that entered the water, the length of time the animal(s) remained off the haulout, and any behavioral responses by pinnipeds that were likely in response to the specified activities, including in response to launch noise or a sonic boom;

6) Environmental conditions including visibility, air temperature, clouds, wind speed and direction, tides, and swell height and direction; and

7) Results of acoustic monitoring, including the following:

A. Recorded sound levels associated with the launch (in SEL, SPL_{peak}, and SPL_{rms});

B. Recorded sound levels associated with the sonic boom (if applicable), in psf; and

C. The estimated distance of the recorder to the launch site and the distance of the closest animals to the launch site.

iv. Results of the semi-monthly sentinel marine mammal monitoring described in Condition 6(i), including:

1) Number of animals observed, by species;

2) General behavior and, if possible, age (including presence and number of pups) and sex class of pinnipeds hauled out;

3) Any reactions to natural or human-caused disturbances;

4) Environmental conditions including visibility, air temperature, clouds, wind speed and direction, tides, and swell height and direction.

(b) USSF must submit a final, comprehensive 5-year report to NMFS Office of Protected Resources within 90 days of the expiration of this LOA. This report must:

i. Summarize the activities undertaken and the results reported in all annual reports;

ii. Assess the impacts at each of the major rookeries; and

iii. Assess the cumulative impacts on pinnipeds and other marine mammals from the activities specified in Condition 2.

(c) If the activity identified in Condition 2 likely resulted in the take of marine mammals not identified in Condition 4(b), then the USSF must notify the NMFS Office of Protected Resources and the NMFS West Coast Region stranding coordinator within 24 hours of the discovery of the take.

(d) In the event that personnel involved in the activities discover an injured or dead marine mammal, USSF must report the incident to the Office of Protected Resources (OPR), NMFS (PR.ITP.MonitoringReports@noaa.gov and itp.davis@noaa.gov) and to the West Coast regional stranding network (866-767-6114) as soon as feasible.

The report must include the following information:

i. Time, date, and location (latitude/longitude) of the first discovery (and updated location information if known and applicable);

ii. Species identification (if known) or description of the animal(s) involved;

iii. Condition of the animal(s) (including carcass condition if the animal is dead);

iv. Observed behaviors of the animal(s), if alive;

v. If available, photographs or video footage of the animal(s); and

vi. General circumstances under which the animal was discovered.

(e) If real-time monitoring during a launch shows that the activity identified in Condition 2 is reasonably likely to have resulted in the mortality or injury of any marine mammal, USSF must notify NMFS within 24 hours (or next business day). NMFS and USSF must then jointly review the launch procedure and the mitigation requirements and make appropriate changes through the adaptive management process, as necessary and before any subsequent launches of rockets and missiles with similar or greater sound fields and/or sonic boom pressure levels.

8. This Authorization may be modified, suspended or withdrawn if USSF fails to abide by the conditions prescribed herein or if the authorized taking is having more than a negligible impact on the species or stock of affected marine mammals.

9. Renewals and Modifications of Letter of Authorization

    (a) A LOA issued under 50 CFR §§ 216.106 and § 217.66 for the activity identified in Condition 2 of this Authorization and 50 CFR § 217.60(a) and (b) shall be modified upon request by USSF, provided that:

        i. The specified activity and mitigation, monitoring, and reporting measures, as well as the anticipated impacts, are the same as those described and analyzed for this subpart (excluding changes made pursuant to the adaptive management provision in paragraph (c) of this section); and

        ii. NMFS determines that the mitigation, monitoring, and reporting measures required by the previous LOA under these regulations were implemented.

    (b) For LOA modification or renewal requests by the applicant that include changes to the activity or the mitigation, monitoring, or reporting measures (excluding changes made pursuant to the adaptive management provision in paragraph (c) of this section) that do not change the findings made for the regulations or that result in no more than a minor change in the total estimated number of takes (or distribution by species or stock or years), NMFS may publish a notice of proposed changes to the LOA in the *Federal Register*, including the associated analysis of the change, and solicit public comment before issuing the LOA.

    (c) An LOA issued under 50 CFR §§ 216.106 and 217.66 for the activity identified in Condition 2 of this Authorization and 50 CFR § 217.60(a) and (b) may be modified by NMFS under the following circumstances:

        i. After consulting with the USSF regarding the practicability of the modifications, NMFS, through adaptive management, may modify (including adding or removing measures) the existing mitigation, monitoring, or reporting measures if doing so creates a reasonable likelihood of more effectively accomplishing the goals of the mitigation and monitoring.

        ii. Possible sources of data that could contribute to the decision to modify the mitigation, monitoring, or reporting measures in an LOA include:

            1) Results from the USSF's monitoring from the previous year(s);

2) Results from other marine mammal and/or sound research or studies; or

3) Any information that reveals marine mammals may have been taken in a manner, extent or number not authorized by these regulations or a subsequent LOA.

iii. If, through adaptive management, the modifications to the mitigation, monitoring, or reporting measures are more than minor, NMFS will publish a notice of the proposed changes to the LOA in the *Federal Register* and solicit public comment.

(d) If NMFS determines that an emergency exists that poses a significant risk to the well-being of the species or stocks of marine mammals specified in the regulations and this Authorization, an LOA may be modified without prior notice or opportunity for public comment. Notice would be published in the *Federal Register* within 30 days of the action.

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For Kimberly Damon-Randall, Director
Office of Protected Resources

Assessment to Determine Applicability of Vandenberg Space Force Base National Marine Fisheries Service Letter of Authorization for Falcon 9 Mainland Booms

2 August 2024

Background

The Department of the Air Force (DAF) contacted the National Marine Fisheries Service (NMFS) regarding mainland acoustic impacts in the Ventura County area as a result of recent SpaceX Falcon missions with easterly trajectories. Since the region of acoustic impact has increased from what was considered in the DAF's application for a Letter of Authorization (LOA; NMFS 2024), the DAF has reassessed acoustic impacts to marine mammals to analyze if the increased impact is covered by the estimated take totals in the LOA or if an amendment is needed. There are two harbor seal haulouts identified on the mainland in the new geographic noise footprint, shown in Figure 1, the Carpinteria Harbor Seal Rookery and the Point Mugu Lagoon haulout.

Our LOA assumes 110 rocket launches from Vandenberg Space Force Base annually. We have assumed 100 Falcon 9 rocket launches in our calculations below to ensure we are account for maximum future potential impact from the easterly trajectories of this rocket.

Potential Noise Impacts

Falcon launches with easterly trajectories may result in sonic booms that impact eastern Santa Barbara, Ventura, and northwestern Los Angeles Counties (Figure 1). Even with identical trajectories, atmospheric conditions create considerable variation in where sonic booms impact and the level at which they impact. To account for this variation, PCBoom can utilize meteorological parameters in the model that affect where and at what level a sonic boom may impact the surface of the earth. In the late 1990's, SRS Technologies, Inc. assembled a series of daily meteorological profiles across 10 years (1984-1994, one per day for 10 years) from radiosonde data for weather balloons released by the VSFB weather squadron. The data include pressure, temperature, wind speed, and wind direction along an elevational profile from ground, every 1,000 feet (ft), to 110,000 ft. Figure 1 depicts the overlaid output from sonic boom modeling software (PCBoom) for four actual SpaceX easterly trajectories, each trajectory run between 29 and 34 times, each run representing 1 of between 29 and 34 randomly selected meteorological profiles that capture potential weather conditions throughout the year (125 model outputs total) overlaid in the image.

We have collected sonic boom overpressure levels in the field for 6 easterly trajectories to determine to what extent the modeled vs actual overpressure levels align (Table 1). Thus far, we have seen that the model predicts higher potential boom levels than actual and thus we are confident that our calculations below are an overestimation.

Table 1. Sonic Boom Data Collection to Date.

Mission	Date	Azimuth	# of Collection Stations	Predicted Boom Level	Actual Boom Level
Starlink 8-7	14 May 2024 18:39Z	144	5	< 0.5 – 2.1 psf	< 0.5 psf
Starlink 8-8	8 June 2024 12:58Z	144	5	< 0.5 – 2.1 psf	0 psf
Starlink 9-1	19 June 2024, 03:40Z	144	15	< 0.5-1.0 psf	< 1.0 psf
Starlink 9-2	24 June 2024, 03:47Z	144	20	< 0.5-1.0 psf	< 0.5 psf
NROL-186	29 June 2024, 03:14Z	155	20	< 1.0-1.99 psf	< 0.1 psf
Starlink 9-3	12 July 2024, 02:39Z	144	15	< 1.0-1.99 psf	<0.5 psf

In addition to sonic boom, rocket engine noise is expected in these areas, but at very low levels. RNOISE was used to model engine noise during Falcon 9 launch from SLC-4. The modeled 90 decibel (dB) unweighted peak sound pressure level (SPL) extends to approximately 7.4 miles southeast of SLC-4 (Figure 2). Santa Barbara is estimated to receive 60 dB unweighted SPL due to rocket engine noise (Figure 2). Additionally, acoustic monitoring in Ventura County for five SpaceX missions with easterly trajectories, engine noise has been below ambient noise levels and thus could not be measured.

NMFS In-Air Acoustic Thresholds

Pinnipeds are categorized into two functional hearing groups based on their generalized hearing sensitivities: (1) otariids and (2) phocids. Within these hearing groups, there is one phocid, the Pacific harbor seal, that hauls out in the area that may experience noise as a result of Falcon launches in Ventura County. NMFS has established thresholds for in-air impulsive noise for Level B harassment (i.e., behavioral disruption and temporary threshold shift [TTS] in hearing sensitivity) and for Level A harassment (permanent threshold shifts [PTS] in hearing sensitivity) based on species' audiograms and the results of studies measuring threshold shifts and behavioral responses (Table 2; NMFS 2021). For all pinnipeds the Level B harassment threshold for behavioral disruption is a sound exposure level (SEL) of 100 decibels (dB).

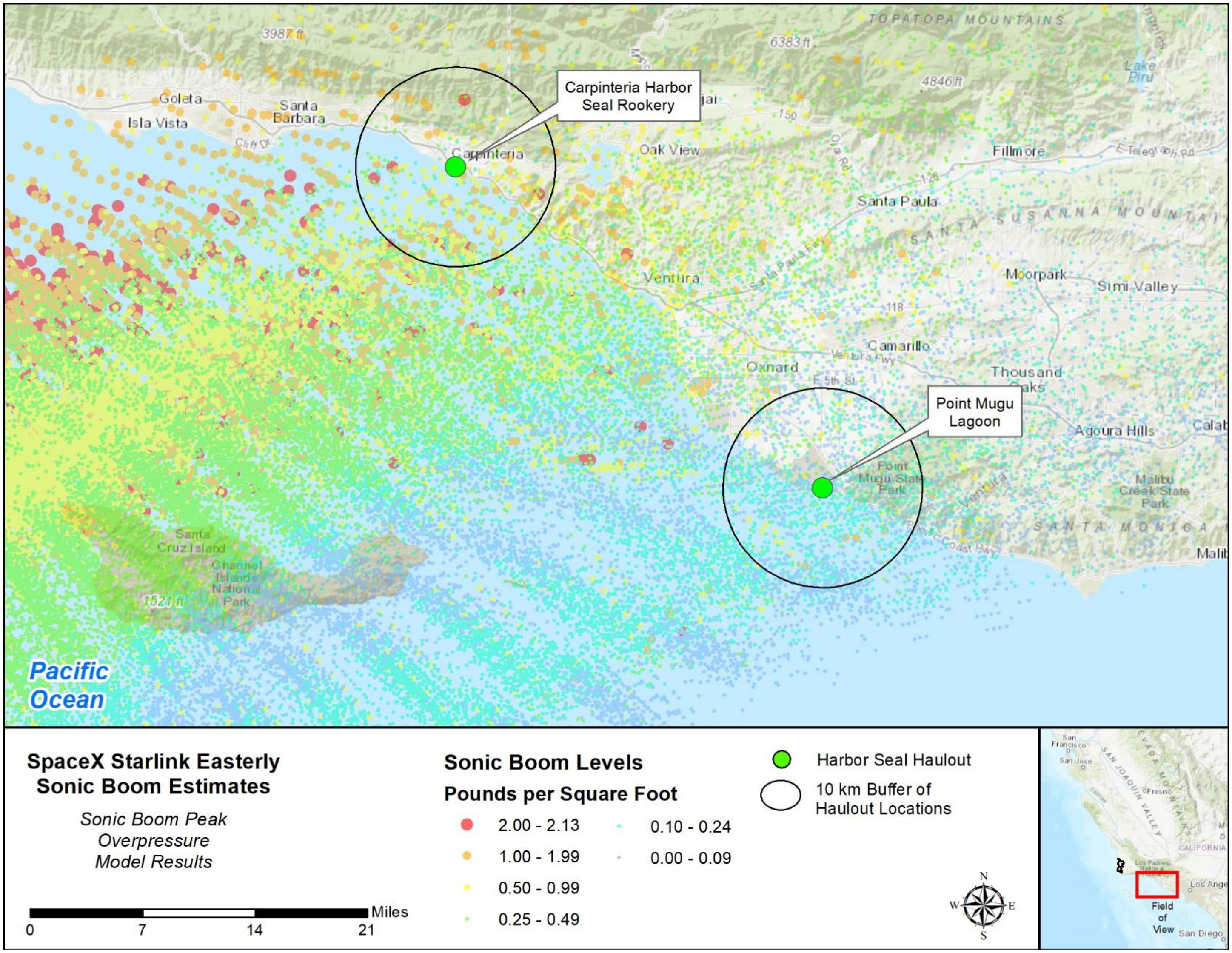

Figure 1. Sonic boom model results for easterly SpaceX Starlink trajectories showing range of possible boom impact areas and levels, depending on meteorological conditions, and mainland harbor seal haulouts (Note: the image is intended to show the array of potential sonic booms; no single launch would result in impacts across the entire areas depicted nor at the specific levels depicted).

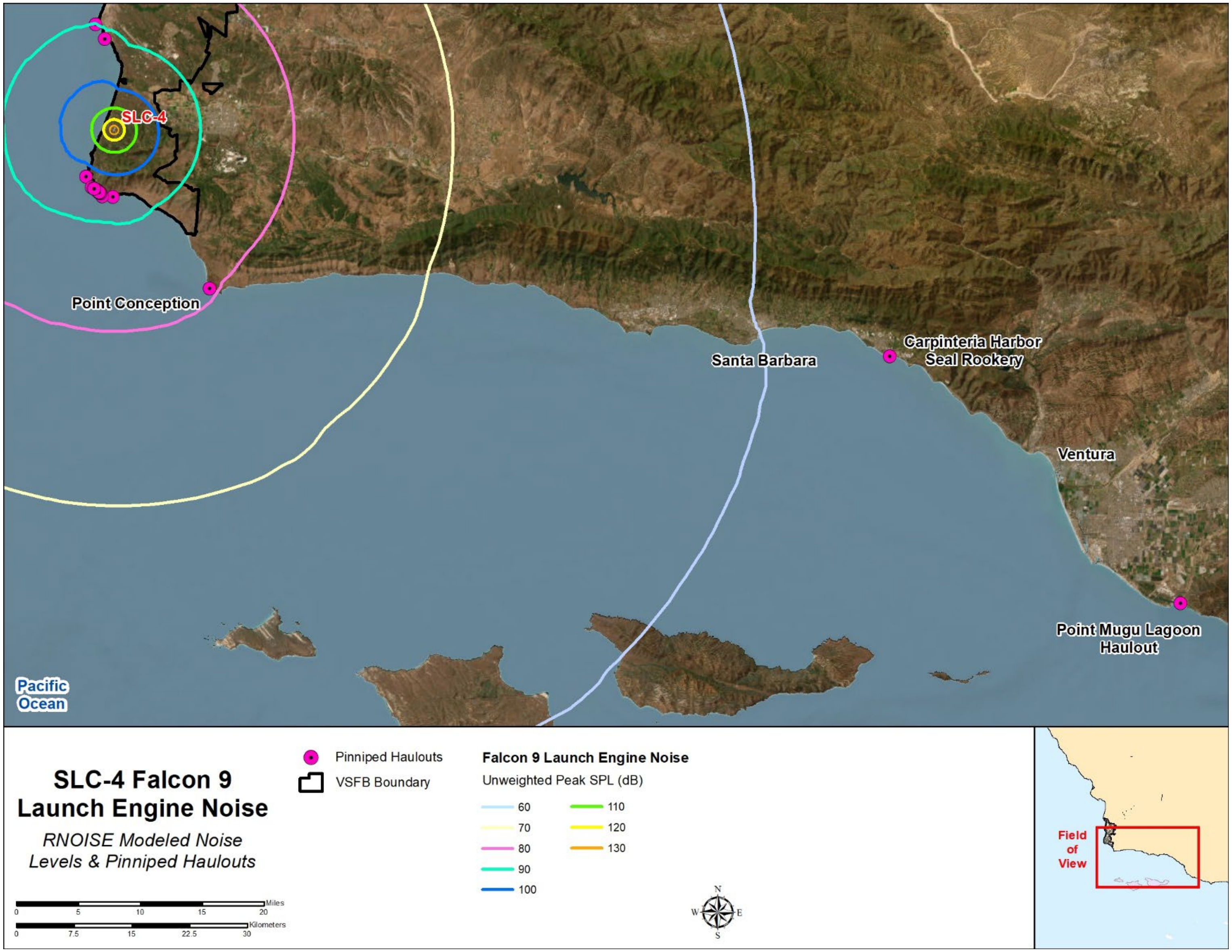

Figure 2. Modeled rocket engine noise for Falcon 9 launch from SLC-4 using RNOISE.

NMFS has also established thresholds for in-air non-impulsive noise for Level B harassment (behavioral disruption) for pinnipeds Table 3 (NMFS 2021). For harbor seals, the Level B harassment threshold (behavioral disruption) for non-impulsive noise is 90 dB root mean square (dB_{rms}). The dB_{rms} is the average dB of a noise over a period of time; therefore, substituting dB peak SPL is a conservative approach to applying the threshold for Level B harassment. NMFS has not established thresholds for Level A harassment resulting from PTS or Level B harassment resulting from TTS. However, according to Southall et al. (2019), the most recent study available, the lower limit for TTS as a result of in-air non-impulsive noise for phocids is 134 dB SEL, and the lower limit for PTS is 154 dB SEL (Table 4).

Table 2. Thresholds for in-air impulsive sound effects on pinnipeds.

Hearing Group	MMPA Level B Exposure		MMPA Level A Exposure
	Behavioral - SEL (unweighted)	TTS - Peak SPL (unweighted; re 20 µPa)	PTS - Peak SPL (unweighted; re 20 µPa)
Otariids	100 dB re 20 μPa^2 sec	170 dB (132.1 psf)	176 dB (263.6 psf)
Phocids		155 dB (23.5 psf)	161 dB (46.9 psf)

Source: NMFS 2021

SEL = sound exposure level; SPL = sound pressure level; dB = decibels; dB re 20 µPa = decibels related to 20 micropascals; dB re 20 μPa^2sec = decibels related to 20 micropascals squared seconds

Table 3. National Marine Fisheries Service current in-air acoustic thresholds for pinnipeds for non-impulsive noise.

Criterion	Criterion Definition	NMFS Threshold
Level A	PTS (injury)	None established
Level B	TTS	None established
Level B	Behavioral disruption for harbor seals	90 dB_{rms}
Level B	Behavioral disruption for non-harbor seal pinnipeds	100 dB_{rms}

Source: NMFS 2021

Table 4. In-air acoustic thresholds for TTS and PTS for pinnipeds and non-impulsive noise.

Group	Criterion Definition	Threshold
Otariids	PTS in hearing sensitivity (physical injury)	177 dB SEL
	TTS in hearing sensitivity	157 dB SEL
Phocids	PTS in hearing sensitivity (physical injury)	154 dB SEL
	TTS in hearing sensitivity	134 dB SEL

Source: Southall et al. 2019

Analysis of Noise Impacts in the Ventura County Area

The DAF applied the NMFS thresholds as the best available science to estimate level of take resulting from in-air impulsive and non-impulsive noise for harbor seals in Ventura County. During missions with easterly trajectories, the received engine noise levels (non-impulsive noise) would be substantially less than 90 dB_{rms}, the NMFS threshold for behavioral disturbance for harbor seals (Table 3). As discussed above, the modeled 90 dB peak SPL extends to approximately 7.4 miles southeast of SLC-4 (Figure 2). Additionally, acoustic monitoring in Ventura County for five SpaceX missions with easterly trajectories, engine noise has been below ambient noise levels and thus could not be measured. Therefore, engine noise is substantially below NMFS thresholds for behavioral disruption of harbor seals and thus no takes are anticipated at either the Carpinteria Harbor Seal Rookery or the Point Mugu Lagoon haulout.

To analyze the potential for take due to sonic boom (impulsive noise), the sonic boom model outputs were compared to harbor seal haulout locations, depicted in Figure 1. Approximately 39% of missions with easterly trajectories are predicted to impact the Carpinteria Harbor Seal Rookery. To estimate the potential levels of these sonic booms, a frequency distribution of potential sonic boom levels was constructed by overlaying a 10-km buffer of the rookery onto the PCBoom model output described above and as depicted in Figure 1. Of the sonic booms predicted to impact within 10 km of the rookery, 88% of the boom levels were predicted to be less than 1.0 psf, and 98% were predicted to be less than 2.0 psf (Figure 2). The highest predicted level was 3.7 psf.

For the Point Mugu Lagoon haulout, approximately 93% of missions with easterly trajectories are predicted to impact the site. However, 99.8% of the boom levels were predicted to be less than 1.0 psf, and 100% were predicted to be less than 1.5 psf (Figure 3). The highest predicted level was 1.6 psf.

Since PCBoom does not generate estimates of noise levels in SEL, recordings of sonic booms from VSFB were used to compare sonic boom psf levels to corresponding SEL values. During the SpaceX Sarah-1 mission, a 2.57 psf sonic boom was recorded on VSFB which corresponded to a measured level of 113.5 dB SEL. For the SpaceX Transporter 8 mission, a 1.07 psf sonic boom was recorded on VSFB which had a measured level of 102.3 dB SEL. Therefore, sonic booms of approximately 1 psf are expected to generally correspond to the NMFS threshold of 100 dB SEL for behavioral disruption for harbor seals (Table 2). This is supported by over two decades of pinniped monitoring by the DAF on the Northern Channel Islands and Vandenberg Space Force Base (VSFB) during sonic booms caused by numerous launches. The DAF has observed that there are generally no significant behavioral disruptions caused to pinnipeds by sonic booms less than 1 psf.

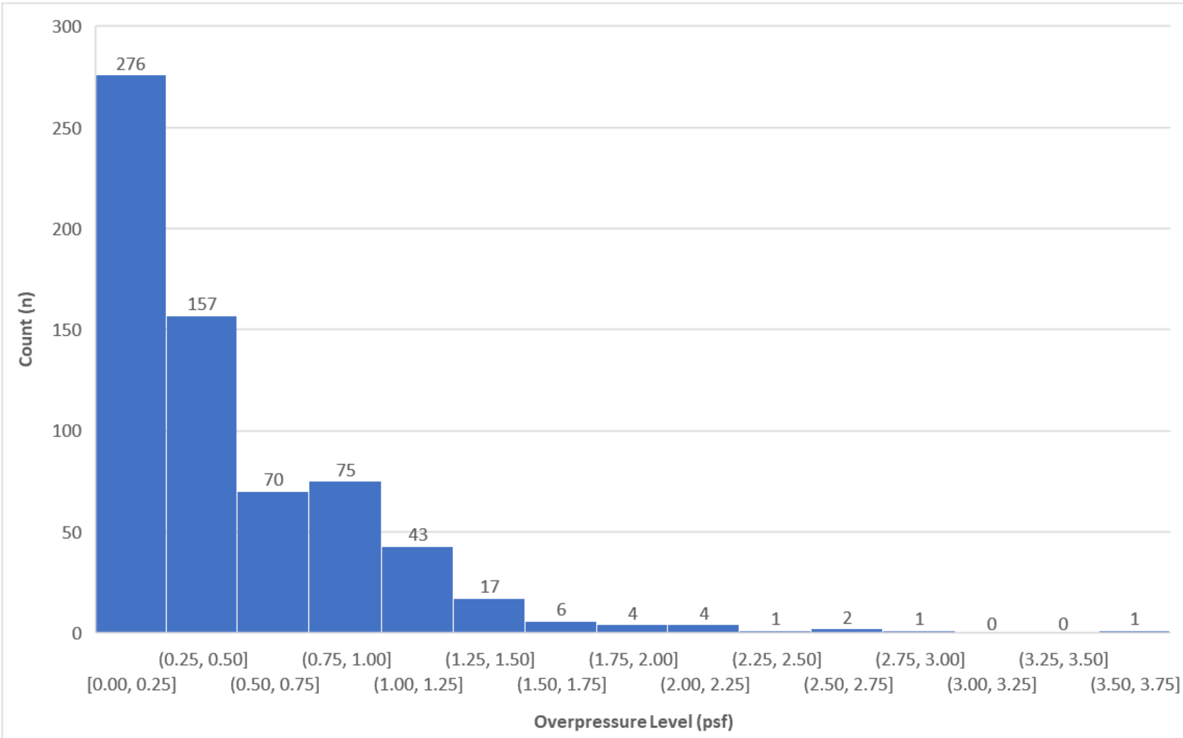

Figure 3. Distribution of PCBoom sonic boom modeling results within 10 km of the Carpinteria Harbor Seal Rookery, as shown in Figure 1.

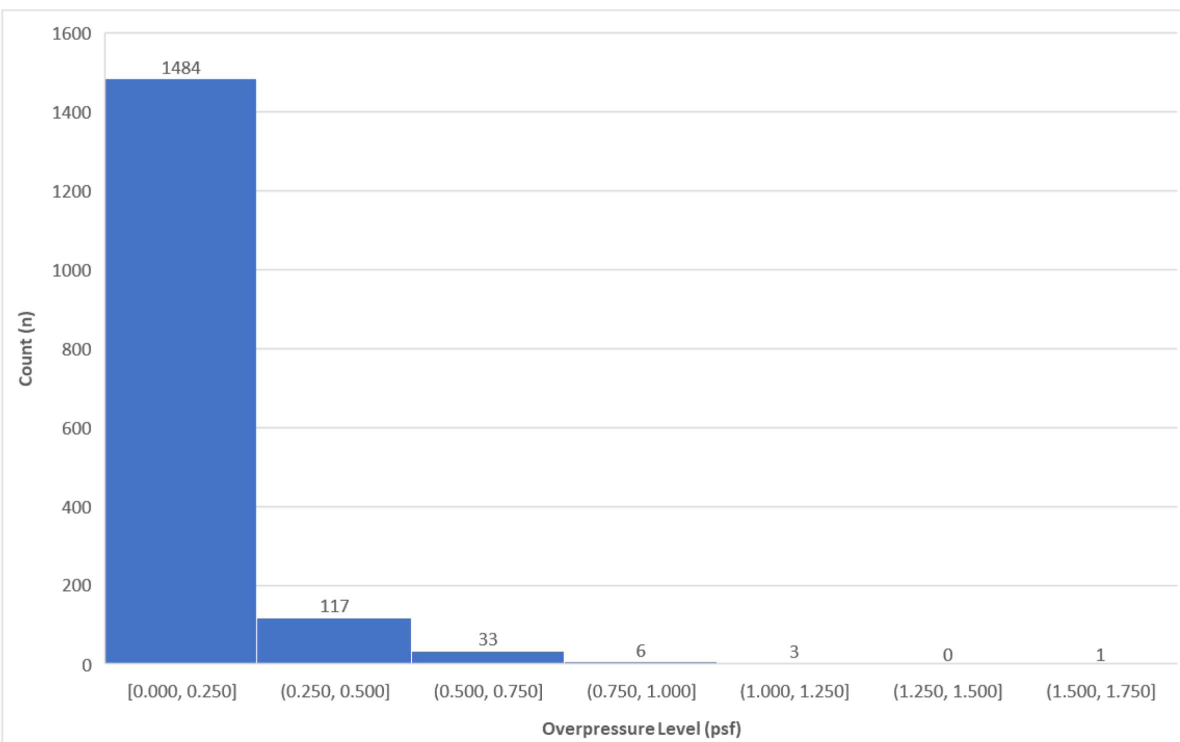

Figure 4. Distribution of PCBoom sonic boom modeling results within 10 km of the Point Mugu Lagoon haulout, as shown in Figure 1.

Therefore, applying NMFS thresholds for behavioral disruption caused by impulsive noise and VSFB pinniped monitoring results, we expect launches with easterly trajectories to result in sonic booms that would be at or above 1 psf for 22% of these missions at the Carpinteria Harbor Seal Rookery and less than 1% of missions at the Point Mugu Lagoon haulout. From 2019 through 2023 (excluding 2020 when counts did not occur due to Covid 19), the average number of adults present at the Carpinteria Harbor Seal Rookery from January through May was 132, with a high of 230 in May 2019 (Carpinteria Seal Watch 2024). The average highest number of pups recorded during this time period was 60 per year, with a high of 68 in 2019 (Carpinteria Seal Watch 2024). We estimate that approximately 80% of future Falcon 9 missions would have easterly trajectories and that 22% of these missions would create a sonic boom greater than 1 psf. Therefore, conservatively, an estimated 2,323 adult Pacific harbor seal takes would occur annually at this location. Based on 100 launches per year: 100 missions/year x 80% of missions with easterly trajectories x 22% x 132 (average number recorded over a 5-year period) = 2,323 takes.

For pups, present from January through May, conservatively an estimated 440 takes would occur each year. Based on 100 missions per year x 80% of missions with easterly trajectories, divided by 12 to get monthly average x 5 for the five-month pup season (Jan-May) x 22% x 60 (average highest number of pups recorded each year) = 440 takes. We used the average highest number of pups (vice average number) because of the short duration they are considered pups prior to weaning.

At the Point Mugu Lagoon haulout, we conservatively assume 1% of missions with easterly trajectories would cause a sonic boom of 1 psf or greater to impact this location. From 2019 through 2023, the average number of adults present at the Point Mugu Lagoon haulout was 104, with a high of 372 in December 2022 (NBVC Point Mugu 2024). The average highest number of pups recorded during this time period was 65 per year, with a high of 72 in 2021 (NBVC Point Mugu 2024). An estimated 83 adult Pacific harbor seals would be taken annually at this location. Based on 100 launches per year: 100 missions/year x 80% of missions with easterly trajectories x 1% x 104 (average number recorded over a 5-year period) = 83 takes.

For pups, present from January through May, an estimated 22 would be taken each year. Based on 100 missions per year x 80% of missions with easterly trajectories, divided by 12 to get monthly average x 5 for the five-month pup season (Jan-May) x 1% x 65 (average highest number of pups recorded each year) = 22 takes. We used the average highest number of pups (vice average number) because of the short duration they are considered pups prior to weaning.

Based on decades of monitoring harbor seal reactions to launch noise, we would expect all or some proportion of the seals to react to sonic booms of 1 psf or greater by moving off the haulout into the water. However, monitoring data shows that these responses are short-lived and animals begin to return to the haulout within minutes, typically returning to pre-launch numbers usually within 10 to 20 minutes and show no signs of lasting behavioral impacts in the days following the launch.

Permitted Annual Take by Level B harassment

VSFB's LOA permits a total of 11,135 Pacific harbor seals to be incidentally taken by Level B harassment annually due to launch activities (NMFS 2024). Although this total did not include estimates of take at haulouts on the south coast of eastern Santa Barbara, Ventura, and northwestern Los Angeles Counties, any increase in annual take by Level B harassment of Pacific harbor seals (estimated to be 2,868per year total) would be offset by a reduction in take on San Miguel Island. This is because as the trajectory of the Falcon 9 and resultant sonic boom moves more to the east and approaches 140 to 145 degrees the sonic boom no longer overlaps San Miguel Island, where there are large numbers of Pacific harbor seals and other pinnipeds. This is illustrated in Figures 5 and 6 below. It is therefore unnecessary to increase the number of permitted takes by Level B harassment of Pacific harbor seals under the LOA, despite the change in geographic area of potential impacts.

References

Carpinteria Seal Watch. 2024. Carpinteria Seal Watch Numbers. Available at: https://carpinteriasealwatch.org/about/. Accessed on 2 July 2024.

National Marine Fisheries Service. 2021. ESA Section 7 Consultation Tools for Marine Mammals on the West Coast. Available online: <https://www.fisheries.noaa.gov/west-coast/endangered-species-conservation/esa-section-7-consultation-tools-marine-mammals-west>. Accessed on 12 January 2024.

National Marine Fisheries Service. 2024. Letter of Authorization. 9 April 2024.

Naval Base Ventura County Point Mugu. 2024. Pinniped Count Data. Provided by Martin Ruane, Natural Resource Manager, Environmental Division, Naval Base Ventura County.

Southall, B. L., J. J. Finneran, C. Reichmuth, P. E. Nachtigall, D. R. Ketten, A. E. Bowles, W. T. Ellison, D. P. Nowacek, and P. L. Tyack. 2019. Marine mammal noise exposure criteria: Updated scientific recommendations for residual hearing effects. Aquatic Mammals 45(2): 125–232.

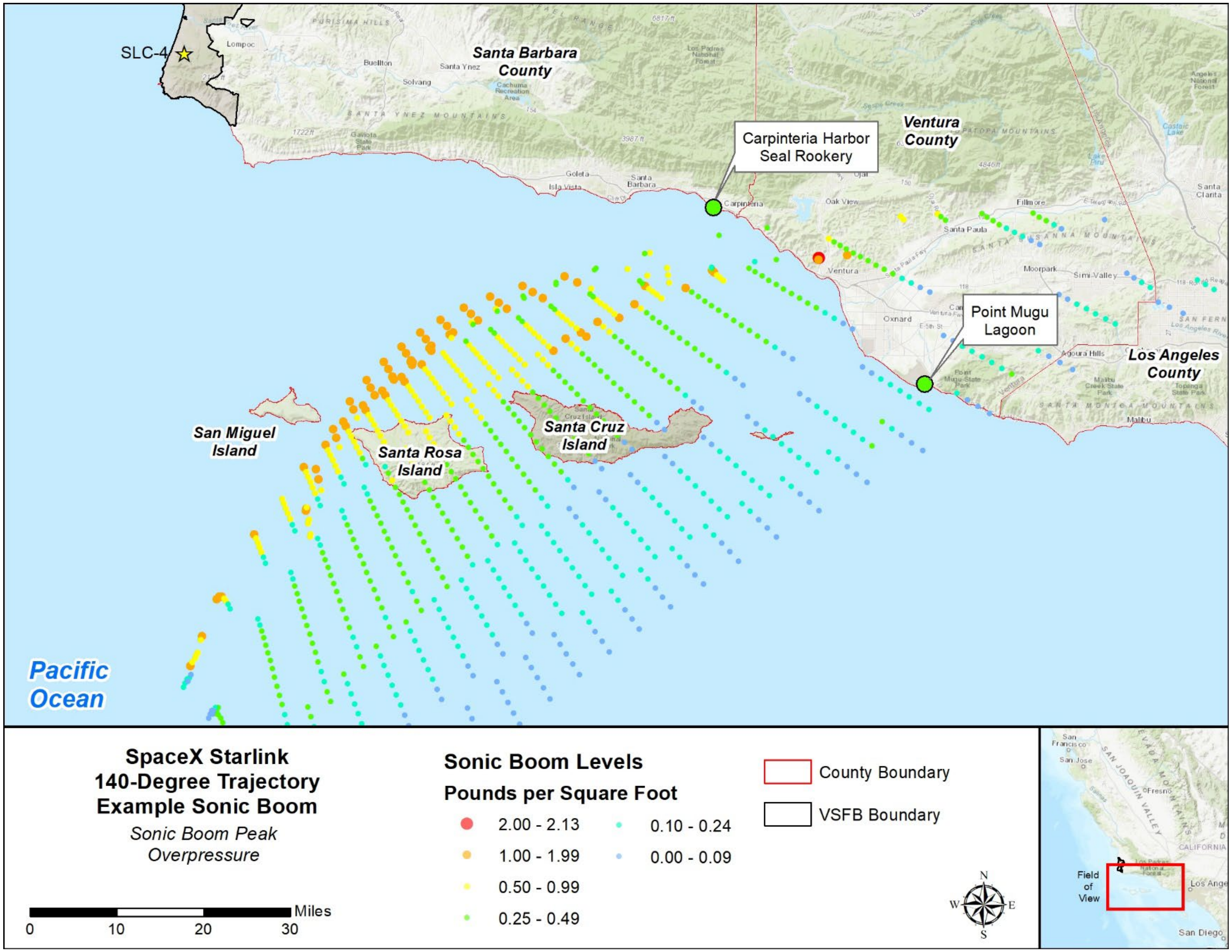

Figure 5. Falcon 9 sonic boom footprint during 140-degree trajectory overlapping mainland California, but not overlapping San Miguel Island.

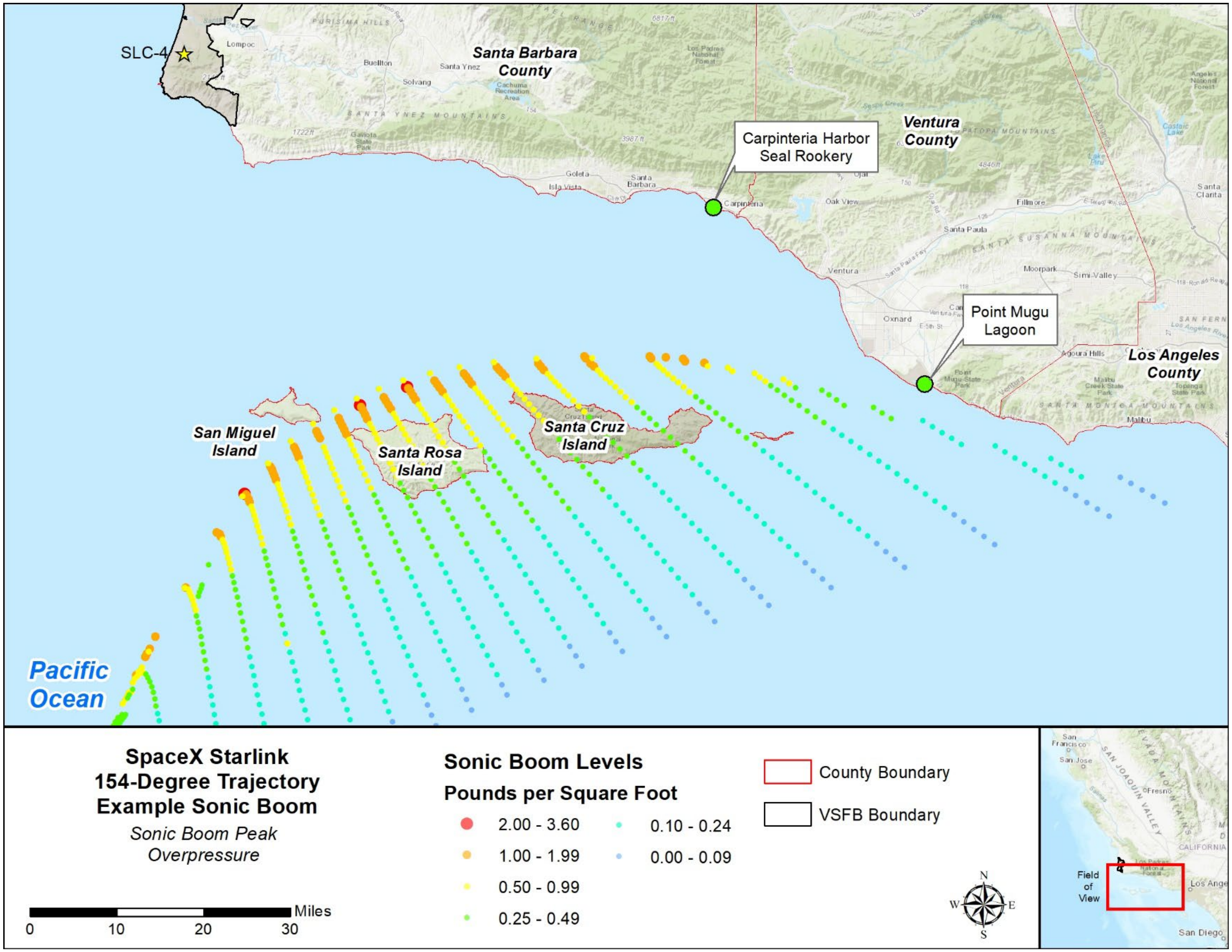

Figure 6. Falcon 9 sonic boom footprint during 154-degree trajectory not overlapping mainland California, some overlap with San Miguel Island.

APPENDIX C
State Historic Preservation Office and Native American Tribal Consultations

DEPARTMENT OF THE AIR FORCE
UNITED STATES SPACE FORCE
SPACE LAUNCH DELTA 30

Lieutenant Colonel Nicholas C. Van Elsacker
Commander, 30th Civil Engineer Squadron
1172 Iceland Ave
Vandenberg SFB CA 93437-6011

Ms. Julianne Polanco
State Historic Preservation Officer
Department of Parks and Recreation
Office of Historic Preservation
P.O. Box 942896
Sacramento CA 94296-0001

Dear Ms. Polanco

SpaceX proposes to increase launch cadence of their Falcon 9 vehicle at Vandenberg Space Force Base (VSFB) Space Launch Complex (SLC)-4 to expand its Starlink network and fill in coverage gaps and provide internet connectivity over the poles. SLC-4 is in the South Base portion of VSFB in Santa Barbara County. The proposed *SpaceX Increased Launch Cadence Project* is limited to increased launch activity from SLC-4 East pad and does not include any new construction, demolition, or physical alterations. The activity would increase the number of launches from 12 to 36, continue first-stage booster return landings at the existing landing pad at SLC-4 West, and include a new northerly trajectory over open ocean. This study considers noise vibrations and their potential effect on cultural resources on VSFB, Lompoc vicinity, and portions of Santa Rosa Island, Santa Cruz Island, and San Miguel Island.

VSFB has carried out a reasonable and good-faith cultural resources investigation that fulfills federal agency responsibilities pursuant to 36 CFR 800.4(a)-(d) and 36 CFR 800.5(a)-(d). Per §800.3(c-f), VSFB is consulting with the California State Historic Preservation Officer (SHPO) on its findings.

SpaceX contracted Dudek, Inc. to prepare an analysis specifically addressing potential impacts on cultural resources from rocket engine noise and sonic boom vibrations associated with static tests, launches and boost-back landings at SLC-4. A threshold of 120 decibels (dB) has been established, above which historic properties could be susceptible to damage. A noise analysis was performed to delineate an area where noise levels are expected to exceed 120 dB. Sonic booms associated with launches were also considered and are measured as pressure in pounds per square foot (psf). The threshold for potential damage resulting from sonic booms (atmospheric overpressure) is established at two psf or greater. The 120dB and greater and 2psf and greater noise vibration study area was delineated as the Area of Direct Impact (ADI).

Given the large number of recorded archaeological sites and buildings within the ADI, it was necessary to assess whether any would be susceptible to the effects of rocket engine noise and included in the Area of Potential Effect (APE). At VSFB, intact midden samples and compact sand cones have shown no visible effect after being exposed to short-duration launch noise of 150dB, and short-duration sonic boom from boost-back exceeding 5psf. Furthermore, monitoring of a sheer cliff-face midden deposit at CA-SBA-530 on South VSFB between SLC-4 and SLC-6 has indicated that while natural erosion from rain, wind, and pounding waves has a significant impact on sheer-cliff deposits, noise vibrations from launch and boost-back events has had no visible effect.

Therefore, VSFB cultural resources staff established that archaeological sites that consist of only surface artifacts and/or buried archaeological material would not be affected by rocket engine noise because soils would protect materials in place. Thus, those resources were excluded from the APE. Furthermore, all but one of the National Register of Historic Places (NRHP)-eligible buildings located within the noise/sonic boom ADI on VSFB are associated with launch complexes and supporting infrastructure and therefore built to withstand concussive forces. They, too, were excluded from the APE. The only NRHP-eligible building situated within the VSFB portion of the noise/sonic boom ADI that is not associated with launch complexes or supporting infrastructure is the former U.S. Coast Guard Lifeboat Rescue Station (P-42-040495). Constructed in 1936 in the Colonial Revival style of architecture, the wood-frame Administrative Barracks and ancillary structures remaining in the complex have been subjected to decades of medium and heavy launches from SLC-4 and nearby SLC-6 with no effect. There has also been no effect from boost-back landings at SLC-4.

Four prehistoric archaeological sites with rock art were identified within the ADI of the noise vibration study. These include CA-SBA-550 (Honda Ridge Rock Art Site), -3686, -3687, and -3688. A condition assessment program has occurred continuously at these rock art sites since 2000. The program has found no evidence of effects to the rock art surfaces from heavy- and medium-payload rocket launches which have occurred from nearby SLC-3, SLC-4, and SLC-6 since the early 2000s. These sites have not been affected by noise vibrations created by SpaceX Falcon 9 launches and boost-backs in the past. Therefore, it is unlikely that these sites would be adversely affected by an increased launch cadence of the same Falcon 9 rocket. As a result, all rock art sites, rock shelters, rock cairns, and similar archaeological sites were excluded from the APE.

A total of 123 archaeological sites on VSFB have been identified in the noise study ADI as eligible for the NRHP. All 123 sites are archaeological deposits which are limited to artifacts laying on the surface or at depth, protected by soil. None of these sites has been affected by past SpaceX launches, nor has the potential to be affected by noise vibrations created by increased SpaceX launches and boost-back. As such, they were excluded from the APE. No other NRHP-eligible/listed archaeological sites identified within the Project ADI contain rock art or other features that could be damaged by rocket engine noise.

The sonic boom arc encompasses all of Santa Cruz Island, Santa Rosa Island, and San Miguel Island. Sonic boom overpressure may reach as much as 5psf over a thin sliver of land on the NCI, but the vast majority of the sonic boom arc over each of the islands is at 2–3psf. The San Miguel, Santa Rosa, and Santa Cruz Islands Archaeological Districts encompass the entirety of their respective islands, and the Districts are NRHP-listed. All contributing resources within the Districts are assumed eligible for the NRHP for the purposes of this Project. Historic properties on the NCI include historic ranches and archaeological deposits, and prehistoric Native American archaeological sites. Historic buildings include wood-frame, masonry, and adobe construction. The prehistoric sites consist of Native American shell middens, burials, habitation sites, and lithic scatters. None of these historic properties have been reported to be affected by noise vibrations created by SpaceX launches from SLC-4 since the first Falcon 9 launch in 2013, or any other medium or heavy-lift launches from SLC-4 or SLC-6 in decades passed.

A recent sand cone and midden chunk test by Smallwood showed that a 45-degree sloped sand cone and a chunk of midden soil was not affected by short-duration launch noise of 150dB, nor short-duration sonic boom from boost-back reaching 5psf. Furthermore, monitoring of the Honda Ridge Rock Art Site and the Historic U.S. Coast Guard Lifeboat Rescue Station Administration Barracks on VSFB have shown that rock art and wood-frame buildings in good condition are not affected by short-duration launch noise and sonic booms from medium and heavy-lift rockets launched from nearby SLC-4 and SLC-6. Therefore, it is highly unlikely that any of the historic properties in the Lompoc vicinity or the NCI has the potential to be affected. None of these resources has the potential to be affected by an increased cadence of launches and boost-back at SLC-4, therefore, none of these resources are included in the APE.

No other known historic properties exist within the Project ADI which could be affected by vibrations from increased launch and boost-back at SLC-4. Details of the investigation are provided in the attachment. VSFB presents the following federal agency determinations for concurrence from the SHPO:

a. The APE for the SpaceX Increased Launch Cadence Project is adequately delineated; and

b. The undertaking will have *no effect* on any known historic properties.

Pending concurrence with our above determinations, VSFB has reached a Section 106 finding of *no historic properties affected* for this undertaking. If you do not object to this finding, VSFB has fulfilled its Section 106 responsibilities for this undertaking and no further consultation is required. If any changes to the design of the project are made with the potential to affect a historic property, VSFB would re-open Section 106 consultation.

If you have any questions or require additional information, please contact Josh Smallwood, Cultural Resources Manager, 30 CES/CEIEA, 1028 Iceland Avenue, Building 11146, Vandenberg SFB; phone: 760-419-0092; e-mail: stacy.smallwood.1@spaceforce.mil. Thank you for your assistance with this undertaking.

Sincerely

VAN ELSACKER.NICHOLAS.CLARENCE.1251205554 Digitally signed by VAN ELSACKER.NICHOLAS.CLARENCE.1251205554 Date: 2023.03.27 08:59:24 -07'00'

NICHOLAS C. VAN ELSACKER, Lt Col, USAF
Commander

Attachment:
Identification of Historic Properties and Finding of No Effect, SpaceX Increased Launch Cadence Project (813-22-058)

Identification of Historic Properties
And
Finding of No Effect

SpaceX Increased Launch Cadence

Vandenberg Space Force Base
Santa Barbara County, California
(813-22-058)

SpaceX Falcon 9 launch from VSFB SLC-4, January 2019 (credit: SpaceX)

March 2023

Identification of Historic Properties
And
Finding of No Effect

SpaceX Increased Launch Cadence

Vandenberg Space Force Base
Santa Barbara County, California
(813-22-058)

Prepared By: Josh Smallwood, M.A., RPA
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1028 Iceland Avenue
Vandenberg Space Force Base, California 93437

Submitted To: Ms. Julianne Polanco
State Historic Preservation Officer
Department of Parks and Recreation
Office of Historic Preservation
P.O. Box 942896
Sacramento, California 94296-0001

March 2023

Contents

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Chapter 1. Summary

§ 800.3: Initiation of the Section 106 Process

SpaceX proposes to increase launch cadence of their Falcon 9 vehicle at Vandenberg Space Force Base (VSFB) Space Launch Complex (SLC)-4 to expand its Starlink network and fill in coverage gaps and provide internet connectivity over the poles. SLC-4 is in the South Base portion of VSFB in Santa Barbara County, California (Figure 1, Figure 2).

The *SpaceX Increased Launch Cadence Project* (hereafter "Project") is limited to increased launch activity from SLC-4 East pad and does not include any new construction, demolition, or physical alterations. The activity would increase the number of launches from 12 to 36, continue first-stage booster return landings at the existing landing pad at SLC-4 West, and include a new northerly trajectory over open ocean with a barge landing 90 miles west of San Francisco Bay. This study considers noise vibrations and their potential effect on cultural resources on VSFB, Lompoc vicinity, and Santa Rosa Island, Santa Cruz Island, and San Miguel Island.

VSFB determined the Project is an undertaking subject to compliance with Section 106 of the National Historic Preservation Act (NHPA) of 1966, as amended. VSFB will comply with Section 106 using the implementing regulations [36 CFR Part 800]. Per §800.3(c-f), VSFB is consulting with the California State Historic Preservation Officer (SHPO) and the Santa Ynez Band of Chumash Indians (SYBCI).

The Federal Aviation Agency (FAA) is a coordinating agency on this consultation because of its role in licensing commercial space launch operations in the United States and approving related airspace closures. The FAA intends to rely on this consultation to support its Section 106 obligations when evaluating SpaceX's requests for new licenses for Falcon 9 operations at VSFB along with potential renewals and modifications to licenses within scope of operations analyzed in this consultation. In addition, the FAA intends to use this consultation when evaluating related airspace closures.

§ 800.4: Identification of Historic Properties

VSFB cultural resources managers and other project personnel discussed the Project and its potential for direct and indirect effects to cultural resources resulting from any related construction, static fire, launches, and boost-back (booster return landings). No ground disturbance or construction is involved with the increased launch cadence. Based on the footprint for noise vibrations, the VSFB Cultural Resources Lead identified the area of direct impacts (ADI; Figures 3a–3d), and then delineated the Area of Potential Effects (APE; Figure 4) in accordance with §800.4(a)(1).

A reasonable and good faith effort to identify historic properties in the APE included a review of previous surveys and cultural resources recorded in the area, conducting a desktop analysis of archaeological sites and historic-age buildings in the noise/sonic boom study area, and identifying all National Register of Historic Places (NRHP) eligible cultural resources in the ADI. SpaceX contracted Dudek, Inc. to prepare an analysis specifically addressing potential impacts on cultural resources from rocket engine noise and sonic boom vibrations associated with static tests, launches and boost-back landings at SLC-4 (Dudek 2023; Appendix A).

A 1972 National Aeronautics and Space Administration (NASA) technical memo established that prolonged noise thresholds greater than 120 decibels (dB) had the potential to damage brittle structural components (window glass and plaster) on historic buildings (Guest and Sloane 1972). Following that approach, this study used the 120 dB contour line as the level at which rocket engine noise had the potential to damage certain types of historic buildings and sensitive archaeological sites. A noise study was performed by ManTech SRS Technologies, Inc. to delineate an area where noise levels are expected to exceed 120 dB (ManTech 2023; Appendix B).

Sonic booms associated with launches were also considered and are measured as pressure in pounds per square foot (psf). Haber et al. (1989) concluded that well-maintained structures are much less likely to be susceptible to damage from sonic booms below 2 psf. Therefore, the threshold for potential damage resulting from sonic booms (overpressure) is established at 2 psf or greater. More recently, NASA has reported that rare minor damage to structures may occur with 2 to 5 psf overpressure (Gibbs 2017). As overpressure increases, the likelihood of structural damage increases. NASA also reports in recent studies that tests have shown that structures in good condition have been undamaged by overpressures of up to 11 psf (Gibbs 2017).

Given the large number of recorded archaeological sites and buildings within the noise vibration study ADI, it was necessary to assess whether any would be susceptible to the effects of rocket engine noise. At VSFB, intact midden samples and compact sand cones have shown no visible effect after being exposed to short-duration launch noise of 150dB, nor short-duration sonic boom from boost-back above 5psf (Smallwood 2022). Furthermore, monitoring of a sheer cliff-face midden deposit at CA-SBA-530 on South VSFB between SLC-4 and SLC-6 has indicated that while natural erosion from rain, wind, and pounding waves has a significant impact on sheer-cliff deposits, noise vibrations from launch and boost-back events has had no visible effect (Smallwood 2022).

Therefore, VSFB cultural resources staff established that archaeological sites that consist of only surface artifacts and/or buried archaeological material would not be affected by rocket engine noise because soils would protect materials in place. Thus, those resources were excluded from the APE. Furthermore, all but one of the NRHP-eligible buildings located within the noise/sonic boom ADI on VSFB are associated with launch complexes and supporting infrastructure and therefore built to withstand concussive forces. They, too, were excluded from the APE. The only NRHP-eligible building situated within the VSFB portion of the noise/sonic boom ADI that is not associated with launch complexes or supporting infrastructure is the former U.S. Coast Guard Lifeboat Rescue Station (P-42-040495). Constructed in 1936 in the Colonial Revival style of architecture, the wood-frame Administrative Barracks and ancillary structures remaining in the complex have been subjected to decades of medium and heavy launches from SLC-4 and nearby SLC-6 with no effect. There has also been no effect from boost-back landings at SLC-4.

Four prehistoric archaeological sites with rock art were identified within the ADI of the noise vibration study. These include CA-SBA-550 (Honda Ridge Rock Art Site), -3686, -3687, and -3688. A condition assessment program has occurred continuously at these rock art sites since 2000. The program has found no evidence of effects to the rock art surfaces from heavy- and medium-payload rocket launches which have occurred from SLC-3, SLC-4, and SLC-6 since the early 2000s. These sites have not been affected by noise vibrations created by SpaceX launches and boost-backs in the past. Therefore, it is unlikely that these sites would be adversely affected by an increased launch cadence of the same Falcon 9 rocket. As a result, all rock art sites, rock shelters, rock cairns, and similar archaeological sites were excluded from the APE.

A total of 123 archaeological sites on VSFB have been identified in the noise study ADI as eligible for the NRHP. All 123 sites are archaeological deposits which are limited to artifacts laying on the surface or at depth, protected by soil. None of these sites has been affected by past SpaceX launches, nor has the potential to be affected by noise vibrations created by increased SpaceX launches and boost-back. As such, they were excluded from the APE. No other NRHP-eligible/listed archaeological sites identified within the Project ADI could potentially be damaged by rocket engine noise.

The sonic boom arc encompasses all of Santa Cruz Island, Santa Rosa Island, and San Miguel Island, collectively referred to as the Northern Channel Islands (NCI). Sonic boom overpressure may reach as much as 5psf over a thin sliver of land on the NCI, but the vast majority of the sonic boom arc over each of the islands is at 2–4psf. The San Miguel, Santa Rosa, and Santa Cruz Islands Archaeological Districts encompass the entirety of their respective islands, and the Districts are NRHP-listed. All contributing resources within the Districts are assumed eligible for the NRHP for the purposes of this Project. Historic properties on the NCI include historic ranches and archaeological deposits, and prehistoric Native American archaeological sites. Historic buildings include wood-frame, masonry, and adobe construction. The prehistoric sites consist of Native American shell middens, burials, habitation sites, and lithic scatters. None of these historic properties have been reported to be affected by noise vibrations created by SpaceX launches from SLC-4 since the first Falcon 9 launch in 2013, or any other medium or heavy-lift launches from SLC-4 or SLC-6 in decades passed.

The recent sand cone and midden chunk test by Smallwood (2022) showed that a 45-degree sloped sand cone and a chunk of midden soil was not affected by short-duration launch noise of 150dB, nor short-duration sonic boom from boost-back above 5psf. Furthermore, monitoring of the Honda Ridge Rock Art Site and the Historic U.S. Coast Guard Lifeboat Rescue Station Administration Barracks on VSFB have shown that rock art and wood-frame buildings in good condition are not affected by short-duration launch noise of 120dB, nor short-duration sonic boom from boost-back of 2-4psf. Therefore, it is highly unlikely that any of the historic properties in the Lompoc vicinity or the NCI has the potential to be affected. None of these resources has the potential to be affected by an increased cadence of launches and boost-back at SLC-4, therefore, none of these resources are included in the APE.

The results of this investigation are reported herein, with additional details provided in the attached Cultural Resources study by Dudek (Dudek 2023; Appendix A) and noise study by ManTech SRS Technologies, Inc. (ManTech 2023; Appendix B).

VSFB seeks concurrence from the SHPO that the APE for this undertaking has been appropriately delineated. VSFB has reached a finding of no effect to historic properties for this undertaking. Therefore, VSFB seeks concurrence from the SHPO on a finding of *no effect* for the SpaceX Increased Launch Cadence Project.

Chapter 2. Project Description

2.1. The Proposed Undertaking

SpaceX proposes to increase launch cadence of their Falcon 9 vehicle at SLC-4 to expand its Starlink network and fill in coverage gaps and provide internet connectivity over the poles. The SpaceX Increased Launch Cadence Project is limited to increased launch activity from SLC-4 East pad and does not include any new construction, demolition, or physical alterations. The activity would increase the number of annual launches from 12 to 36, continue first-stage booster return landings at the existing landing pad at SLC-4 West, and include a new northerly trajectory over open ocean. This study considers noise vibrations and their potential effect on cultural resources.

2.2. Area of Direct Impacts

No new construction is planned for the increased launch cadence at SLC-4. The ADI for this project is the polygon which delineates noise vibration levels above 120 dB (Figure 3a), as well as a sonic boom arc which will occur during southward launches across the Pacific Ocean along an azimuth of between 140 and 188 degrees (Figure 3b). Launches on azimuths greater than 188 degrees will cross over open ocean and will not result in a sonic boom over land. The sonic boom arc produced from a 140–188 degree azimuth launch will produce ground-level atmospheric overpressure of two psf or greater across the entirety of the Northern Channel Islands (NCI; i.e., San Miguel, Santa Rosa and Santa Cruz Islands) (Figure 3b). Boost-back landings at SLC-4W will produce ground-level atmospheric overpressure of 2 psf across most of the Lompoc Valley, with as much as 4psf in the western part of the valley, and 5psf at VSFB (Figure 3c). A new northwesterly trajectory would launch the Falcon 9 rocket along a launch azimuth of between 301 and 325 degrees over open ocean with a barge landing 90 miles west of San Francisco Bay (Figure 3d). Open-ocean launch azimuths are not included in the APE because they will not result in a sonic boom over land. Research was conducted to identify historic properties within the ADI that would have the potential to be impacted by noise exceeding 120 dB or sonic booms exceeding 2 psf.

2.3. Area of Potential Effects

The APE for this Project includes the ADI plus the entirety of any cultural resources which have the potential to be affected by noise vibration levels above 120 dB, as well as sonic boom overpressures of 2 psf or greater (Figure 4). Therefore, research was conducted to identify cultural resources within the ADI that would have the potential to be impacted by noise exceeding 120 dB or sonic booms exceeding 2 psf.

For the cultural resource noise vibration study, the APE was defined using the maximum sound level contours from the noise study conducted for the Project by ManTech (ManTech 2023; Appendix B). The 120 dB contour represented the lowest noise level at which historic buildings could potentially be affected by noise. As such, the APE was defined as the area inside the 120-dB and 2psf noise vibration polygon (Figure 4).

Chapter 3. Summary of Identification Efforts

A cultural resources records search for the on-Base portion of the Project APE was carried out at the 30th Civil Engineer Squadron, Installation Management Flight, Cultural Resources Office (30 CES/CEIEA) at VSFB. Background research included reviews of archaeological studies, site records and condition assessments for the area within the 120 dB noise study area and 2 psf sonic boom study area. The VSFB geographic information system (GIS) was also consulted along with a review of the Office of Historic Preservation's (OHP) Directory of Properties in the Historic Property Data File for Santa Barbara County dated April 5, 2012.

The GIS data and records search revealed that the entirety of the noise/sonic boom study area has been previously surveyed for cultural resources and 350 cultural resources have been recorded within the noise/sonic boom ADI. The vast majority of these are archaeological sites with no above-ground buildings, structures, or objects that could potentially be affected by launch noise vibrations. Four of these sites are rock art sites discussed below. The balance, a total of 103 historic-age buildings, have been identified and recorded within the noise/sonic boom ADI on VSFB. These buildings are all associated with launch complexes and supporting infrastructure and therefore built to withstand concussive forces.

The four rock art sites include CA-SBA-550 (NRHP-eligible Honda Ridge Rock Art Site), -3686, -3687, and -3688. A condition assessment program has occurred continuously at CA-SBA-550 since 2000. The program has found no evidence of effects to the rock art surfaces from heavy- and medium-payload rocket launches which have occurred from SLC-3, SLC-4, and SLC-6 since the early 2000s. Rock art sites CA-SBA-3686, -3687, and -3688 are small panels in rock shelters at the bottom of Honda Canyon. These three rock art sites have also experienced heavy- and medium-payload rocket launches from SLC-3, SLC-4, and SLC-6 since the early 2000s, with no effect.

A total of 123 other archaeological sites on VSFB have been identified in the noise study ADI as eligible for the NRHP. None of these archaeological sites contain rock art or other features that could be damaged by rocket engine noise. All 123 sites are archaeological deposits which are limited to artifacts laying on the surface or at depth, protected by soil. None of these sites has the potential to be affected by noise vibrations created by SpaceX launches and boost-back.

A cultural resources records search was also conducted through the California Historical Resources Information System (CHRIS) for the portions of the APE covering the Lompoc Vicinity, Santa Rosa Island, Santa Cruz Island, and San Miguel Island. SpaceX retained Dudek to perform the records search, which was conducted at the Central Coast Information Center

(CCIC) on February 10 and 24, 2023. The records search included a review of all recorded archaeological sites and built environment resources that are listed/eligible for the NRHP. Additionally, Dudek reviewed the NRHP, the California Register of Historical Resources (CRHR), the California Historic Property Data File, and the lists of California State Historical Landmarks, California Points of Historical Interest, and Archaeological Determinations of Eligibility for the off-Base portions of the APE.

Table 3-1 provides both built environment and archaeological cultural resources in the Lompoc Vicinity that are listed on or determined eligible for the listing on the NRHP. Historic properties in the Lompoc vicinity include wood-frame, masonry, and adobe buildings, and archaeological sites.

Table 3-1: NRHP-listed/eligible properties located within the Lompoc vicinity portion of the APE.

Resource Identifier	Description
La Purisima Mission	Adobe mission buildings
Lompoc Public Library (Carnegie)	Masonry building
Lompoc Veterans Memorial Building	Masonry building
Site of Mission de la Purisima Concepcion de Maria Santisima	Adobe ruins
Artesia School	Wood-frame building
Well, Hill 4	Oil well
Spanne Building	Wood-frame building
105 H St Building	Wood-frame building
U.S. Army Disciplinary Barracks, U.S. Lompoc Prison	Masonry buildings
Lompoc Theater	Masonry building
CA-SBA-2370	Prehistoric archaeological site

Table 3-2 provides both built environment and archaeological cultural resources on the NCI (San Miguel, Santa Rosa, and Santa Cruz Islands) that are listed on or determined eligible for listing on the NRHP. The San Miguel, Santa Rosa, and Santa Cruz Islands Archaeological Districts encompass the entirety of their respective islands, and the Districts are NRHP-listed. All contributing resources within the Districts are assumed eligible for the NRHP for the purposes of this Project. Historic properties on the NCI include historic ranches and archaeological deposits, and prehistoric Native American archaeological sites. Historic buildings include wood-frame, masonry, and adobe construction.

Table 3-2: NRHP-listed/eligible cultural resources located within the NCI portion of the APE.

Resource Identifier	Description
Santa Cruz Island Archeological District	Prehistoric and historic-period archaeological sites (shell middens, burials, lithic scatters, habitation sites)
Santa Cruz Island Ranching District	Historic ranch buildings
Santa Rosa Island Archaeological District	Prehistoric and historic-period archaeological sites (shell middens, burials, lithic scatters, habitation sites)
Santa Rosa Island Ranch	China Camp Cabin
Santa Rosa Island Ranch	Clapp Springs
Santa Rosa Island Ranch	Horse Barn
Santa Rosa Island Ranch	Main Ranch House
Santa Rosa Island Ranch	Old School House
Santa Rosa Island Ranch	Rope House
Santa Rosa Island Ranch	Army Camp Water System
Santa Rosa Island Ranch	South Point Lighthouse
San Miguel Island Archaeological District	Prehistoric and historic-period archaeological sites (shell middens, burials, lithic scatters, habitation sites)
Nidever Adobe	Adobe building
Waters Ranch House Site	Historic-period ranch site

Chapter 4. Native American Consultation

VSFB communicates frequently with the Santa Ynez Band of Chumash Indians, the federally recognized Indian Tribe affiliated with the land managed by VSFB. Issues and VSFB projects of Native American concern are discussed with the Tribal Elders and Tribal staff members.

This report is being submitted to the Tribe and to the SHPO concurrently. A copy of the transmittal letter to the Tribe is included in Appendix C. VSFB will continue consultation with the Tribe for the life of the project. Disagreements between VSFB and the Tribe and other substantive comments will be brought to the attention of the SHPO.

Chapter 5. Results of Study

Given the large number of recorded archaeological sites and buildings within the noise vibration study ADI, it was necessary to assess whether any would be susceptible to the effects of rocket engine noise. At VSFB, intact midden samples and compact sand cones have shown no visible effect after being exposed to 130 dB launch noise and 4 psf sonic boom overpressure from boost-back (Smallwood 2022). Furthermore, monitoring of a sheer cliff-face midden deposit at CA-SBA-530 on South VSFB between SLC-4 and SLC-6 has indicated that while natural erosion from rainfall, wind, and pounding waves has a significant impact on sheer-cliff deposits, noise vibrations from launch and boost-back events has had no visible effect (Smallwood 2022).

Over the course of the two SpaceX Falcon 9 launches and boost-back landing events on December 16 and 29, 2022, Smallwood monitored a cliffside shell midden site (CA-SBA-530) located 11,210 feet to the southwest of SLC-4 to assess any potential damage from launch/boost-back vibrations. The site is situated within the 130dB noise vibration/4psf sonic boom study area and features a sheer cliff edge where sand and midden are actively eroding downslope due to natural forces, such as wind/water erosion, pounding waves, and gravity. The midden at site CA-SBA-530 had damage from rains prior to the first December launch but showed no visual difference after the launch/boost-back events. There was no noticeable cracking or crumbling from launch vibrations and/or sonic boom atmospheric overpressure.

Additionally, Smallwood set up a 12-inch-tall, 45-degree slope sand cone and a 12x12x12-inch midden chunk on a concrete pad situated 3,180 feet to the southwest of the SpaceX boost-back pad at SLC-4 to conduct a noise vibration test during the course of the two December SpaceX launches/boost-back landings. Smallwood borrowed the midden chunk from the sheer cliff edge at CA-SBA-530, where it was laying in secondary deposition getting ready to tumble down the slope into the ocean. SpaceX's SWOT mission of 16 December 2022 resulted in a 4.7 psf landing sonic boom at Honda Canyon, which is 11,000 feet southwest of the SLC-4 West pad (ManTech 2023:23). Smallwood's test samples were 8,000 feet closer to the landing pad than Honda Canyon; therefore, they were exposed to greater than 4.7 psf overpressure. The midden chunk and sand cone showed no visual difference after the launch/boost-back, other than a few fine grains of sand which likely flaked off as the samples dried in the wind. However, there was no cracking or crumbling from launch vibrations/sonic boom overpressures. Once the test was completed, Smallwood returned the midden chunk to its place of origin on the eroding slope at CA-SBA-530.

VSFB cultural resources staff have established that archaeological sites that consist of only surface artifacts and/or buried archaeological material would not be affected by rocket engine noise because soils would protect materials in place. Thus, those resources were excluded from the APE. Furthermore, all the buildings located within the noise/sonic boom ADI on VSFB are associated with launch complexes and supporting infrastructure and therefore built to withstand concussive forces. They, too, were excluded from the APE.

Four prehistoric archaeological sites with rock art were identified within the ADI of the noise vibration study. These include CA-SBA-550 (Honda Ridge Rock Art Site), -3686, -3687, and -3688. A condition assessment program has occurred continuously at these rock art sites since 2000. The program has found no evidence of effects to the rock art surfaces from heavy- and medium-payload rocket launches which have occurred from SLC-3, SLC-4, and SLC-6 since the early 2000s. These sites have not been affected by noise vibrations created by SpaceX Falcon 9 launches and boost-backs in the past. Therefore, it is unlikely that these sites would be adversely affected by an increased launch cadence of the same Falcon 9 rocket. As a result, all rock art sites, rock shelters, rock cairns, and similar archaeological sites were excluded from the APE.

A total of 123 other archaeological sites on VSFB have been identified in the noise study ADI as eligible for the NRHP. None of these archaeological sites contain rock art or other features that could be damaged by rocket engine noise. All 123 sites are archaeological deposits which are limited to artifacts laying on the surface or at depth, protected by soil. None of these sites has the potential to be affected by noise vibrations created by SpaceX launches and boost-back. As such, they were excluded from the APE.

The sonic boom arc encompasses all of Santa Cruz Island, Santa Rosa Island, and San Miguel Island. Sonic boom overpressure may reach as much as 5psf over a thin sliver of land on the NCI, but the vast majority of the sonic boom arc over each of the islands is at 2–3psf.

The San Miguel, Santa Rosa, and Santa Cruz Islands Archaeological Districts encompass the entirety of their respective islands, and the Districts are NRHP-listed. All contributing resources within the Districts are assumed eligible for the NRHP for the purposes of this Project. Historic properties on the NCI include historic ranches and archaeological deposits, and prehistoric Native American archaeological sites. Historic buildings include wood-frame, masonry, and adobe construction. The prehistoric sites consist of Native American shell middens, burials, habitation sites, and lithic scatters. None of these historic properties have been reported to be affected by noise vibrations created by SpaceX launches from SLC-4 since the first Falcon 9 launch in 2013.

The recent sand cone and midden chunk test by Smallwood (2022) showed that a 45-degree sloped sand cone and a chunk of midden soil was not affected by short-duration launch noise of 150dB, nor short-duration sonic boom from boost-back reaching 5psf. Furthermore, monitoring of the Honda Ridge Rock Art Site and the Historic U.S. Coast Guard Lifeboat Rescue Station Administration Barracks on VSFB have shown that rock art and wood-frame buildings in good condition are not affected by short-duration launch noise and sonic booms from medium and heavy-lift rockets launched from nearby SLC-4 and SLC-6. Therefore, it is highly unlikely that any of the historic properties in the Lompoc vicinity or the NCI has the potential to be affected. None of these resources has the potential to be affected by an increased cadence of launches and boost-back at SLC-4, therefore, none of these resources are included in the APE. No other known historic properties exist within the Project ADI which could be affected by vibrations from increased launch and boost-back at SLC-4.

Chapter 6. Findings

VSFB carried out a reasonable and good-faith effort to identify historic properties within the APE pursuant to 36 CFR 800.4(a)-(d) and 36 CFR 800.5(a)-(d). In summary, VSFB presents the following findings and determinations to the SHPO for the purposes of reaching agreement:

- The APE for the SpaceX Increased Launch Cadence Project is adequately delineated; and

- The undertaking will have *no effect* on any known historic properties.

VSFB reached a Section 106 finding of *no historic properties affected* for this undertaking. Barring objection to this finding by the SHPO, VSFB has fulfilled its Section 106 responsibilities for this undertaking and no further consultation is required. If any changes to the design of the project are made with the potential to affect a historic property, VSFB would re-open Section 106 consultation.

Chapter 7. References

Gibbs, Yvonne
2017 NASA Armstrong Fact Sheet: Sonic Booms. Found at: https://www.nasa.gov/centers/armstrong/news/FactSheets/FS-016-DFRC.html.

Guest, S., and R. M. Slone, Jr.
1972 Structural Damage Claims Resulting from Acoustic Environments Developed During Static Firing of Rocket Engines. Paper presented at the NASA Space Shuttle Technology Conference.

Haber, Jerry, David Nakaki, Craig Taylor, George Knipprath, Vijay Kopparam, and Mark Legg
1989 *Effects of Aircraft Noise and Sonic Booms on Structures: An Assessment of the Current State-of-Knowledge*. BBN Systems and Technologies Corp., Canoga Park, California. Prepared for Air Force Systems Command, Brooks Air Force Base, Texas, Report.

ManTech SRS Technologies, Inc
2023 Noise Study for SpaceX Falcon 9 Launch and Landing Operations at Vandenberg Space Force Base, California. On file, 30 CES/CEIEA Cultural Resources, Vandenberg Space Force Base, California.

Smallwood, Josh
2022 Personal observation of Base Archaeologist Josh Smallwood.

Chapter 8. Figures

FIGURE 1 PROJECT VICINITY

SpaceX Increased Launch Cadence (813-22-058)

Vandenberg Space Force Base Santa Barbara County, CA

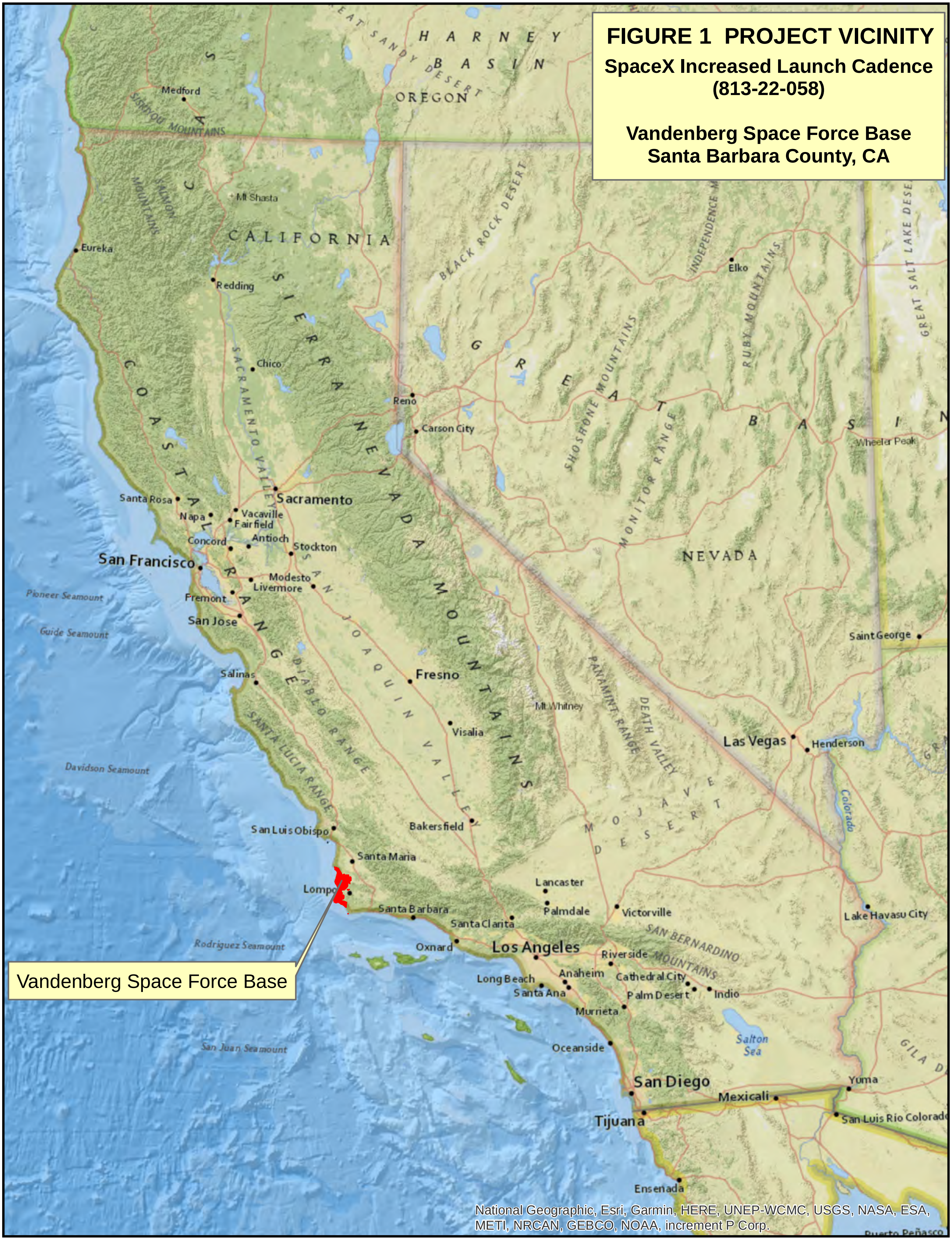
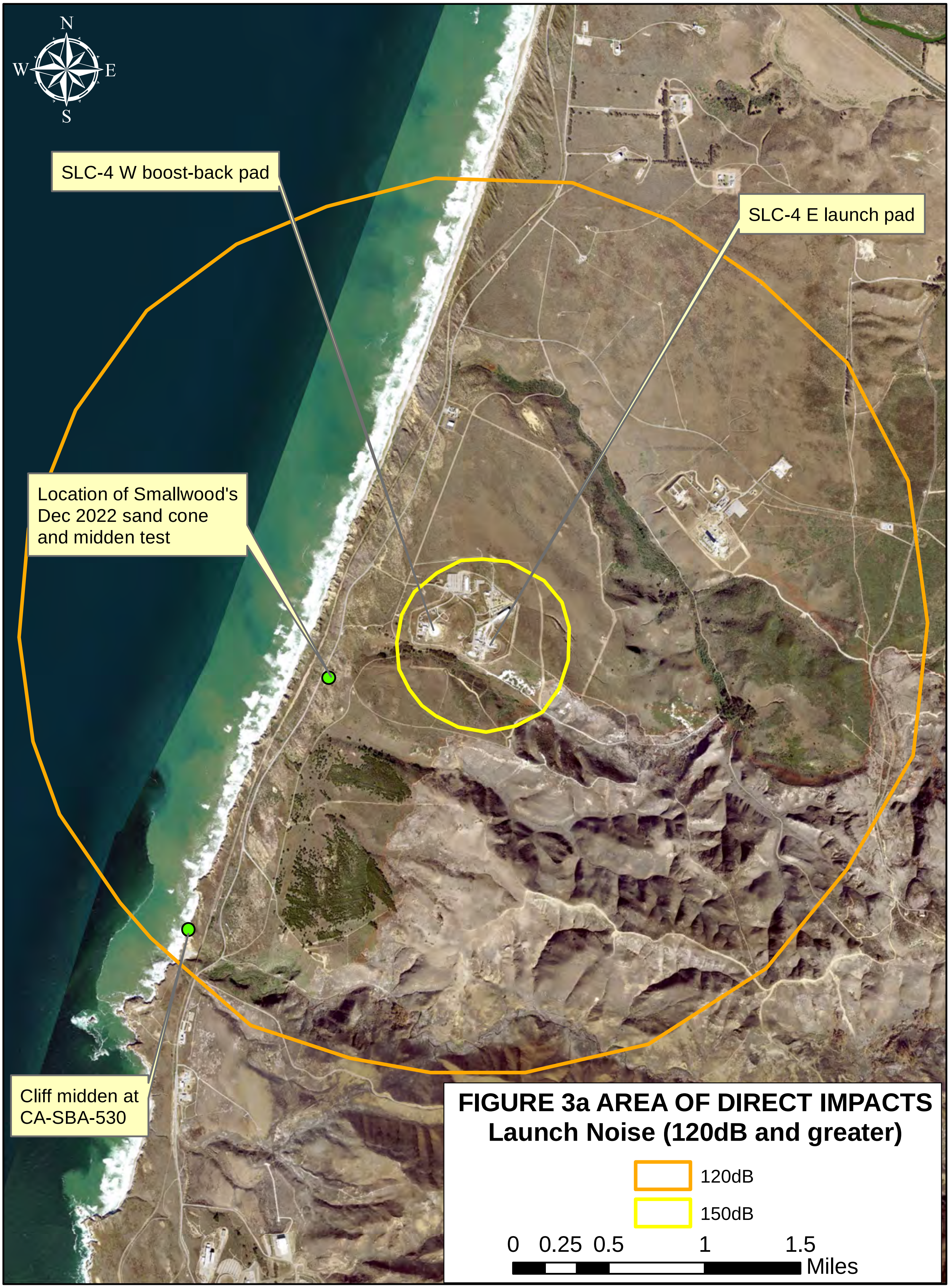


FIGURE 2 PROJECT LOCATION


N
W
E
S
SLC-4 W boost-back pad
SLC-4 E launch pad
Location of Smallwood's Dec 2022 sand cone and midden test
Cliff midden at CA-SBA-530
FIGURE 3a AREA OF DIRECT IMPACTS
Launch Noise (120dB and greater)
120dB
150dB
0 0.25 0.5 1 1.5
Miles


N
W
E
S
SLC-4
FIGURE 3b AREA OF DIRECT IMPACTS
Launch Sonic Boom (2psf and greater)
InstallationBoundary
2-4 psf launch sonic boom
5 psf launch sonic boom
0
4
8
16
24
Miles


N
S
E
W
Lompoc
SLC-4 W boost-back pad
Location of Smallwood's Dec 2022 sand cone and midden test
Cliff midden at CA-SBA-530
FIGURE 3c AREA OF DIRECT IMPACTS
Boost-back landing (2psf and greater)
InstallationBoundary
2psf_boost-back sonic boom
5psf_boost-back sonic boom
0 1.5 3 6 9
Miles

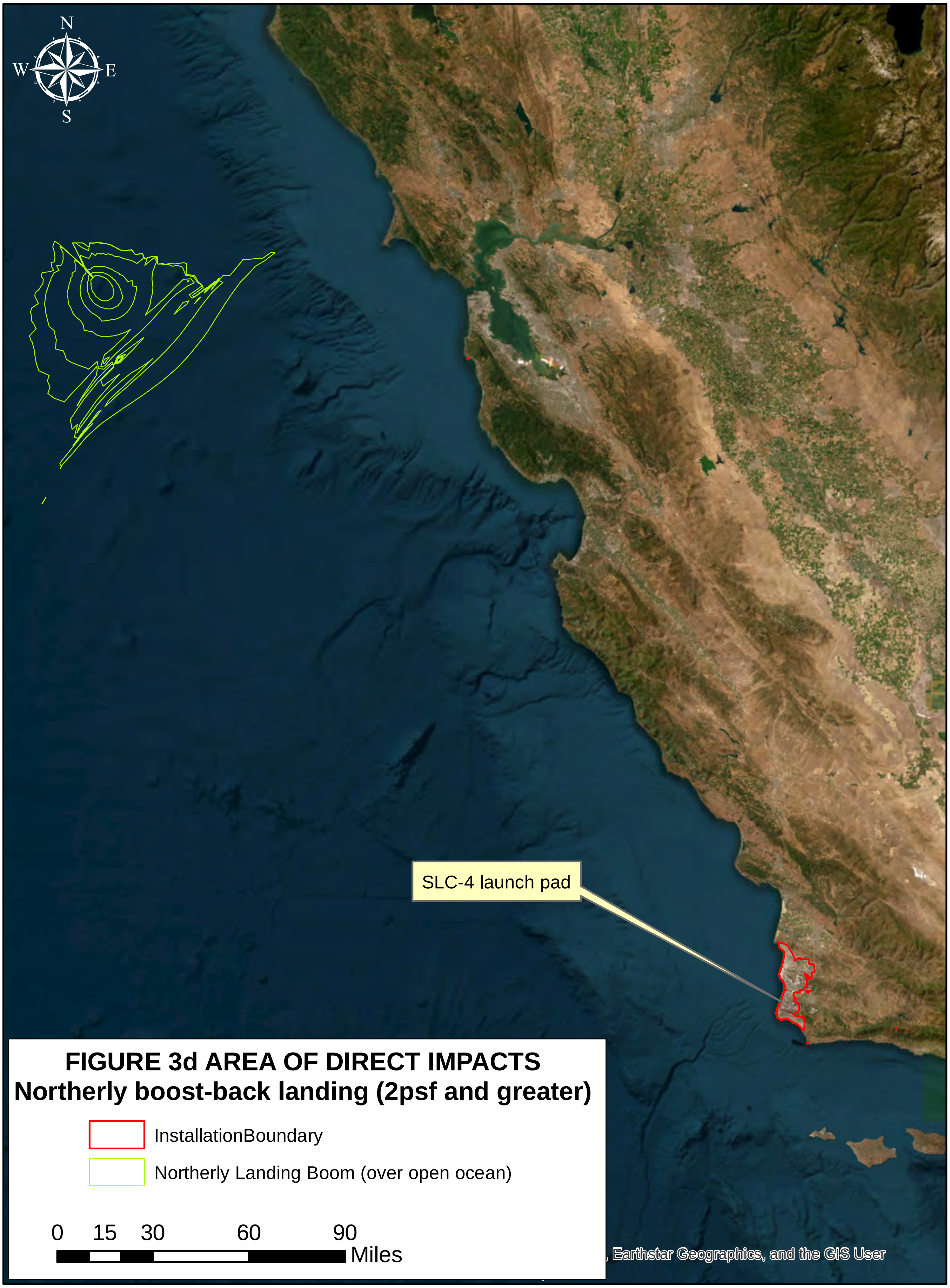


FIGURE 3d AREA OF DIRECT IMPACTS
Northerly boost-back landing (2psf and greater)

FIGURE 4 AREA OF POTENTIAL EFFECT

Appendix A Dudek 2023

CONFIDENTIAL MEMORANDUM

To:	Brian Pownall - SpaceX Elyse Procopio - SpaceX Kyle Meade - SpaceX
From:	Heather McDaniel McDevitt, MA, RPA - Dudek
Subject:	Cultural Resources Inventory Report - Falcon 9 Cadence Increase Project at Vandenberg Space Force Base, California and Offshore Landing Locations
Date:	March 15. 2023
cc:	Micah Hale, PhD, RPA - Dudek
Attachment(s):	Figure 1. SLC-4E Launch/Static Fire Engine Noise Unweighted Maximum Sound Levels Figure 2. Composite Launch Sonic Boom Contour Figure 3. Composite Landing Sonic Boom Contour Figure 4. Northerly Mission Landing Peak Sonic Boom Overpressure Figure 5. Cultural Resources Study Area

Space Exploration Technologies Corp. (SpaceX) retained Dudek to conduct a cultural resources inventory to support compliance with Section 106 of the National Historic Preservation Act (NHPA) as part of the Supplemental Environmental Assessment (SEA) for the proposed Falcon 9 Cadence Increase Project at Vandenberg Space Force Base (VSFB), California and Offshore Landing Locations (Proposed Action). The intent of the cultural resources inventory is to determine if resources exist within the study area that have potential to be affected by the Proposed Action (Figure 1. Cultural Resources Study Area). A separate cultural resources records search for the on-Base portion of the area of potential effect (APE) for the Proposed Action was conducted by the 30th Civil Engineer Squadron, Installation Management Flight, Cultural Resources Office (30 CES/CEIEA) employing the Vandenberg Space Force Base (VSFB) database of cultural resources. This memo includes the following components: a brief project description for the Proposed Action; methods; summary of the California Historical Resources Information System (CHRIS) records search results for the Proposed Action cultural resources study area located off-base; results summary of the records search conducted by the 30 CES/CEIEA for the Proposed Action cultural resources study area located on-base; and conclusions regarding whether the Proposed Action would result in an effect to cultural resources located within the APE.

Project Description

SpaceX is proposing to increase the annual cadence for Falcon 9 operations at Vandenberg Space Force Base (VSFB) and include additional downrange offshore landing locations in the Pacific Ocean. The purpose of the Proposed Action is to provide greater mission capability to the Department of Defense (DOD), National Aeronautics and Space Administration (NASA), and commercial customers by increasing Falcon 9 launch cadence capacity from 12 to 36 launches per year. SpaceX developed the Falcon 9 and Falcon Heavy vertical orbital launch vehicles with the intent to launch commercial and government payloads from VSFB with reusable launch technology employing an in-air boost-back maneuver, return flight, and landing of the Falcon 9 first stage either downrange on a droneship in the Pacific Ocean or at the Space Launch Complex (SLC)-4W pad at VSFB. Therefore, the proposed launch increase includes an associated increase in boost-back landings of the first stage up to 36 times with only 12 of the first stage landings occurring at SLC-4W and the remainder occurring on the droneship located in the Pacific Ocean. Additionally, there is potential for a static fire test of the engines, lasting a few seconds, to precede each launch by one to two days. The Falcon 9 operations include a launch azimuth between 140 and 301 degrees as well as a northly mission profile with a launch azimuth between 301 and 325 degrees. ManTech SRS Technologies (2023) conducted a noise study to support Federal Aviation Administration (FAA) and United States Space Force (USSF) environmental review and approval of the Proposed Action under the National Environmental Policy Act (NEPA) employing new and improved noise modeling than previously used to characterize noise impacts associated with launches, boost-back landings, and static fire events.

Area of Potential Effects

The area of potential effect (APE) of an undertaking is defined as "the geographic area or areas within which an undertaking may directly or indirectly cause changes in the character or use of historic properties, if any such properties exist" (36 CFR 800-16(d)). The APE considers any physical, visual, or auditory effects that the project may have on historic properties. Since no ground-disturbing or landscape-altering actions are proposed, the APE for the current project only considers auditory effects and was predicated on vibratory impacts. As explained in this section, these auditory effects include noise exceeding 120 dB and sonic booms exceeding 2 psf based on previous studies that have determined at which levels structures and archaeological resources could potentially be affected by rocket noise and sonic booms.

In 1972, Guest et al. conducted analysis to assess claims that rocket engine thrusts were potentially impacting areas adjacent to a test site located at Marshall Space Flight Center's Mississippi Test Facility. The results of the study established that the potential to damage the most sensitive structural components such as windows and plaster on historic buildings occurred as a result of prolonged noise thresholds greater than 120 dB. Furthermore, the FAA uses the 120 dB noise contour for engine noise to define areas that may experience structural damage resulting from space launch vehicle noise. Accordingly, ManTech (2023) was retained to conduct a noise study to determine maximum sound level contours for the Proposed Action and identify where stratified A-weighted maximum noise levels (Lmax) are expected to occur for all launches (northerly and southerly) as illustrated in Figure 1. SLC-4E Launch Engine Noise Unweighted Maximum Sound Levels. ManTech's (2023) study found that the 120 dB contour extents over land as follows: approximately 2.3 miles (mi) for Falcon 9 launch events originating from SLC-4; approximately up to 2.1 mi for first stage landing events occurring at the SLC-4 pad; and approximately 1.3 mi for static fire events occurring prior to launches at SLC-4. Each of the 120 dB and greater Lmax contours occur entirely within VSFB. Landing events occurring at the droneship in the Pacific Ocean would not result in 120 dB and greater Lmax contours occurring over land.

A study conducted to assess the effects of aircraft noise and sonic booms on structures (Haber et al. 1989) determined that potential damage resulting from sonic booms measuring at 2-4 psf were nominal and categorized as failures that occurred due to the poor condition of the structures or elements of the structure. Additionally, in a study commissioned by NASA it was reported that only rare and minor damage may occur with overpressures between 2 and 5 psf and that experimental testing of sonic boom effects has shown structures in good condition remain undamaged by overpressures up to 11 psf (Gibbs 2017). The Proposed Action will not result in overpressures any greater than 5 psf. Accordingly, the threshold for potential damage resulting from sonic booms (overpressure) for this Proposed Action is established at 2 psf or greater. ManTech (2023) was retained to conduct a noise study to determine those launch azimuths for the Proposed Action that have the potential to produce a sonic boom that could impact land during all launches (northerly and southerly) and identify where overpressures of 2 psf or greater are expected occur as illustrated in Figure 2. Composite Launch Sonic Boom Contour and all landings (northerly and southerly) as illustrated in Figure 3. Composite Landing Sonic Boom Contour. According to ManTech's (2023) study findings, launch azimuths ranging between 140 to 188 with sonic booms of 2 psf or greater have a potential to impact land within the NCI. However, launch trajectories with azimuths between 188 and the currently approved northerly azimuth of 301 do not have the potential to produce a sonic boom that could impact land during launch. Additionally, ManTech determined that sonic booms of 2 psf or greater produced during southerly trajectory landing events have the potential to impact land within the NCI. Sonic booms impact during landings events are as follows: south VSFB are predicted to range between 1.5 and 5.0 psf, the City of Lompoc is predicted between 0.5 and 1.5 psf, and on occasion, depending on mission trajectories and atmospheric conditions, the western portion of Lompoc have the potential to experience psf levels of up to 4.0. Sonic booms of 2 psf or greater resulting from northerly mission landings occur over the Pacific Ocean and therefore, would not impact land as illustrated in Figure 4. Northerly Mission Landing Peak Sonic Boom Overpressure. In short, sonic boom overpressure measurements of 2 psf or greater resulting from the Proposed Action are predicted to occur within significant portions of the Lompoc Valley, including VSFB, and the three most northerly Channel Islands (NCI) of San Miguel Island, Santa Rosa Island, and Santa Cruz Island with sonic booms reaching 5 psf primarily occurring on VSFB and over open ocean.

In consultation with the 30 CES/CEIEA concerning the Proposed Action and its potential for direct and indirect effects to cultural resources resulting from any related construction, static fire, launches, and boost-back landings, an area of direct impacts (ADI) and subsequent APE was determined. Since no ground-disturbing or landscape-altering actions are proposed, the ADI for the Proposed Action is limited to auditory effects predicated on vibratory impacts. The ADI for the Proposed Action includes the area within which noise vibration reach levels above 120 dB, as well as sonic booms in excess of 2 psf (see Figure 5. Cultural Resources Study Area with Noise Level Overlays).

Methods

A cultural resource records search of the California Historical Resources Information System (CHRIS) for the cultural resource study area outside of the VSFB was conducted at the Central Coastal Information Center (CCIC) on February 10 and 24, 2023. The records search included a review of all recorded archaeological sites and built environment resources. Additionally, a review of the National Register of Historic Places (NRHP), the California Register of Historical Resources (CRHR), the California Historic Property Data File, and the lists of California State Historical Landmarks, California Points of Historical Interest, and Archaeological Determinations of Eligibility was conducted.

In consultation with the 30 CES/CEIEA, Dudek reviewed available literature to determine what types of resources located within the cultural resource study area have the potential to be impacted by the Proposed Action. Analysis specifically addressing potential impacts on built environment historic properties from rocket engine noise and sonic boom vibrations associated with static tests, launches and boost-back landings at SLC-4 considered previously conducted studies. These studies include those by Guest and Sloane (1972) and Gibbs (2017) that establish the thresholds at which prolonged noise thresholds (static fires) and sonic booms have the potential to impact historic properties. Additionally, Dudek reviewed a previous study that considered potential impacts to archaeological sites (Norcerino et al. 2021) and consulted with Mr. Josh Smallwood of the 30 CES/CEIEA regarding the results of experimental analysis conducted by the 30 CES/CEIEA at VSFB (Smallwood personal communication 2023). The experimental analysis included the placement and observation of a 12-inch-tall, 45-degree slope sand cone and a 12x12x12-inch midden chunk on a concrete pad located 3,180 feet to the southwest of the SLC-4 SpaceX boost-back pad to determine if noise vibration resulting from two December SpaceX launches/boost-back landings would result in any visual change to the materials. No visual impacts were observed in either the midden chunk or sand cone after the launch/boost-back with the exception of a few fine grains of sand shifting down the cone likely resulting from the samples drying in the wind. Importantly, there was no cracking or crumbling observed, on the midden chunk or sand cones from launch vibrations/sonic boom overpressures (Smallwood personal communication 2023). Smallwood asserted that based on experimental analysis and observations of archaeological sites located on base, VSFB cultural resources staff have established that archaeological sites consisting of only surface artifacts and/or buried archaeological material do not have the potential to be affected by rocket engine noise. A sheer cliff-face midden deposit present within CA-SBA-530 located in the southern portion of the VSFB between SLC-4 and SLC-6 was monitored for impacts resulting from noise vibrations. Despite the observation of significant impacts resulting from natural erosion due to rainfall, wind, and wave compression, no visible effect resulting from noise vibrations due to launch and boost-back events has been observed (Smallwood personal communication 2023).

A condition assessment program has occurred at the NRHP-eligible Honda Ridge Rock Art Site (CA-SBA-550), located 7,000 feet east of SLC-6, since the early 2000s (Nocerino et al. 2021; Smallwood personal communication 2023). The program has found no evidence of effects to the rock art surfaces from heavy- and medium-payload rocket launches and boost backs or sonic boom overpressure (Smallwood personal communication 2023). Therefore, all archaeological resources, including those with rock art, cairns, and rock shelters were excluded from further consideration because they are highly unlikely to be affected by short-duration launch noise from an increased cadence of SpaceX launches, static fires, and boost-back landings.

Finally, all but one building located on VSFB and within the cultural resource study area are associated with launch complexes and supporting infrastructure and are built to withstand concussive forces. The only historic building located on VSFB and within the APE that is not associated with launch complexes or supporting infrastructure is the former U.S. Coast Guard Lifeboat Rescue Station (P-42-040495). The Colonial Revival architectural style, wood-frame structure was built in 1936 as administrative barracks and ancillary structures. The buildings have been subjected to many years of medium and heavy launches and boost-back landings at SLC-4 as well as launches conducted at nearby SLC-6 with no reported and observed effect.

Based on these considerations, the off-Base cultural resources records search focused on resources identified by the CHRIS as NRHP listed or eligible for listing in accordance with the Office of Historic Preservation (OHP) attribute codes (OHP 1995). Those categories identified for consideration of the potential for effects resulting from the Proposed Action included built environment resources and archaeological features located above ground such as rock art, cairns and rock shelters.

Records Search Results

Table 1 provides both built environment and archaeological cultural resources that are listed on or determined eligible for listing on the NRHP and are, as previously mentioned, identified as including elements that may have the potential for effects resulting from the Proposed Action. For the purpose of this assessment and since the San Miguel, Santa Rosa, and Santa Cruz Archaeological Districts encompass the entirety of their respective islands, all contributing resources within the districts are assumed eligible for the NRHP for the purposes of this Proposed

Action. As such, individual archaeological resources on the NCI are captured in the respective island's archaeological district.

Table 1. NRHP-listed or eligible cultural resources located within the APE

Reference Number	Resource Type	Resource Name or Type	Description	NRHP Evaluation
Lompoc Valley Area of the APE				
_70000147	Built Environment	La Purisima Mission	Adobe mission buildings	Listed
_90001818	Built Environment	Lompoc Public Library (Carnegie)	Masonry building	Listed
_16000664	Built Environment	Lompoc Veterans Memorial Building	Masonry building	Listed
_78000775	Built Environment	Mission de la Purisima Concepcion de Maria Santisima Site	Adobe mission buildings	Listed
OTIS ID: 488380	Built Environment	Artesia School	Wood-frame building	Eligible
P-42-003865	Built Environment	Well, Hill 4	Oil well	Eligible
OTIS ID: 565260	Built Environment	Spanne Building	Wood-frame building	Eligible
OTIS ID: 565254	Built Environment	105 H St Building	Wood-frame building	Eligible
OTIS ID: 689985	Built Environment	U.S. Army Disciplinary Barracks, U.S. Lompoc Prison	Masonry building	Eligible
OTIS ID: 533649	Built Environment	Lompoc Theater	Masonry building	Eligible
P-42-040480	Archaeological	Site of Original Mission and remaining ruins of buildings of Mission de la Purisima Conception de Maria Santisima	Adobe ruins	Eligible
Santa Cruz Island				
_80000405& _100007199	Archaeological	Santa Cruz Island Archeological District	Various types of archaeological sites	Listed
OTIS ID: 529803	Built Environment	Santa Cruz Island Ranching District	Various structure types: wood-frame, masonry, and adobe construction	Eligible
Santa Rosa Island				
_100007896	Archaeological	Santa Rosa Island Archaeological District	Various types of archaeological sites	Listed
OTIS ID: 529721	Built Environment	Santa Rosa Island Ranch – China Camp Cabin	Wood-frame building	Eligible
OTIS ID: 529722	Built Environment	Santa Rosa Island Ranch – Clapp Springs	Wood-frame building	Eligible

Reference Number	Resource Type	Resource Name or Type	Description	NRHP Evaluation
OTIS ID: 529725	Built Environment	Santa Rosa Island Ranch – Horse Barn	Wood-frame building	Eligible
OTIS ID: 529726	Built Environment	Santa Rosa Island Ranch – Main Ranch House	Wood-frame building	Eligible
OTIS ID: 529728	Built Environment	Santa Rosa Island Ranch – Old School House	Wood-frame building	Eligible
OTIS ID: 529738	Built Environment	Santa Rosa Island Ranch – Rope House	Wood-frame building	Eligible
OTIS ID: 529747	Built Environment	Santa Rosa Island Ranch – Army Camp Water System	Wood-frame building	Eligible
OTIS ID: 529748	Built Environment	Santa Rosa Island Ranch – South Point Lighthouse	Wood-frame building	Eligible
San Miguel Island				
_79000258	Archaeological	San Miguel Island Archaeological District	Various types of archaeological sites	Listed
4-SMI-456	Built Environment	Nidever Adobe	Adobe ruins	Eligible
Unknown	Built Environment	Waters Ranch House Site	Wood-frame building	Eligible

On-Base. The records search of VSFB cultural resources database conducted by the 30 CES/CEIEA revealed that the entirety of the cultural resources study area located within the VSFB has been previously surveyed for cultural resources resulting in the identification of 350 previously recorded cultural resources within this portion of the APE. Of these resources, four archaeological sites and 103 historic-age buildings fit the criteria previously outlined as those with above-ground buildings, structures, or objects that are NRHP-listed or eligible and could potentially be affected by launch noise vibrations. The four archaeological resources are rock art sites and the 103 historic-age buildings are associated with launch complexes and supporting infrastructure that have been built to withstand concussive forces. A total of 123 other archaeological sites on VSFB have been identified within the APE but do not include elements that could potentially be affected by launch noise vibrations and sonic boom overpressure.

Off-Base within Lompoc Valley. A cultural resource records search of the CHRIS conducted by Dudek revealed that large portions of the cultural resources study area located within off-base portion of the Lompoc Valley has been previously surveyed for cultural resources resulting in the identification of at least 1,795 previously recorded cultural resources within this portion of the APE. Of these resources, one archaeological site and ten historic-age buildings fit the criteria previously outlined as those with above-ground buildings, structures, or objects that are NRHP-listed or eligible and could potentially be affected by launch noise vibrations and sonic boom overpressure.

Northern Channel Islands (San Miguel Island, Santa Rosa Island, and Santa Cruz Island). A cultural resource records search of the CHRIS conducted by Dudek revealed that large portions of the cultural resources study area located within the NCI have been previously surveyed for cultural resources resulting in the identification of at least 2,204 cultural resources. All three islands, San Miguel, Santa Rosa, and Santa Cruz are NRHP-listed as archaeological districts encompassing the entirety of their respective islands. For the purposes of this study, all contributing resources within the districts are assumed eligible for the NRHP, Likewise, the historic buildings present on Santa Cruz Island are NRHP-listed as the Santa Cruz Island Ranching District. Historic properties on the NCI include historic ranches and archaeological deposits, and prehistoric Native American archaeological sites. Historic buildings and archaeological sites include wood-frame, masonry, adobe construction and adobe ruins. The prehistoric sites consist of Native American shell middens, burials, habitation sites, and lithic scatters.

CONCLUSIONS

The Proposed Action is subject to NHPA Section 106 compliance and AFMAN 32-7003, Cultural Resources Management. Section 106 compliance also satisfies federal agencies' NEPA responsibilities to consider potential project-related effects on historic properties. The NHPA, Section 106, requires federal agencies to consider the effects of proposed federal undertakings on historic properties that are listed in or eligible for listing in the NRHP. If a cultural resource is listed in, or eligible for, the NRHP it is considered a "historic property" for purposes of Section 106 and is significant. Compliance with Section 106 requires the federal agency to determine either that the undertaking would have no effect, no adverse effect, or an adverse effect to historic properties (that is, to significant cultural resources). The Section 106 implementing regulations (36 CFR Part 800) prescribe the process for making these determinations.

In consultation with the 30 CES/CEIEA concerning the Proposed Action and its potential for direct and indirect effects to cultural resources resulting from any related construction, static fire, launches, and boost-back landings, a ADI and subsequent APE was determined. Since no ground-disturbing or landscape-altering actions are proposed, the ADI for the Proposed Action is limited to auditory effects predicated on vibratory impacts. Based on standard thresholds for potential effects resulting from launch noise and sonic booms, this study was conducted to identify historic properties within the ADI determined to be where noise vibration levels exceed 120 dB and the sonic boom arc exceeds 2psf as a result of the Proposed Action.

The 120 dB launch noise contour would not be experienced outside of VSFB. All but one building located on VSFB are associated with launch complexes and supporting infrastructure and are built to withstand concussive forces. The only historic building located on VSFB that is not associated with launch complexes or supporting infrastructure is the former U.S. Coast Guard Lifeboat Rescue Station (P-42-040495). The Colonial Revival architectural style, wood-frame structure was built in 1936 as administrative barracks and ancillary structures. The structures have been subjected to many years of medium and heavy launches and boost-back landings at SLC-4 as well as launches conducted at nearby SLC-6 with no reported and observed effect. Accordingly, there would be no effect to any NRHP eligible resources in the built environment at VSFB from launch noise exceeding 120 dB.

Built environment and archaeological resources located within the ADI could be subject to sonic booms of up to 4 and 5 psf. Specifically, the 2 psf and greater sonic boom impact area encompasses all of Santa Cruz, Santa Rosa, and San Miguel islands and may reach an overpressure of as much as 5 psf over a very narrow portion of land on the NCI; however, a large portion of the NCI will be exposed to an overpressure no more than of 2–3 psf. Sonic booms are dependent on launch trajectory, inclination, and atmospheric conditions. The Proposed Action is not expected to result in a repeated alignment of the sonic boom overpressure footprint within specific areas of the APE and the duration of the overpressure effects are estimated to last less than one second per sonic boom (personal communication with SpaceX staff 2023). Previous studies, experimental analysis and observations of archaeological sites located on VSFB have provided good evidence that archaeological sites consisting of only surface artifacts and/or buried archaeological material do not have the potential to be affected by rocket engine noise exceeding 120 dB and sonic booms exceeding 2 psf. Furthermore, both archaeological and built environment resources within the ADI have been subjected to many years of medium and heavy launches and boost-back landings at SLC-4 as well as launches conducted at nearby SLC-6 with no reported and observed effect.

A reasonable and good-faith effort to identify historic properties within the APE pursuant to 36 CFR 800.4(a)-(d) and 36 CFR 800.5(a)-(d) has been conducted by both the 30 CES/CEIEA and Dudek. A desktop analysis of archaeological sites and historic-age buildings in the launch noise/sonic boom study area, and identification of all NRHP eligible cultural resources in the APE was conducted and historic properties were assessed for their potential to be affected by the Proposed Action. Based on thresholds established by previous studies and the results of previous experiments and observational assessments (Gibbs 2017; Guest and Sloane 1972; Haber et al. 1989; NASA 2017; Nocerino et al. 2021; and Smallwood personal communication 2023) it is highly unlikely that the identified historic properties located within the ADI have the potential to be affected by the Proposed Action and the undertaking will have *no effect* on any known historic properties.

Please do not hesitate to contact Dudek at any time with questions or concerns about this investigation. I can be reached at hmcdevitt@dudek.com or by calling 805-308-3581.

Very Respectfully,

Heather McDaniel McDevitt, MA, RPA
Principal Investigator

REFERENCES

Gibbs, Yvonne. 2017 NASA Armstrong Fact Sheet: Sonic Booms. Found at: https://www.nasa.gov/centers/armstrong/news/FactSheets/FS-016-DFRC.html.

Guest, S., and R. M. Slone, Jr. 1972 Structural Damage Claims Resulting from Acoustic Environments Developed During Static Firing of Rocket Engines. Paper presented at the NASA Space Shuttle Technology Conference.

Haber, Jerry, David Nakaki, Craig Taylor, George Knipprath, Vijay Kopparam, and Mark Legg. 1989. *Effects of Aircraft Noise and Sonic Booms on Structures: An Assessment of the Current State-of-Knowledge*. BBN Systems and Technologies Corp., Canoga Park.

ManTech SRS Technologies, Inc. 2023 Noise Study for SpaceX Falcon 9 Launch and Landing Operations at Vandenberg Space Force Base, California. On file, 30 CES/CEIEA Cultural Resources, Vandenberg Space Force Base, California.

Nocerino, Eric, Josh Small wood and Edward B. Yarbrough. 2021. Rocket Engine Noise Effects of Cultural Resources: Addendum to the Section 106 Compliance Report for the Blue Origin Orbital Launch Site Project, Vandenberg Space Force Base, Santa Barbara County, California. Prepared for Tetra Tech.

OHP, 1995. *Instructions for Recording Historical Resources*. Prepared by California Department of Transportation. Prepared for California Office of Historic Preservation.

Smallwood, Josh. 2023. Personal Communication

SpaceX. 2023. Personal Communication

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Attachments

Figure 1. SLC-4E Launch/Static Fire Engine Noise Unweighted Maximum Sound Levels
Figure 2. Composite Launch Sonic Boom Contour
Figure 3. Composite Landing Sonic Boom Contour
Figure 4. Northerly Mission Landing Peak Sonic Boom Overpressure
Figure 5. Cultural Resources Study Area

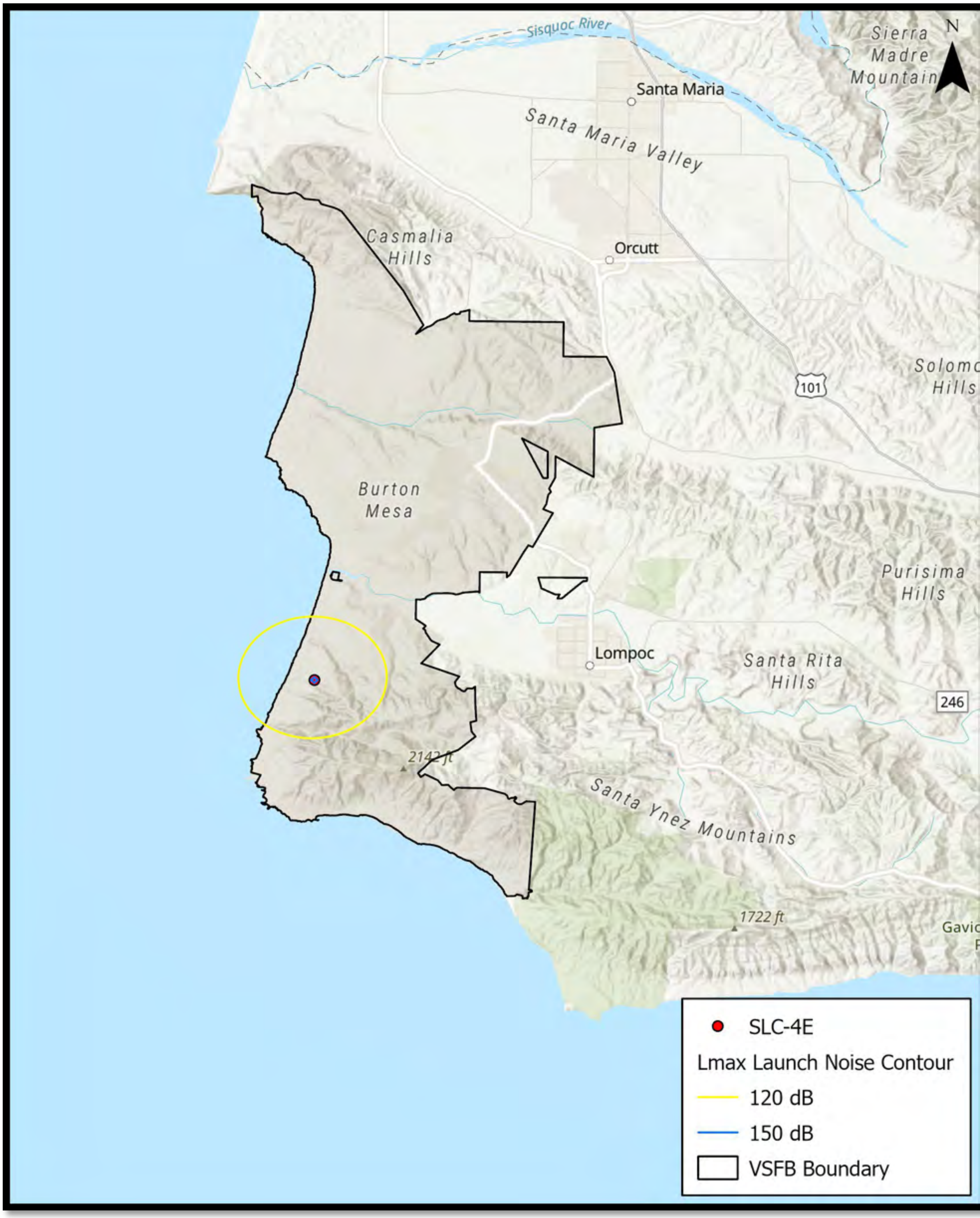

Figure 1. SLC-4E Launch/Static Fire Engine Noise Unweighted Maximum Sound Levels

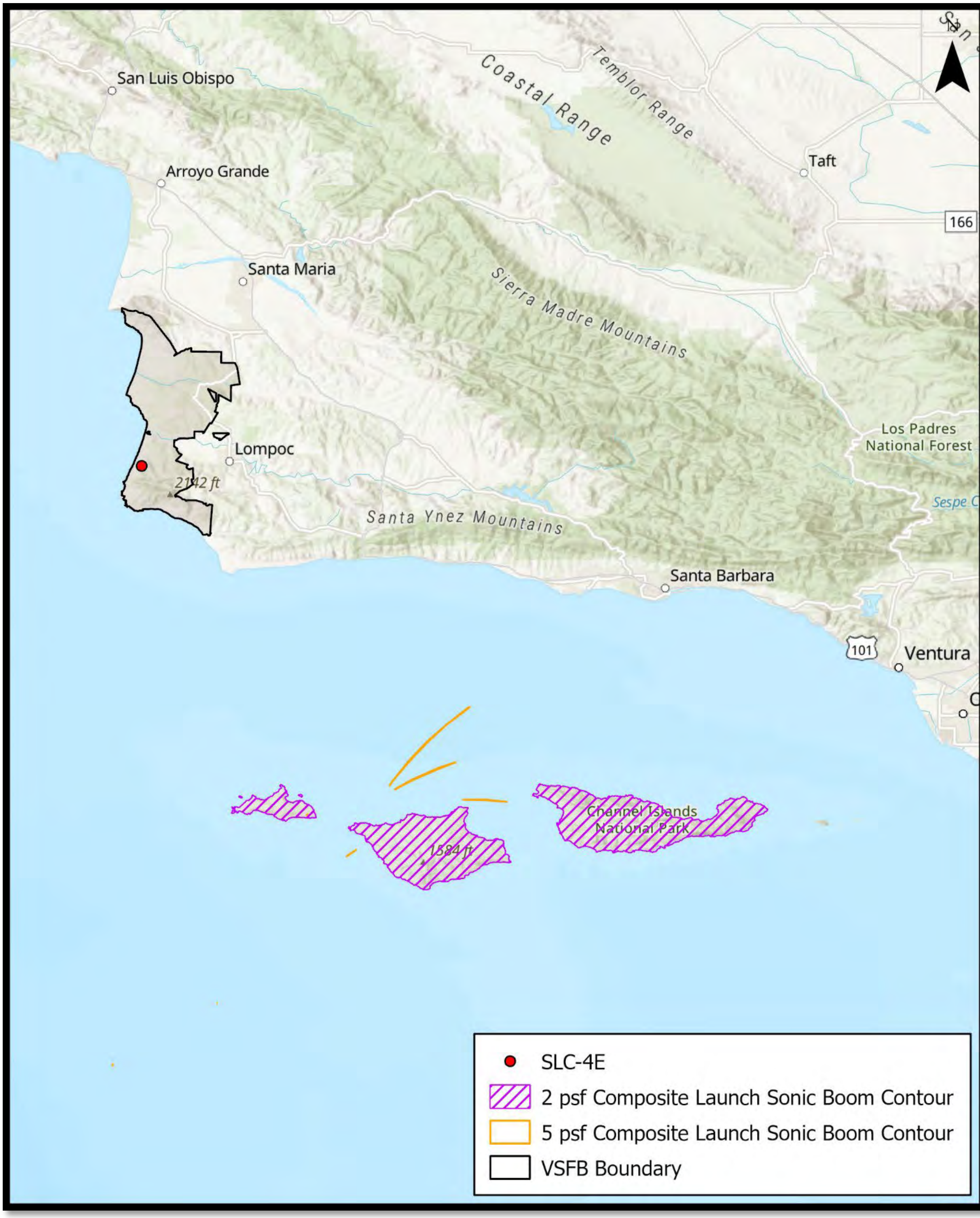

Figure 2. Composite Launch Sonic Boom Contour

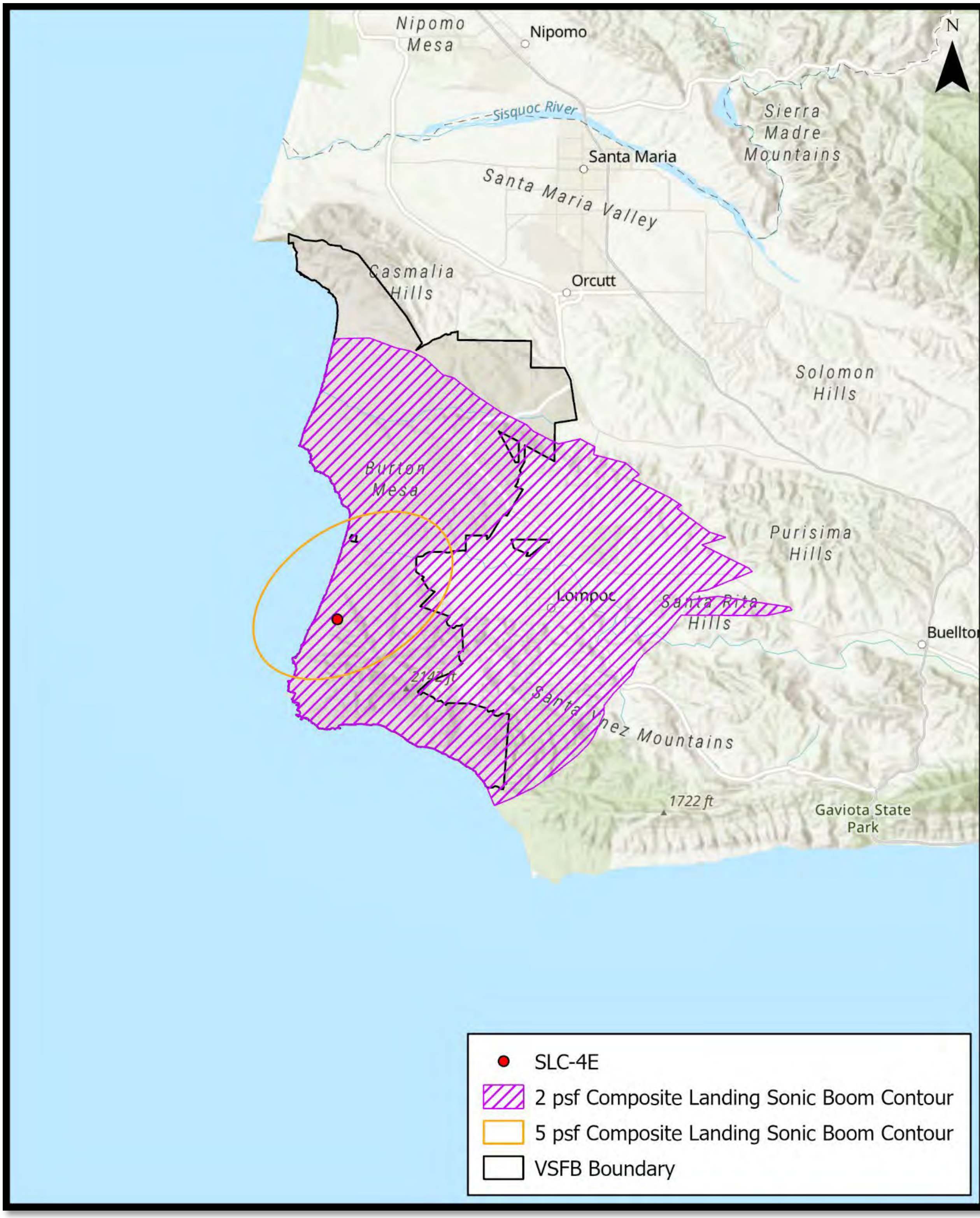

Figure 3. Composite Landing Sonic Boom Contour

Figure 4. Northerly Mission Landing Peak Sonic Boom Overpressure

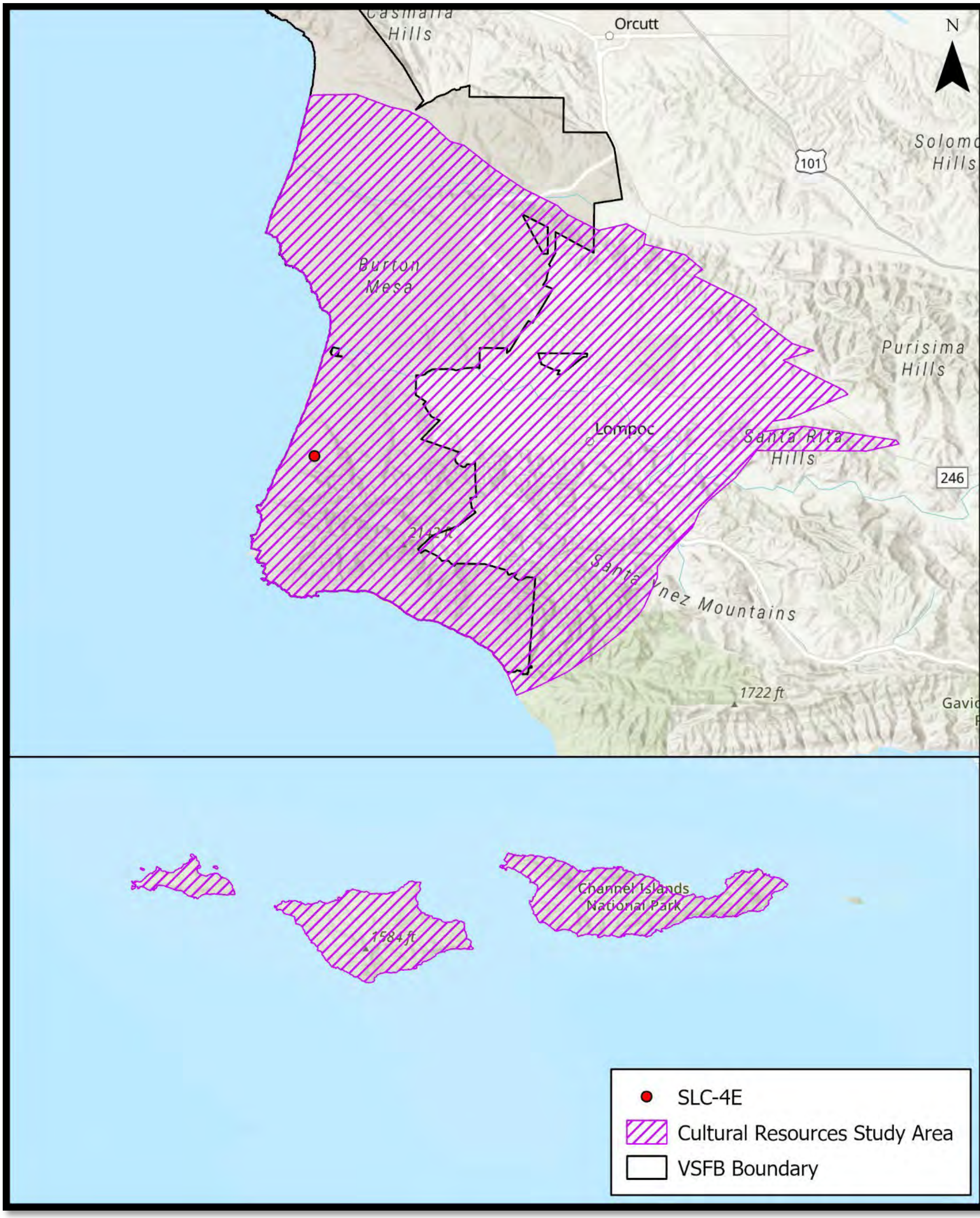

Figure 5. Cultural Resources Study Area

Appendix B   ManTech 2023

Noise Study for SpaceX Falcon 9 Launch and Landing Operations at Vandenberg Space Force Base, California

24 February 2023

Prepared for

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Acronyms and Abbreviations

CNEL	community noise equivalent level
dB	decibel(s)
dBA	A-weighted decibel(s)
DNL	Day-Night Average Sound Level
DoD	Department of Defense
FAA	Federal Aviation Administration
ft.	foot or feet
Hz	Hertz
L_{Amax}	A-weighted maximum noise levels
lbf	pound-force
lbm	pound-mass
L_{max}	unweighted maximum noise levels
LOA	Letter of Authorization
LOX	liquid oxygen
M1D	Merlin 1D
mi	mile(s)
MSRS	ManTech SRS Technologies, Inc.
NEPA	National Environmental Policy Act
NIOSH	National Institute for Occupational Safety and Health
NCI	Northern Channel Islands
M	million
OSHA	Occupational Safety and Health Administration
psf	pound per square foot
RP-1	rocket propellant 1
SLC-4E	Space Launch Complex 4 East
SLC-4W	Space Landing Complex 4 West
SpaceX	Space Exploration Technologies Corporation
USSF	United States Space Force
VSFB	Vandenberg Space Force Base

1.0 Introduction

Space Exploration Technologies Corp. (SpaceX) proposes to increase the annual cadence for Falcon 9 operations at Vandenberg Space Force Base (VSFB) and include additional downrange offshore landing locations in the Pacific Ocean (Figures 1-1 and 1-2). SpaceX has been performing launches of the Falcon 9 vehicle at Space Launch Complex 4 East (SLC-4E) since 2013. In 2018, SpaceX began landing the first stage at Space Landing Complex 4 West (SLC-4W; also referred to as Landing Zone 4). Under current United States Space Force (USSF) approvals under the National Environmental Policy Act (NEPA) and Federal Aviation Administration (FAA) launch vehicle licensing, SpaceX is approved to conduct up to 12 Falcon 9 launches each year and up to 12 first stage landings at SLC-4W each year.

Multiple noise studies of the Falcon 9 program at VSFB have been performed to support FAA and USSF environmental review and approval under NEPA. However, prior noise studies utilized older noise modeling methods that have been improved over the past five years. Accordingly, new noise modeling has been conducted to characterize the noise impacts resulting from the proposed increase in operations and new trajectories at VSFB. In order to characterize rocket engine noise and sonic boom impacts on the surrounding environment resulting from SpaceX's proposed increase in cadence and additional trajectories and landing locations, ManTech SRS Technologies, Inc. (MSRS) used RUMBLE v2.0, a launch vehicle acoustic simulation model, and PCBoom v4.99, a sonic boom modeling program, to predict the noise levels, peak overpressures, and affected geographic areas. The results of these analyses support the Draft Supplemental Environmental Assessment for the Falcon 9 cadence increase at SLC-4 and associated regulatory documents, USSF approval through the NEPA process, and FAA issuance of launch licenses.

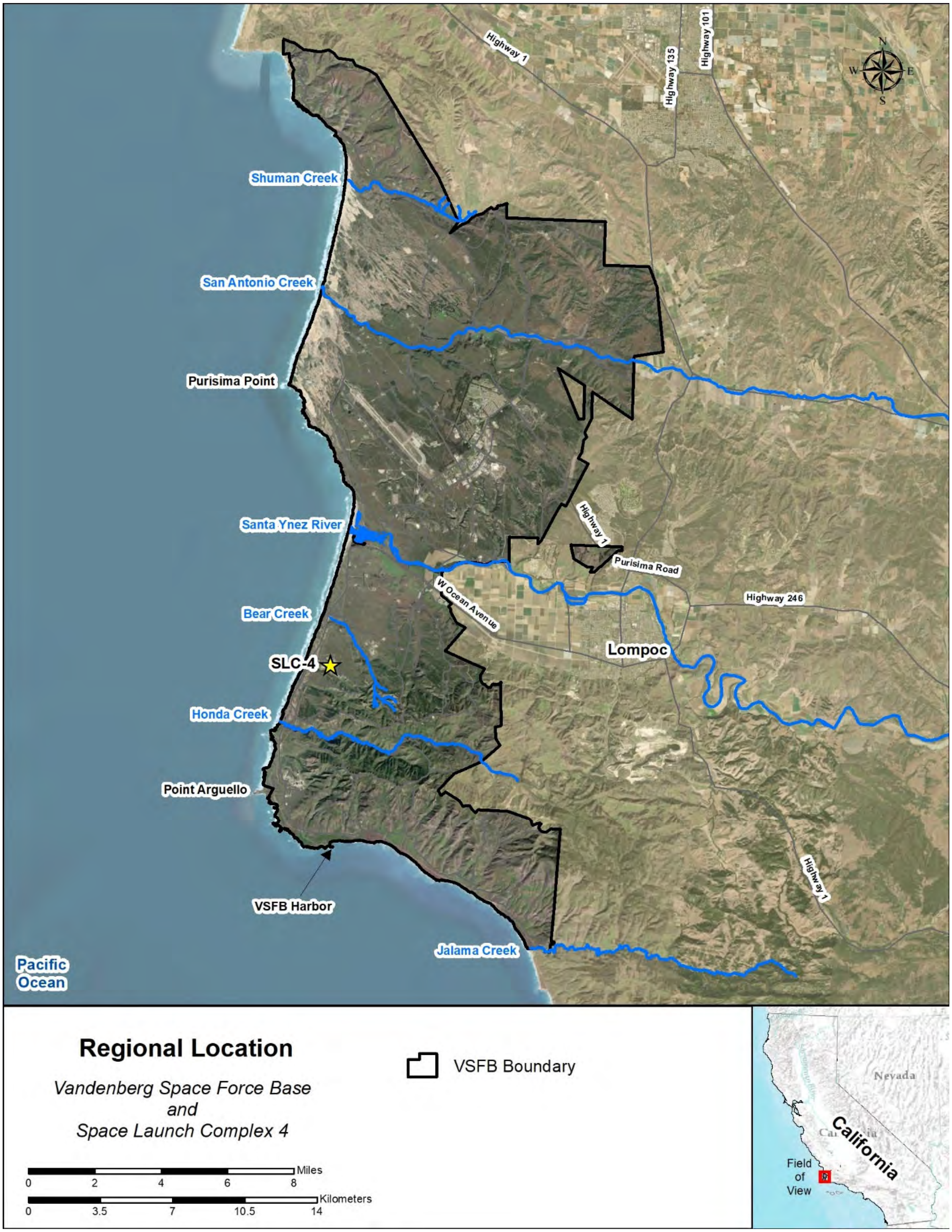

Figure 1-1. Regional location of SLC-4 at Vandenberg Space Force Base.

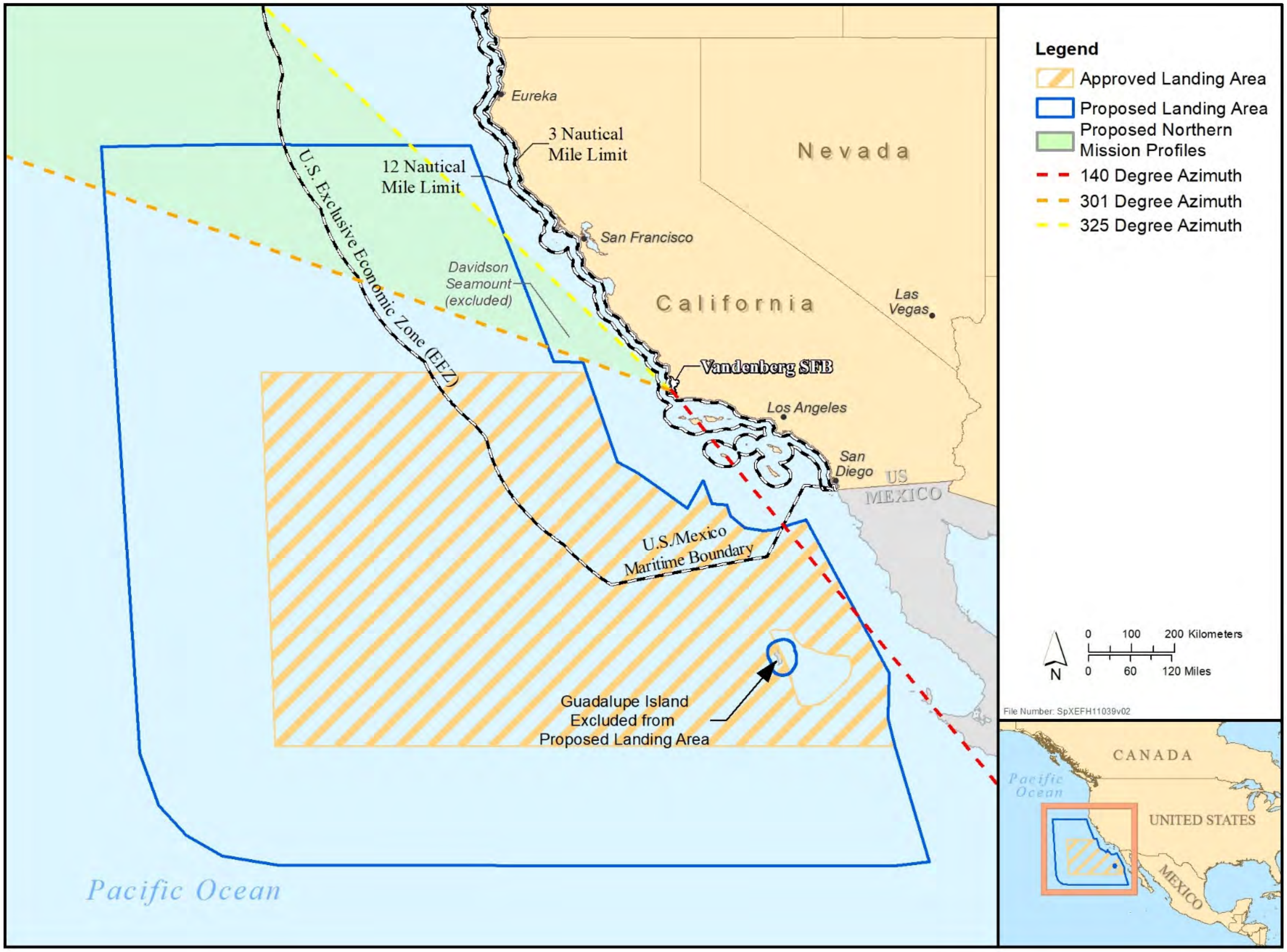

Figure 1-2. Currently approved and proposed downrange first stage landing areas.

2.0 Description of Falcon 9 Program at SLC-4

2.1 Falcon 9 Vehicle Specifications

The Falcon 9 is 229 feet (ft.) tall with a diameter of 12 ft. The first stage is 160 ft. in height, including the interstage that would be attached to the first stage during landing. The first stage includes nine Merlin 1D (M1D) engines, each capable of providing 190,000 pounds (pound-force) of thrust at sea level (for a total of approximately 1.7 million pounds of thrust at liftoff). The M1D engines are propelled by liquid oxygen (LOX) and rocket propellant 1 (RP-1). They are configured in a circular pattern, with eight engines surrounding a center engine. The first stage has four deployable landing legs which are locked against the first stage during ascent. These legs are used on missions that include first stage boost-back and landing. Four grid fins near the top of the first stage support precision reentry and landing operations. The grid fins help align the first stage booster for reentry after separating from the rest of the launch vehicle in space. The specifications are presented in Table 2-1.

Table 2-1. Falcon 9 Launch Vehicle Specifications.

Specification	Falcon 9
Total Vehicle Height	229 ft
Diameter	12 ft
First Stage Height	160 ft
First Stage Engines	9 M1D engines
Propellant	LOX/RP-1
Propellant Quantity (total)	1,135,925 lbm
Engine Thrust (per engine)	190,000 lbf
Total Thrust (at liftoff)	1.71 M lbf

Notes: lbm = pound-mass; lbf = pound-force; LOX = liquid oxygen; RP-1 = rocket propellant 1, M = million

2.2 Proposed Launch and Vehicle Recovery Operations

SpaceX proposes to increase the annual number of launches of the Falcon 9 from SLC-4E from the currently approved 12 times per year to up to 36 times per year. Following each launch, SpaceX would perform a boost-back and landing of the first stage up to 36 times, either downrange on a droneship or at SLC-4W at VSFB. SpaceX does not propose to increase the number of first stage landings at SLC-4W from the currently approved 12 events per year. Each launch may be preceded by a static fire test of the engines 1 to 3 days before launch, which lasts a few seconds. The need to conduct a static fire test is mission dependent, but there would be no more than 36 static fire events per year. Launch operations would occur day or night, at any time during the year. There would be approximately 7 to 14 days between each launch event. Under current USSF and FAA approvals, SpaceX Falcon 9 missions from VSFB may range in launch azimuth from 140 degrees to 301 degrees. SpaceX proposes to add a northerly mission profile with a launch azimuth between 301 and 325 degrees to accommodate new downrange landing locations (Figure 2-1)

3.0 Noise Modeling Methods

3.1 Engine Noise Modeling

MSRS used RUMBLE v2.0, a publicly available software tool developed by Blue Ridge Research and Consulting, LLC (BRRC), to model rocket engine noise. This sophisticated model incorporates numerous components, including the acoustic power of the rocket engine source, forward flight effects, the angle from the source to the receiver (directivity), Doppler effect, propagation between the source and receiver (ray path), atmospheric absorption, and ground interference to estimate received noise levels. A full description of the methodology employed in the model can be found in Bradley et al. 2018.

The received noise is estimated by combining the source components and propagation effects. Model inputs include both details regarding the airframe (height, diameter, mass, number of stages) as well as details regarding each engine used by that airframe (engine weight, propellant type, thrust, nozzle exit diameter, nozzle exit velocity, number of nozzles, and the number of engines employed). RUMBLE uses this in conjunction with the trajectory of the airframe (which includes coordinates, speed, heading, pitch, time varying thrust, weight, and length) to calculate and prepares the modeled received noise for three noise metrics relevant to environmental noise analysis (see Section 4.1). For static fire calculations, no trajectory file is used, rather details regarding the static fire are utilized (location, nozzle exit height, nozzle exit direction, and duration).

MSRS utilized the vehicle specification (Table 2-1) and representative launch and landing trajectories, including the new northerly mission profile, to model launch and landing noise. There were no appreciable differences in launch engine noise model results from the southerly and northerly mission profiles, therefore, we present only the southerly mission profile here. Similarly, there were little differences in landing engine noise results based on representative first stage landing trajectories, therefore, we utilized the landing trajectory from the 16 December 2022 mission for the landing engine noise model results included herein. Results from these other mission profiles are available upon request.

MSRS used RUMBLE to estimate the unweighted maximum sound level (L_{max}) in decibels (dB) and the "A-weighted" maximum sound level (L_{Amax}) in A-weighted decibels (dBA) resulting from rocket engine noise during launch, landing, and static fire events. The maximum sound level is the highest sound level during a single noise event. A-weighting is a frequency-dependent adjustment used to approximate the range of human sensitivity. The general range of human hearing is from 20 to 20,000 cycles per second, or Hertz (Hz); humans hear best in the range of 1,000–4,000 Hz, therefore a weighting function is applied which gives higher value to sound energy within these ranges. L_{Amax} is thus a good indicator of perceived loudness in the human environment.

MSRS also used RUMBLE to estimate Community Noise Equivalent Level (CNEL), which is a weighted average of noise levels over time used in the State of California to assess the potential annoyance of airport noise on surrounding communities. While the FAA's primary metric used to determine noise impacts on communities is the Day-Night Average Sound Level (DNL), the FAA accepts the CNEL in California since California adopted the use of CNEL prior to FAA adopting DNL. CNEL, like DNL, adds a ten times weighting (equivalent to a 10 dBA penalty) to each aircraft operation between 10:00 p.m. and 7:00 a.m.; however, CNEL also adds a three times weighting (equivalent to a 4.77 dBA penalty) for each aircraft operation during evening hours (7:00 p.m. to 10:00 p.m.).

In order to model CNEL, MSRS assumed the following:

- 36 launches per year
- 12 first stage landings at SLC-4 per year
- 36 static fire events per year
- 50 percent of operations would occur between 10:00 p.m. and 7:00 a.m.

3.2 Sonic Boom Modeling

MSRS used PCBoom v4.99 to predict the peak overpressures and impact locations of potential sonic booms, as generated by the Falcon 9 vehicle, during launches and first stage recoveries. PCBoom considers the size and shape of the vehicle and the trajectory in relationship to the thrust, drag, and weight of the vehicle, which vary during the flight of the vehicle, to estimate the initial signature of the overpressure. The model then propagates the overpressure through site and seasonally specific meteorological provides obtained from a 10-year RAWINSONDE database profile that includes the high wind, low wind, low temperature, high temperature, and median profiles sampled evenly throughout each month of the year (National Oceanic and Atmospheric Administration 2022). A full description of the methods used by PCBoom v4.99 can be found in Bradley et al. 2018.

The inputs of the model specifically addressed the geometry the Falcon 9 launch vehicle and first stage (Table 2-1). The software was used to model multiple representative launch trajectories with initial azimuths between 140 and 325 degrees. Multiple landing trajectories were also modeled, including the extents of the proposed northerly (325 degrees) and southerly (140 degrees) mission profiles and multiple representative landing trajectories for first stage recoveries at SLC-4W. Multiple sample meteorological conditions were selected from a 10-year RAWINSONDE database. A total of 30 modeling runs per trajectory were performed.

4.0 Noise Modeling Results

4.1 Engine Noise Modeling Results

4.1.1. Falcon 9 Maximum Unweighted Sound Levels

The modeling results of the unweighted maximum sound levels for launch, landing, and static fire events from SLC-4 are presented in Figures 4-1 through 4-3 below. The FAA uses the 120 dB L_{max} noise contour for engine noise to define areas that may experience structural damage as a result of space launch vehicle noise (Fenton and Methold 2016; Guest and Slone 1972; Haber et al. 1989). The 120 dBA L_{max} contour for Falcon 9 launch event reaches approximately 2.3 miles (mi) over land from SLC-4 and entirely on VSFB (Figure 4-1). For first stage landing events the

120 dB L_{max} contour extends over land approximately up to 2.1 mi and is entirely within VSFB (Figure 4-2). Similarly, the 120 dB L_{max} contour for static fire events, extends approximately 1.3 mi and is entirely within VSFB (Figure 4-3).

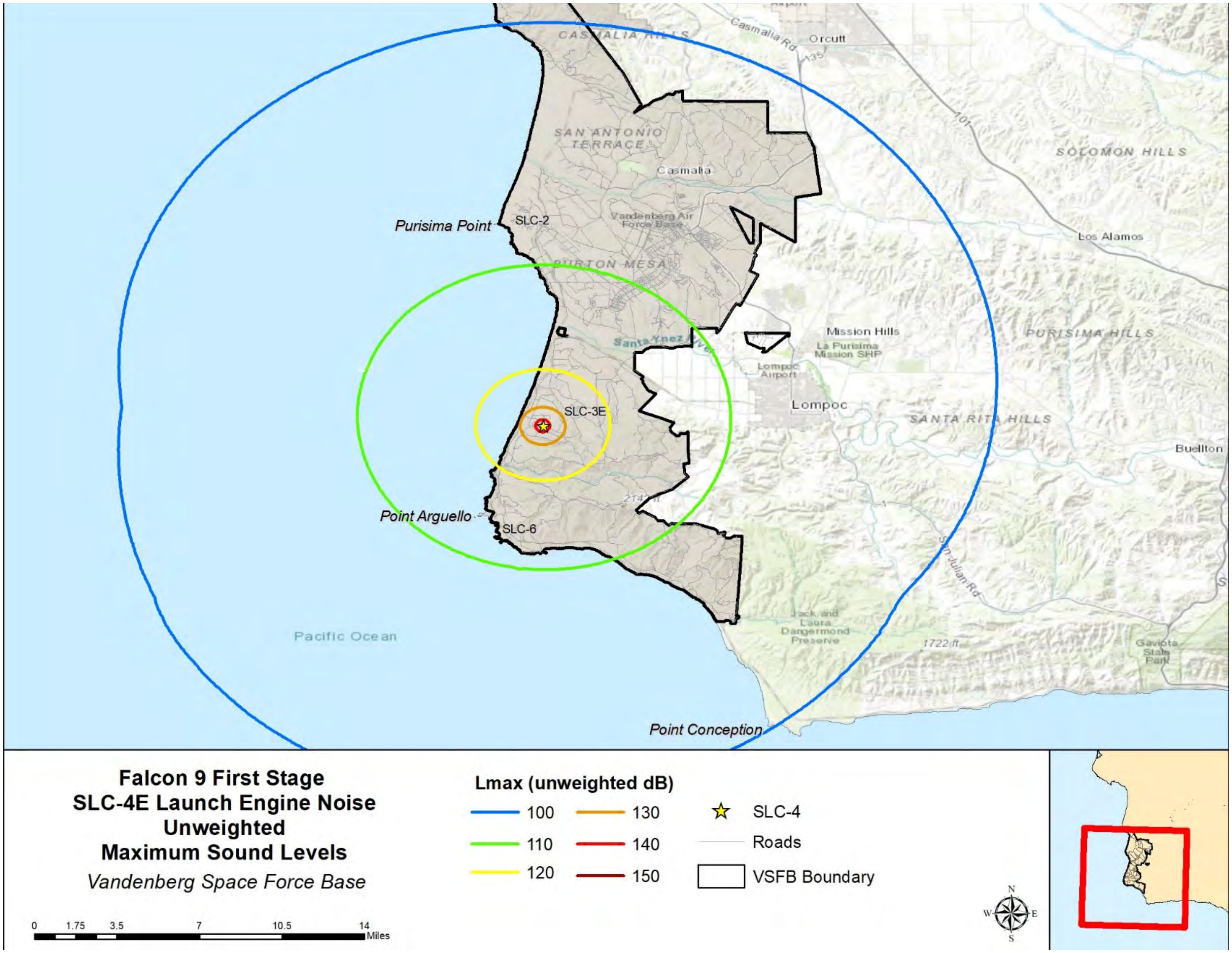

Figure 4-1. Maximum unweighted engine noise during Falcon 9 launch from SLC-4E.

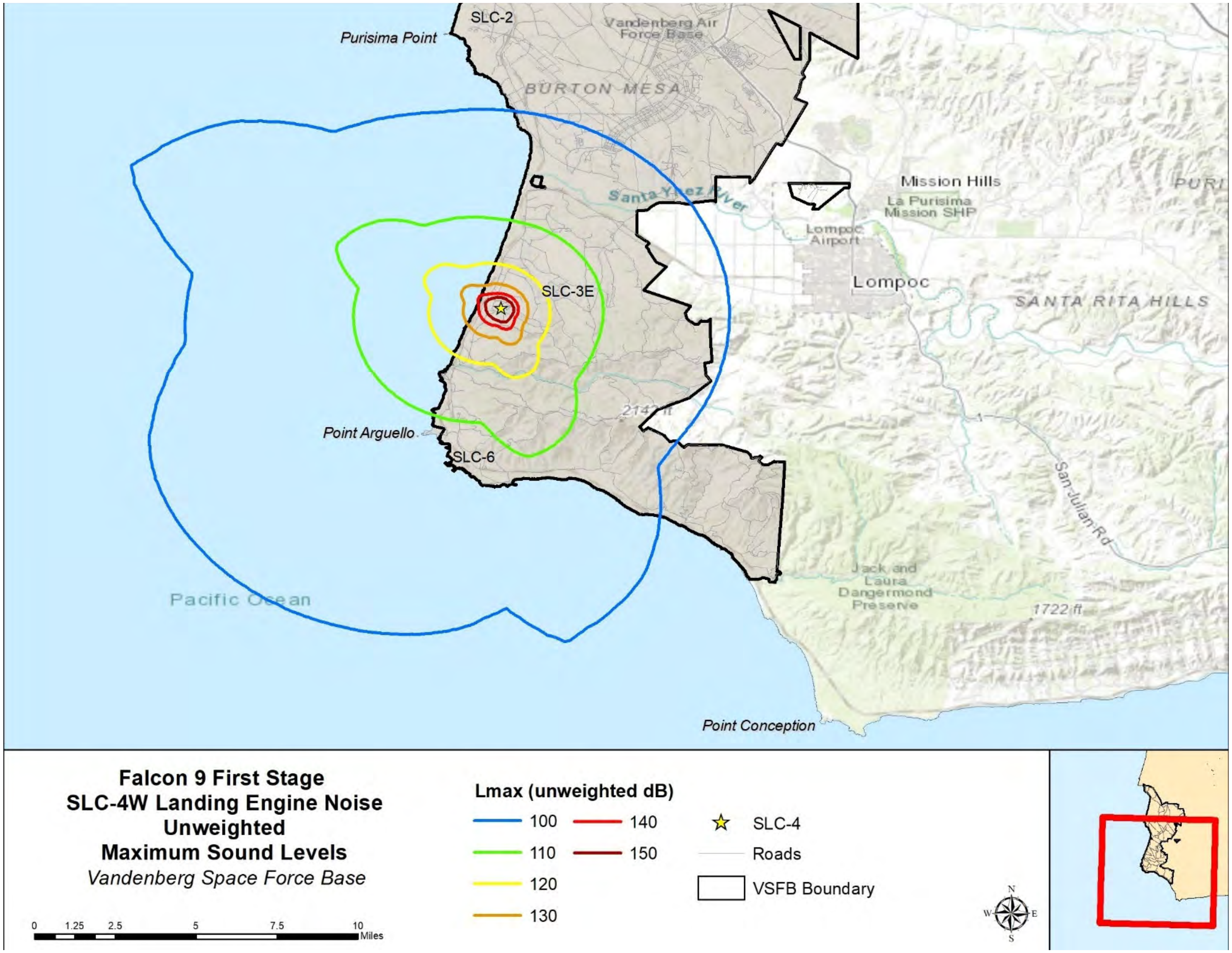

Figure 4-2. Maximum unweighted engine noise during Falcon 9 landing at SLC-4W.

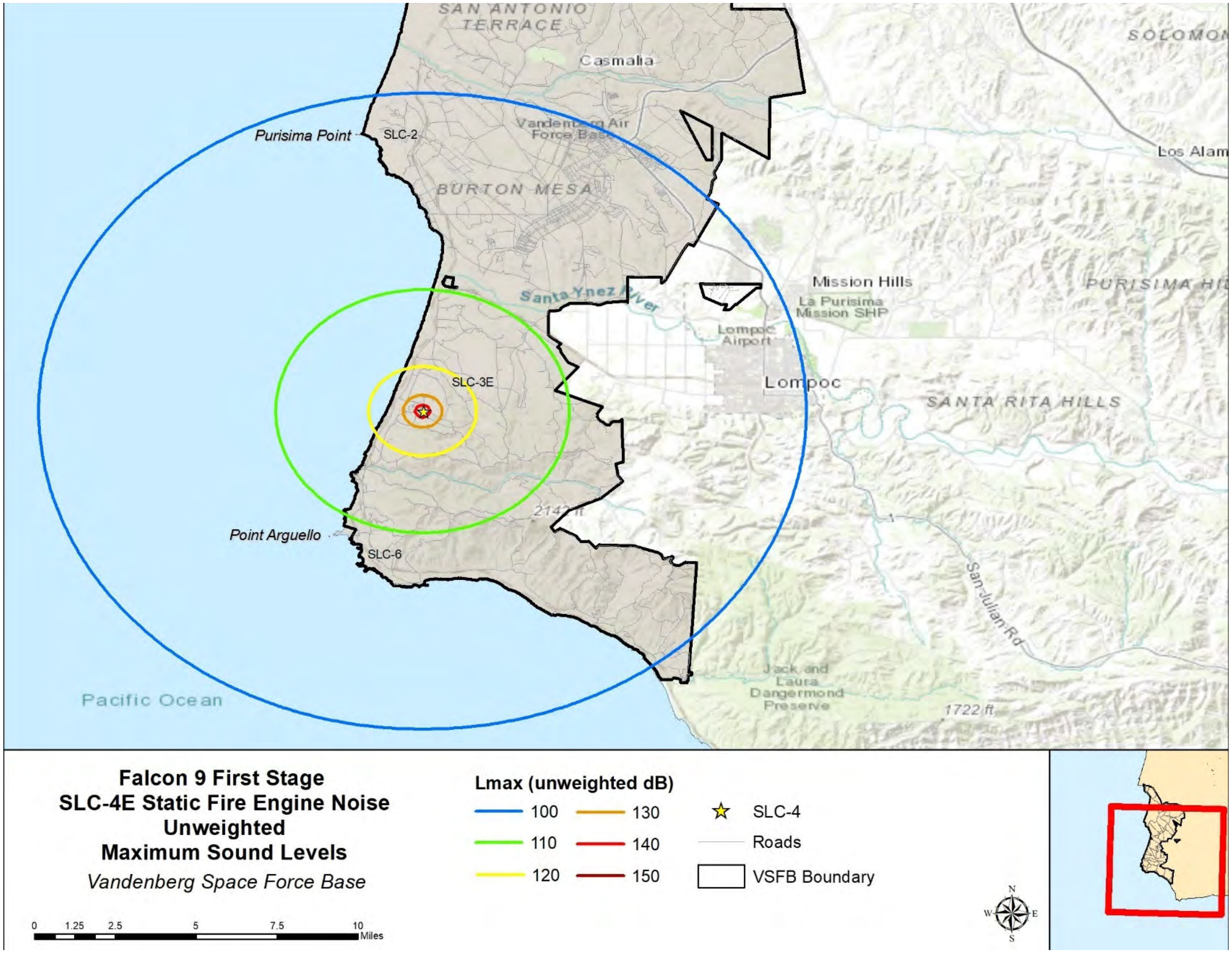

Figure 4-3. Maximum unweighted engine noise during Falcon 9 static fire test at SLC-4E.

4.1.2. Falcon 9 Maximum A-weighted Sound Levels

The results of modeling of the A-weighted maximum sound levels for launch, landing, and static fire events from SLC-4 are presented in Figures 4-4 through 4-6 below. The Department of Defense (DoD) Instruction 6055.12, *Hearing Conservation Program* (DoD 2019), the National Institute for Occupational Safety and Health (NIOSH 1998), and the Occupational Safety and Health Administration (OSHA 2022) provide upper noise level limits to protect human hearing from exposure to noise levels and prevent noise-induced hearing loss. OSHA sets the lowest limit at 115 dBA L_{Amax} with an allowable exposure of 15 minutes (OSHA 2022). The DoD and NIOSH set the allowable exposure at 115 dBA of 28 seconds.

The 115 dBA L_{Amax} contour for Falcon 9 launch event extends approximately 0.6 miles (mi) over land from SLC-4 (Figure 4-4) and is entirely within VSFB. Similarly for first stage landing and static fire events, the 115 dBA L_{Amax} contours extend approximately 0.9 mi and 0.4 mi from SLC-4, respectively (Figures 4-5 and 4-6). For both landing and static fire events, the predicted 115 dBA L_{Amax} contours are also contained entirely within VSFB. The City of Lompoc would receive approximately 80 dBA L_{Amax} during launch, 70 dBA L_{Amax} during landing, and between 70 and 75 dBA L_{Amax} during static fire tests (Figures 4-4 through 4-6).

4.1.3. Falcon 9 Community Noise Equivalent Levels

The A-weighted CNEL contours for Falcon 9 at SLC-4 is presented in Figures 4-4. A CNEL exceeding 65 dBA is generally considered unacceptable for a residential neighborhood and the CNEL 60 dBA contour is used to define the area of potentially significant noise impacts to communities (FAA 2015). The 60 dBA CNEL extends up to approximately 2.7 mi from SLC-4 and is entirely contained within VSFB (Figure 4-7).

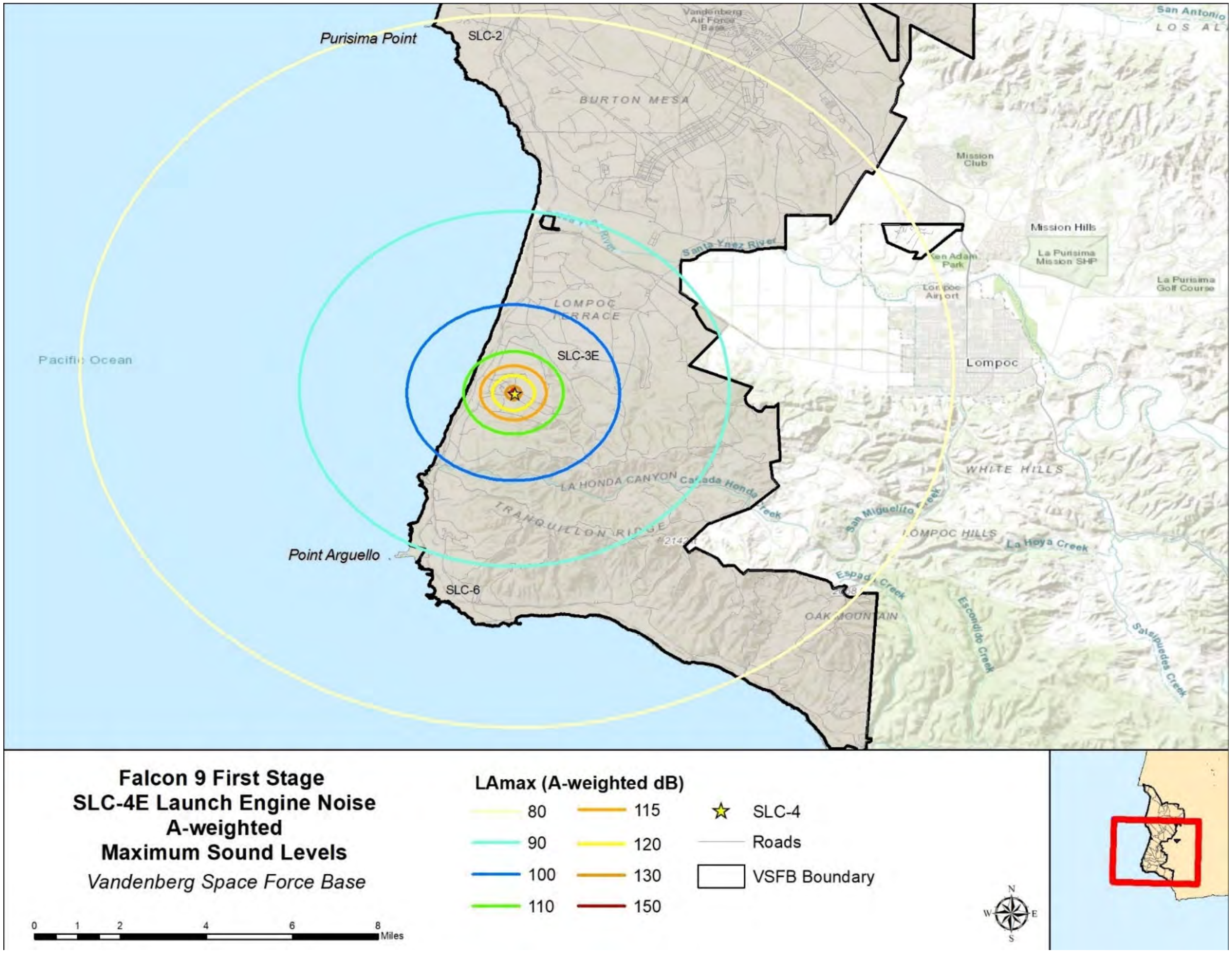

Figure 4-4. Maximum A-weighted engine noise during Falcon 9 launch from SLC-4E.

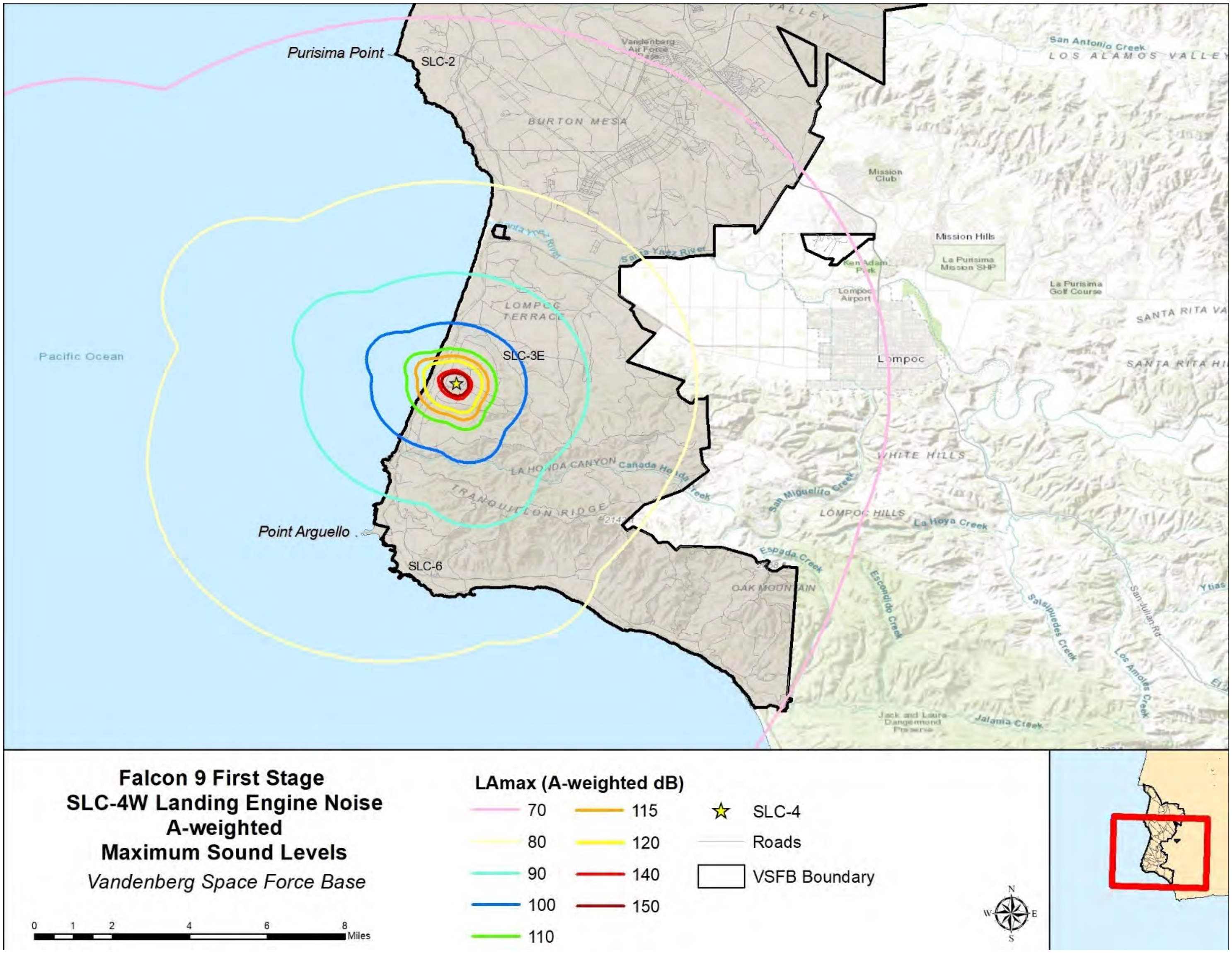

Figure 4-5. Maximum A-weighted engine noise during Falcon 9 landing at SLC-4W.

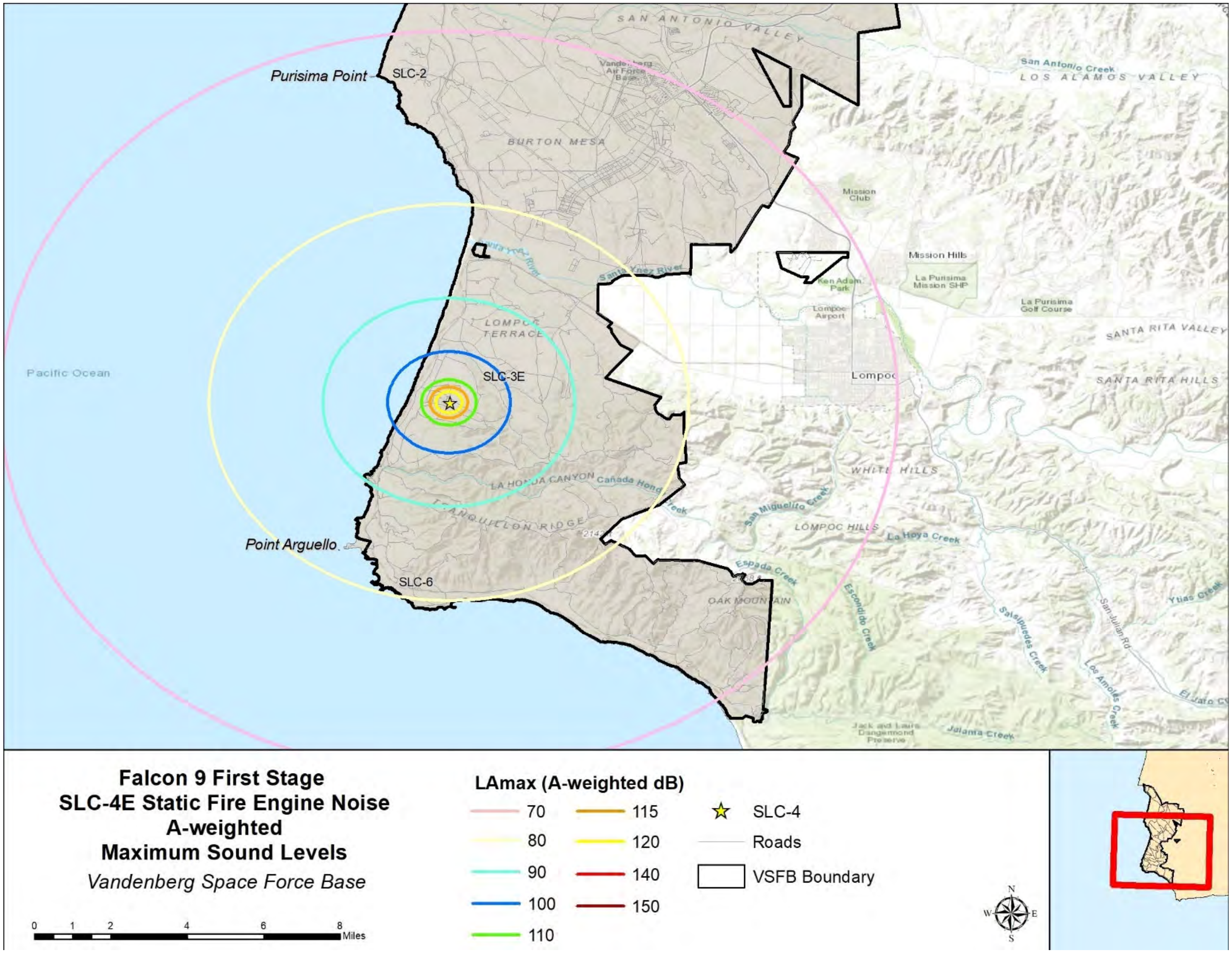

Figure 4-6. Maximum A-weighted engine noise during Falcon 9 static fire test at SLC-4E.

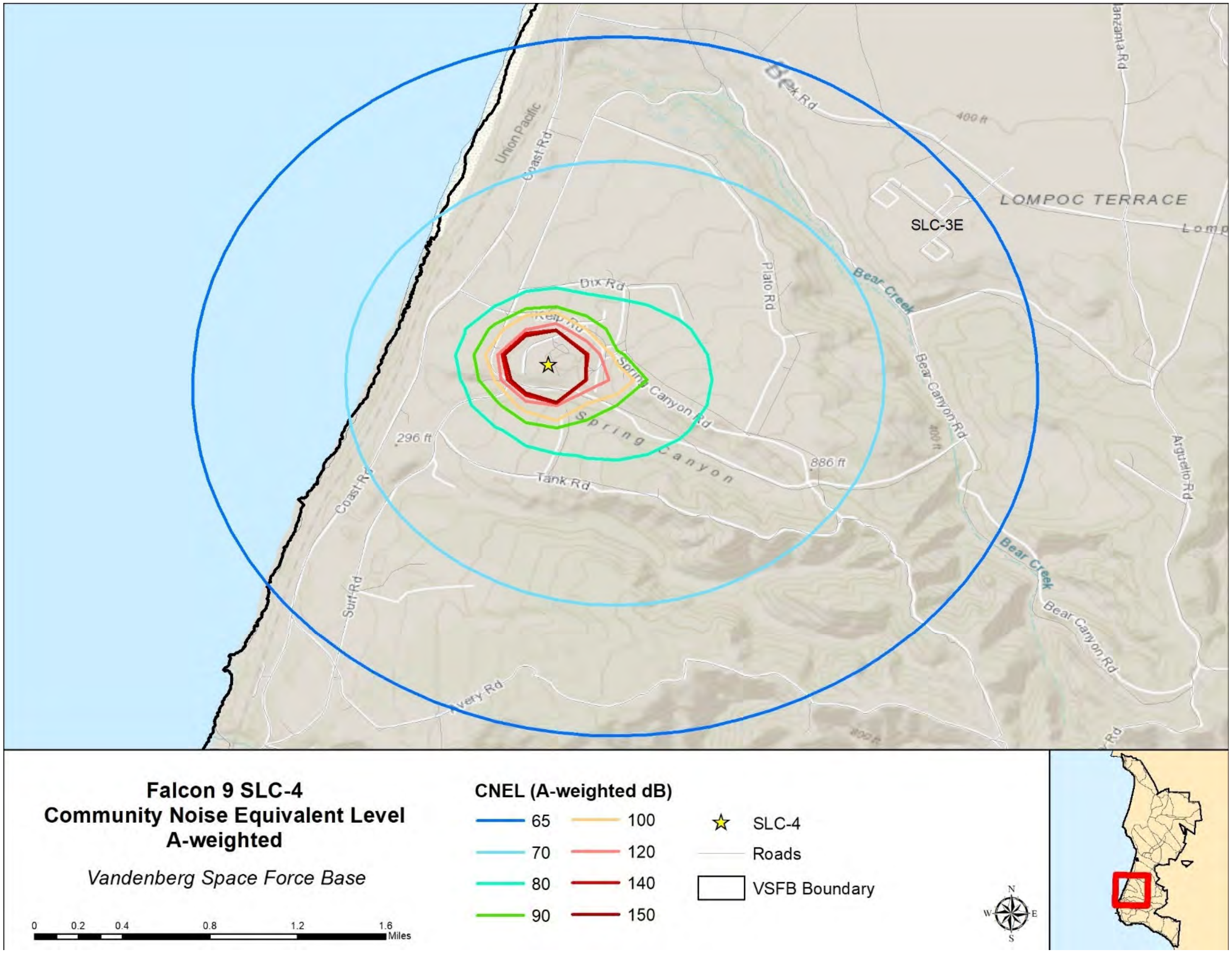

Figure 4-7. Community noise equivalent levels from the proposed Falcon 9 launch and landing operations at SLC-4.

4.2 Sonic Boom Modeling Results

4.2.1. Southerly Launch Trajectories

During ascent, a sonic boom could be generated. Depending on the steepness of the launch trajectory, the sonic boom may or may not impact the surface of the earth. Based on past modeling results, approximately 24 percent (7 out of 29) of Falcon 9 launches from SLC-4E since 2017 have not produced sonic booms that impact the surface of the earth because the ascent of the rocket was too steep. When the sonic booms are predicted to impact the earth's surface, they are primarily predicted to impact the open ocean. Since 2017, only 7 of the 22 Falcon 9 launches from SLC-4E that were predicted to produce sonic booms that impacted the surface of the earth were also predicted to impact the Northern Channel Islands (NCI). Of those that have been predicted to impact the NCI, the sonic boom may range up to 5.0 psf (see example in Figure 4-8). A series of representative sonic boom model outputs from an array of trajectories with potential to impact the NCI are provided in Figures 4-8 through 4-11. In addition, MSRS examined 12 representative launch trajectories with southerly launch azimuths spanning 140 to 188 degrees using a broad sample of meteorological profiles to determine the potential for sonic booms of 2 psf or greater impacting the NCI. Figure 4-12 shows the combined results using the median meteorological profiles for each mission. Launch trajectories with azimuths between 188 and the currently approved northerly azimuth of 301 have would not produce a sonic boom that could impact land during launch were therefore not evaluated. The proposed launch azimuths between 301 and 325 are discussed in Section 4.2.4.

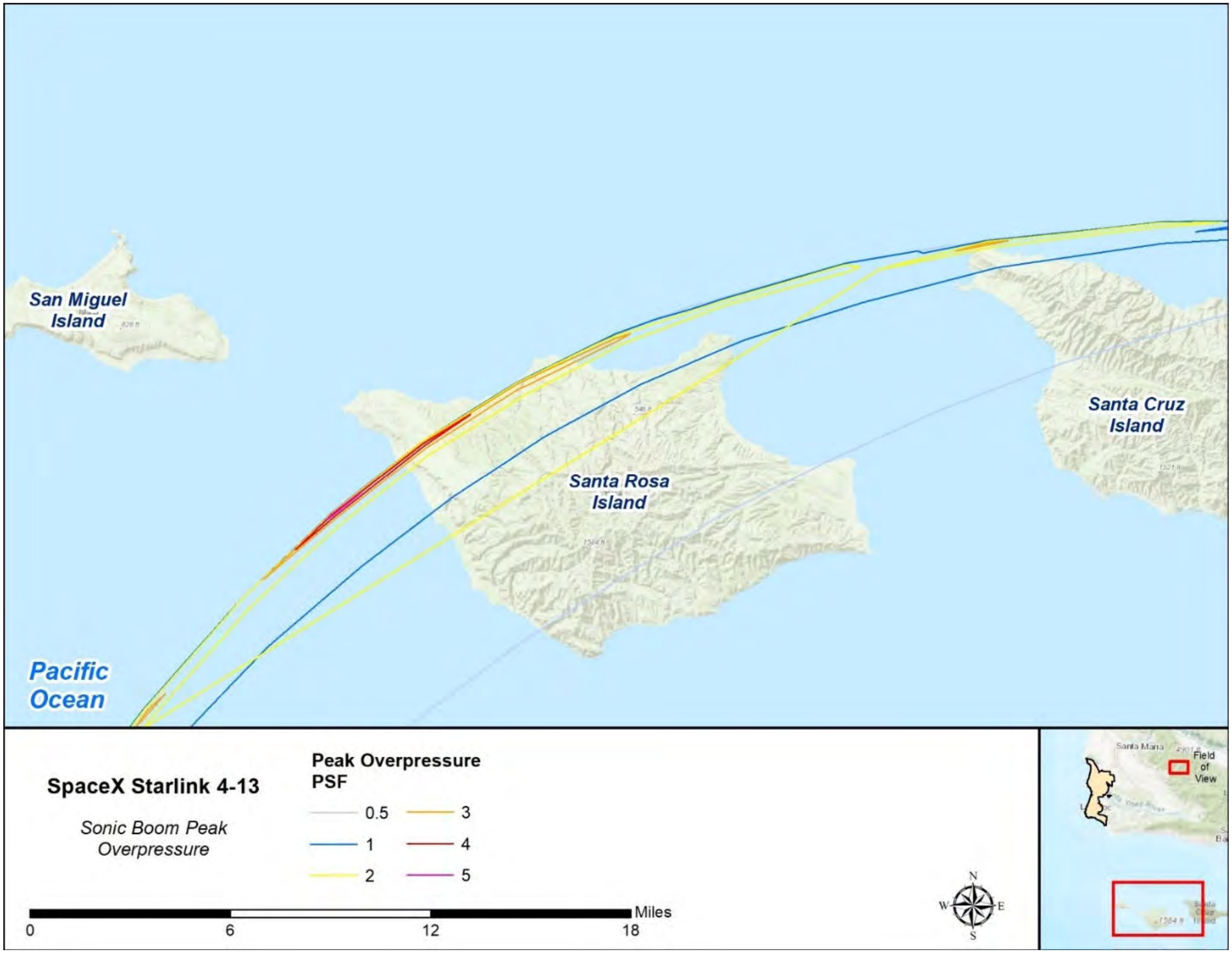

Figure 4-8. Example model output from Starlink 4-13 mission showing potential for up to 5 psf sonic boom impacting the Northern Channel Islands.

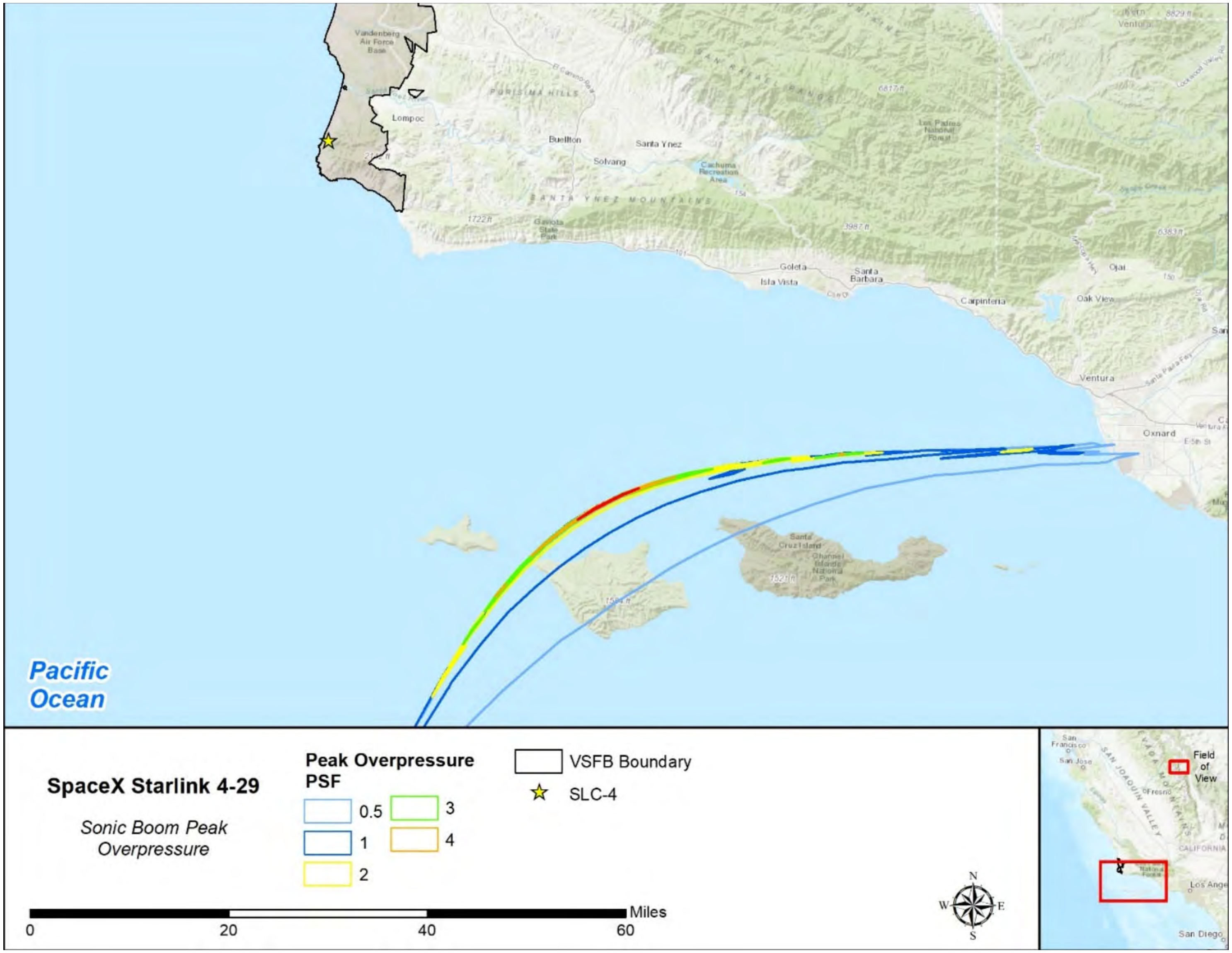

Figure 4-9. Example sonic boom footprint from Starlink 4-29 mission.

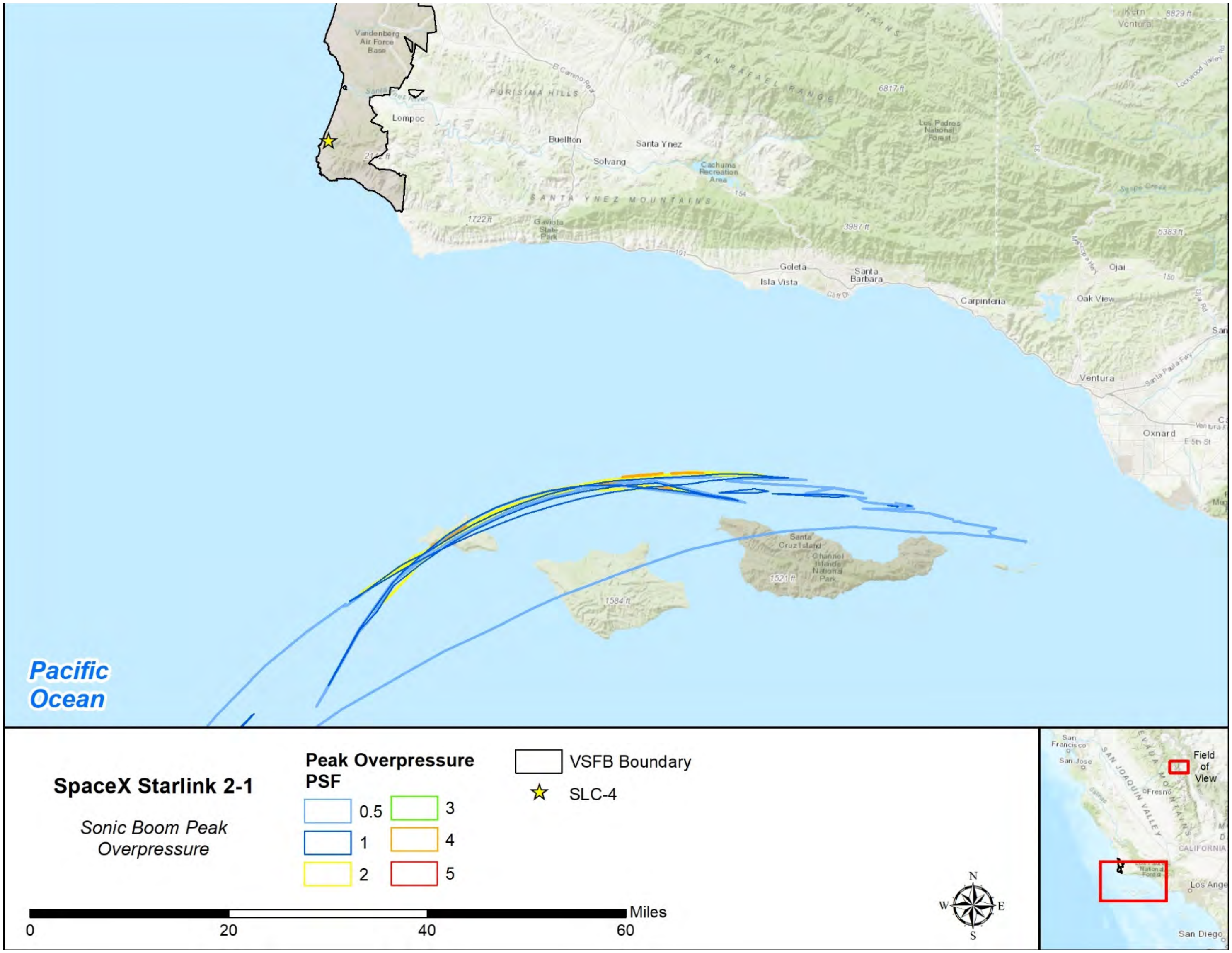

Figure 4-10. Example sonic boom footprint from Starlink 2-1 mission.

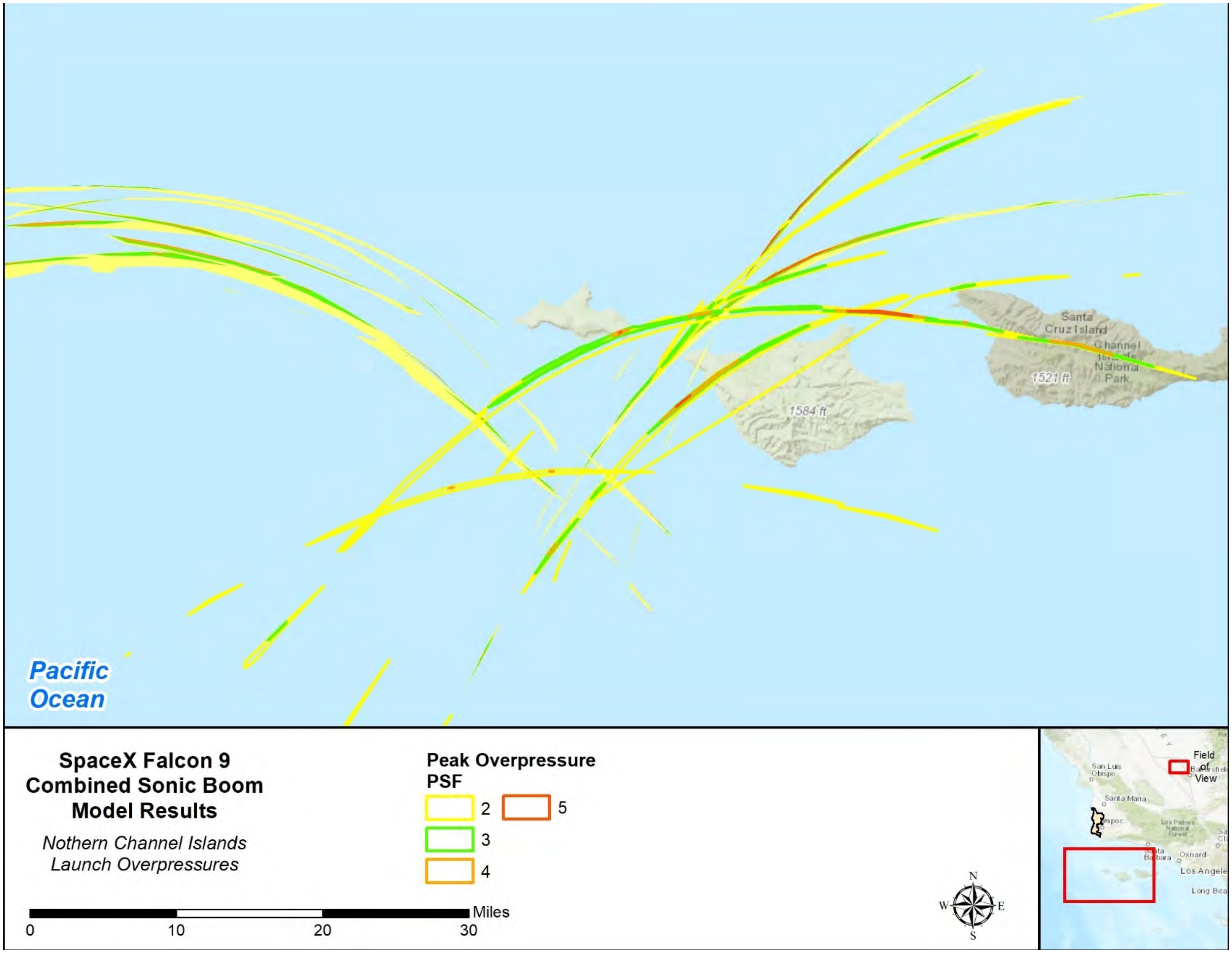

Figure 4-11. Sonic boom model results depicting boom contours greater than 2 psf from 12 representative southerly trajectories.

4.2.2. Southerly Droneship First Stage Landing Trajectories

During descent, the first stage would produce a sonic boom that could be up to 8.5 psf at the immediate landing location. Sonic booms would be directed entirely at the ocean surface without impacting any land for the majority of downrange droneship landings. This is because the eastern boundaries of the Approved Landing Area and the Proposed Landing Area were designed by buffering land forms with the radial distance of typical sonic boom footprints in order to avoid potential noise impacts to mainland Mexico, Isla Guadalupe, and the Southern Channel Islands (Figure 1-2). Figure 4-13 shows a typical sonic boom profile for Falcon 9 first stage landing on a droneship on the eastern edge of the Proposed Landing Areas with a southerly mission profile. Although mission trajectories modeled for this study did not produce the following result, past modeling has predicted that sonic booms up to 3.1 psf may impact the NCI during landing events at SLC-4W or on a droneship located offshore near VSFB (Bradley 2015; James et al. 2017; U.S. Air Force 2018).

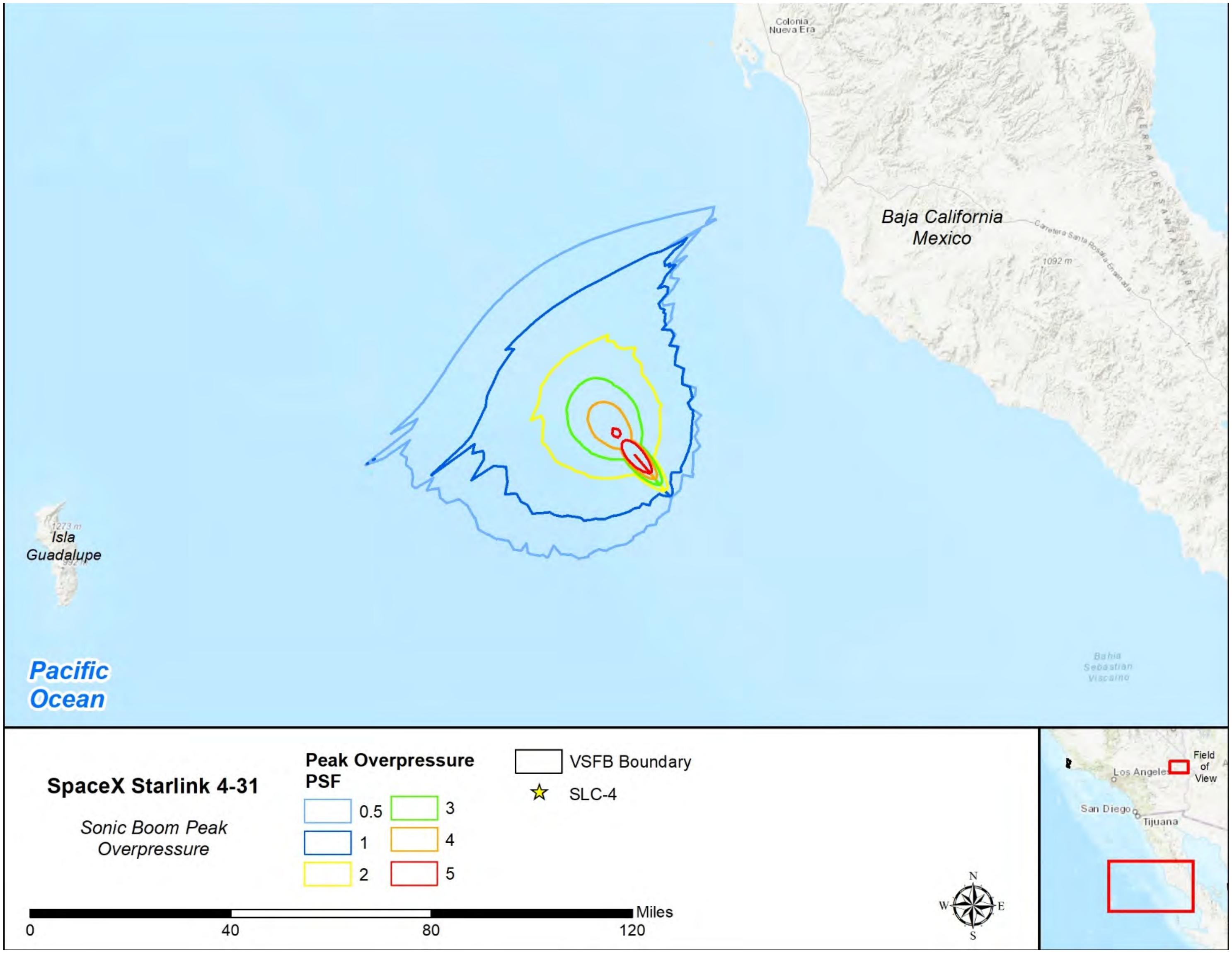

Figure 4-12. Example of a typical sonic boom profile for Falcon 9 First Stage landing on a droneship with a southerly mission profile.

4.2.3. First Stage SLC-4W Landing Trajectories

The Falcon 9 first stage would generate a sonic boom during descent to land at SLC-4W. MSRS performed modeling for 7 representative recent missions. The results predict that the first stage landing at SLC-4W has a maximum sonic boom between 2 and 5 psf. Three representative model results of representative landing trajectories are provided below (Figures 4-14 through 4-16). Sonic booms on south VSFB were typically predicted to range between 1.5 and 5.0 psf. Sonic boom levels in the City of Lompoc should typically range between 0.5 and 1.5 psf during SLC-4W landing events. On occasion, the western portion of Lompoc could experience psf levels as high as 4.0 depending on mission trajectories and atmospheric conditions (see Figures 4-17 and 4-18). Table 4-1 provides the predicted range of sonic boom levels versus measured values at several monitoring locations on VSFB. Since 2020, the measured sonic boom levels have been fairly consistent with the predicted values. This coincides with the release of an improved version of PCBoom software.

Table 4-1. Falcon 9 SLC-4W landing sonic boom PCBoom model versus measured results.

Mission	Date	Monitoring Location	Modeled Value (psf)	Measured Value (psf)
SAOCOM	7 Oct 2018	Oil Well Canyon	2.0	1.78
SAOCOM	7 Oct 2018	Sudden Flats	1.0	0.71
Radarsat	12 Jun 2019	Oil Well Canyon	1.0 – 1.5	2.87
Radarsat	12 Jun 2019	South Surf	1.0 – 1.5	3.63
Radarsat	12 Jun 2019	Purisima	0.5 – 1.0	2.66
Sentinel 6A	21 Nov 2020	Oil Well Canyon	2.0	2.35
Sentinel 6A	21 Nov 2020	Sudden Flats	2.0	1.76
NROL-87	2 Feb 2022	Oil Well Canyon	1.5 – 2.0	1.84
NROL-87	2 Feb 2022	Honda Canyon	2.0 – 3.0	2.42
NROL-85	17 Apr 2022	Oil Well Canyon	1.5 – 2.0	1.29
NROL-85	17 Apr 2022	South Surf	1.5 – 2.0	1.95
SARah-1	18 Jun 2022	Oil Well Canyon	1.5 – 2.0	1.38
SARah-1	18 Jun 2022	South Surf	2.0 – 3.0	2.53
SARah-1	18 Jun 2022	Purisima	1.0 – 1.5	1.12
SWOT	16 Dec 2022	Oil Well Canyon	3.0	2.54
SWOT	16 Dec 2022	Sudden Flats	3.0	3.4
SWOT	16 Dec 2022	Honda Canyon	4.0 - 5.0	4.7

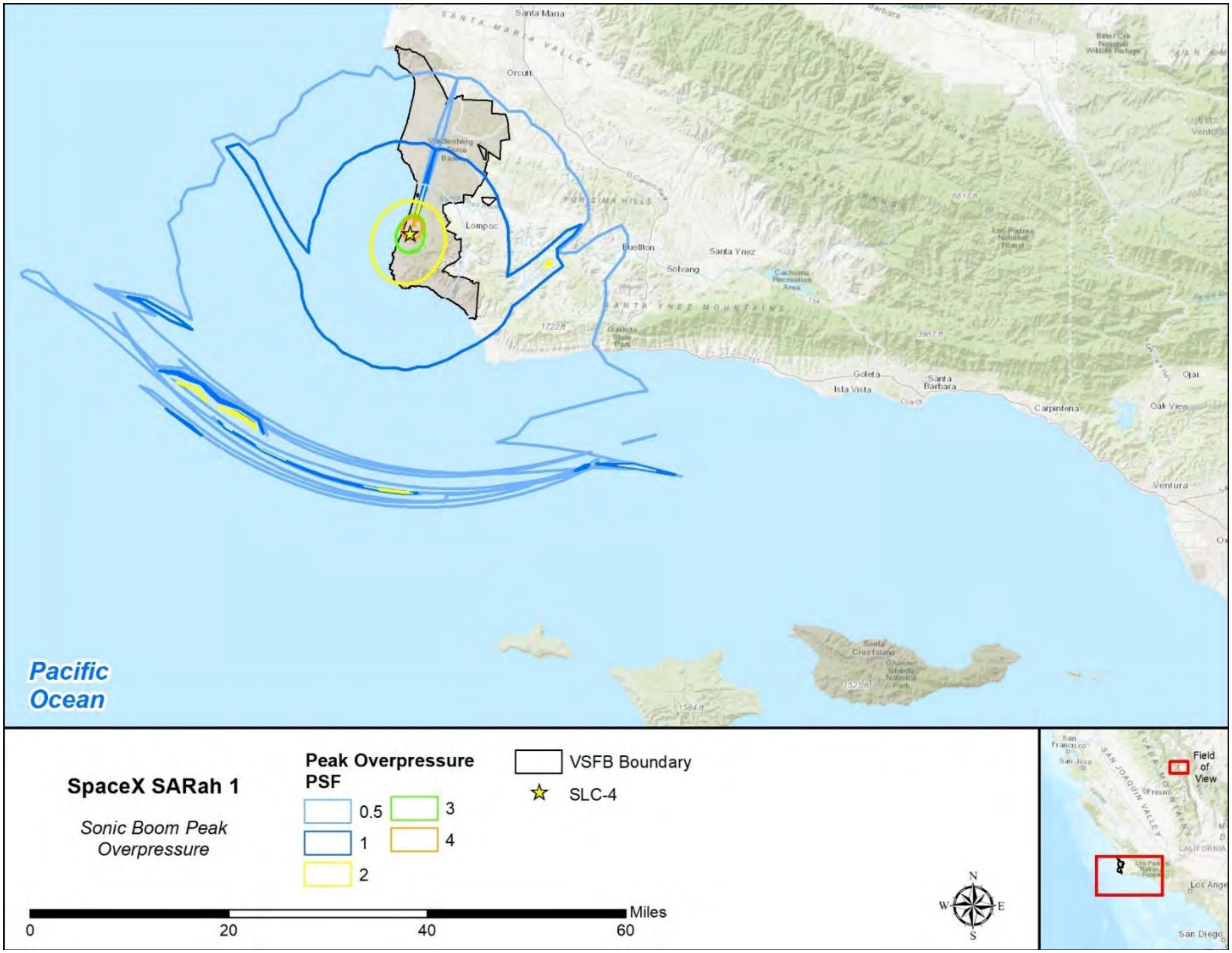

Figure 4-13. Example of a typical sonic boom profile for Falcon 9 first stage landing at SLC-4W (SARah-1 mission).

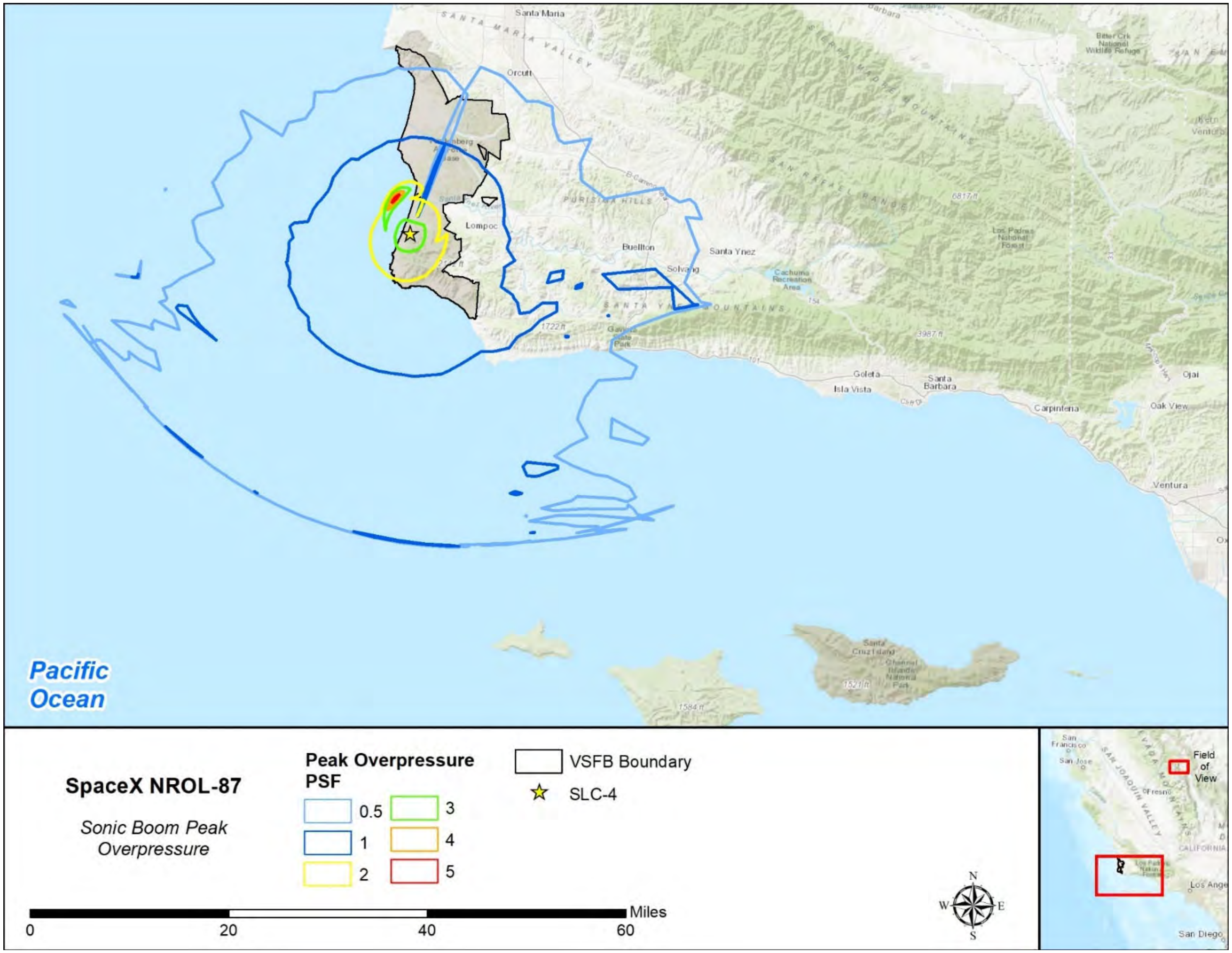

Figure 4-14. Example of a typical sonic boom profile for Falcon 9 first stage landing at SLC-4W (NROL-87 mission).

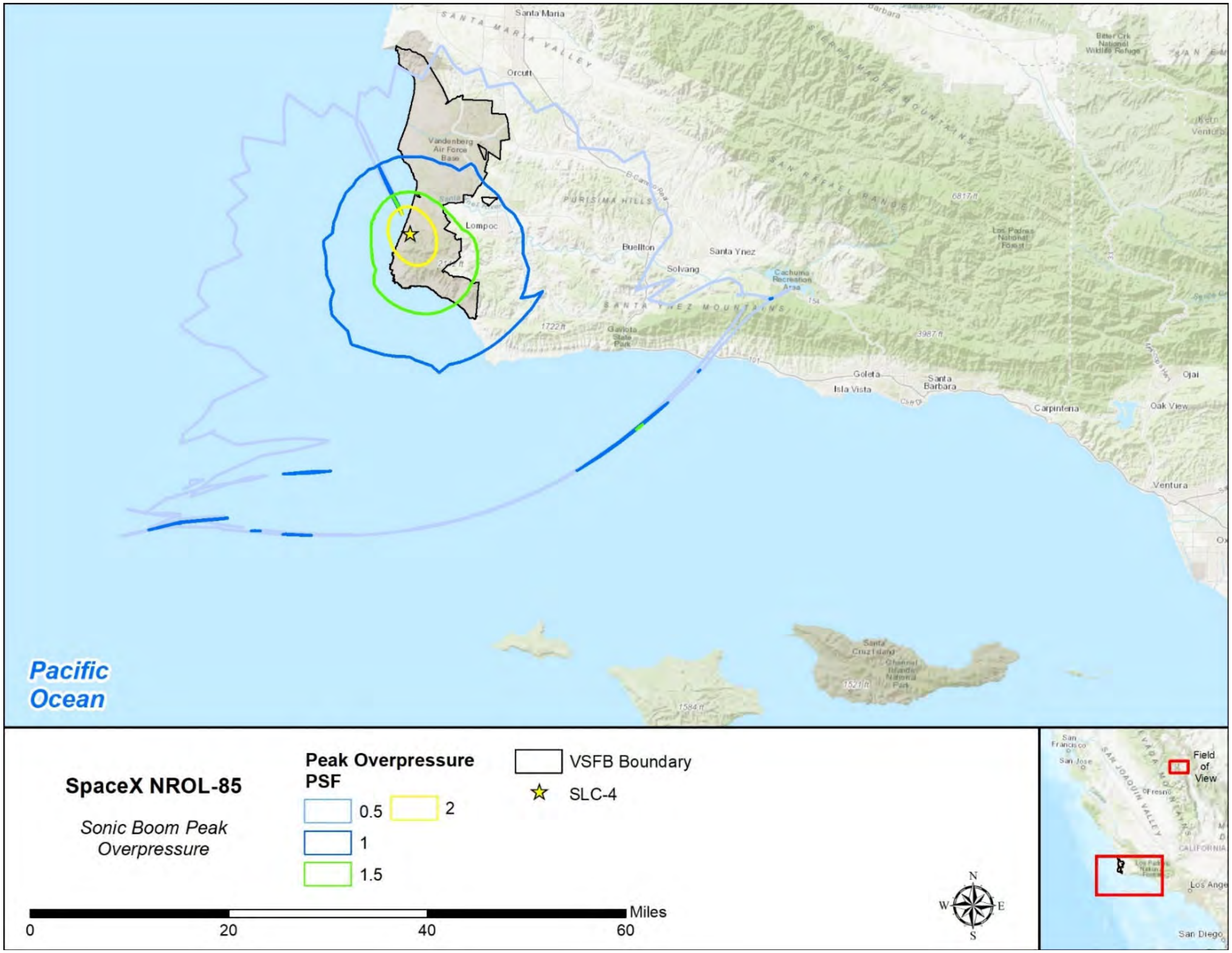

Figure 4-15. Example of a typical sonic boom profile for Falcon 9 first stage landing at SLC-4W (NROL-85 mission).

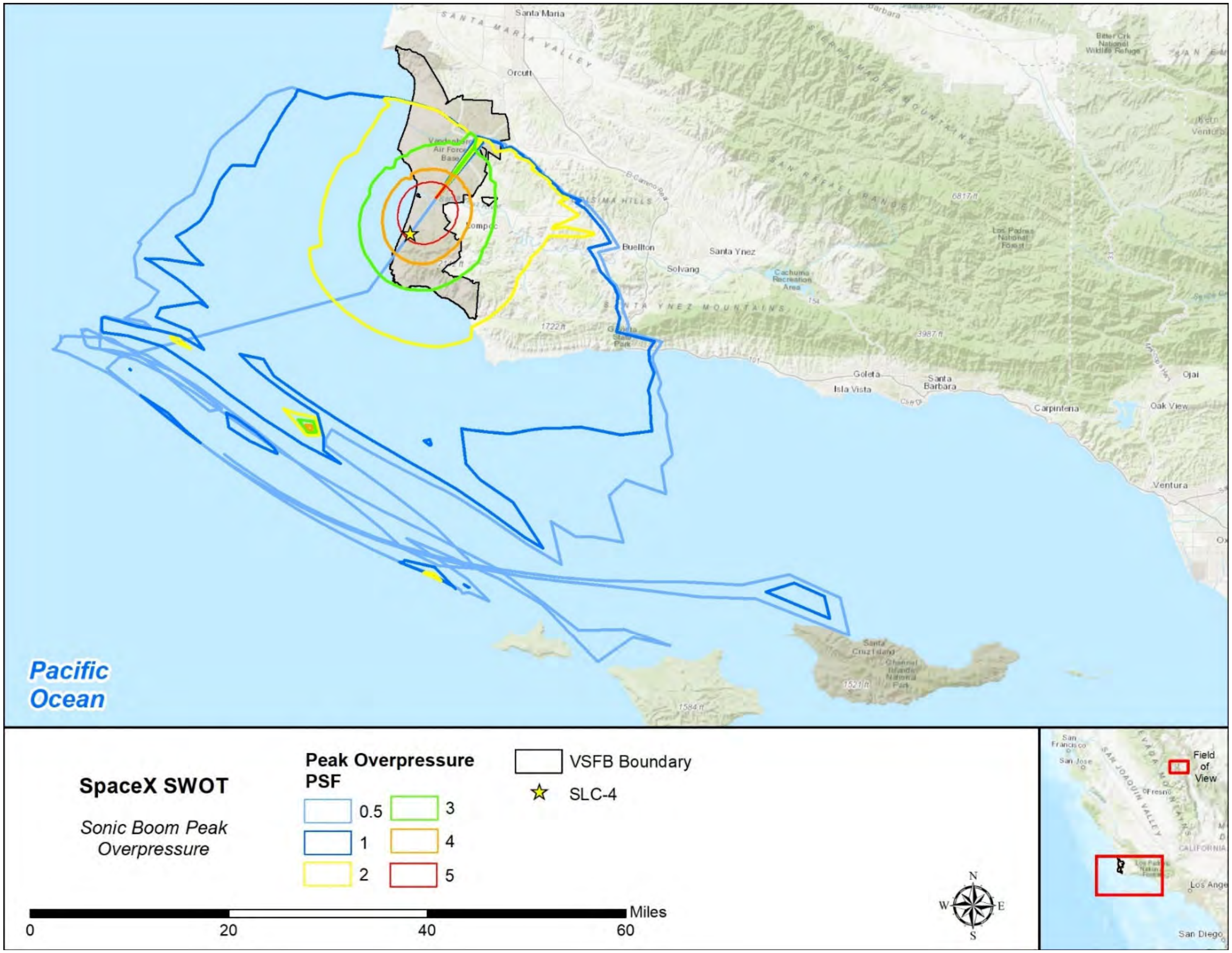

Figure 4-16. Falcon 9 first stage SLC-4W landing sonic boom results for the SWOT mission with uncharacteristically higher levels over Lompoc.

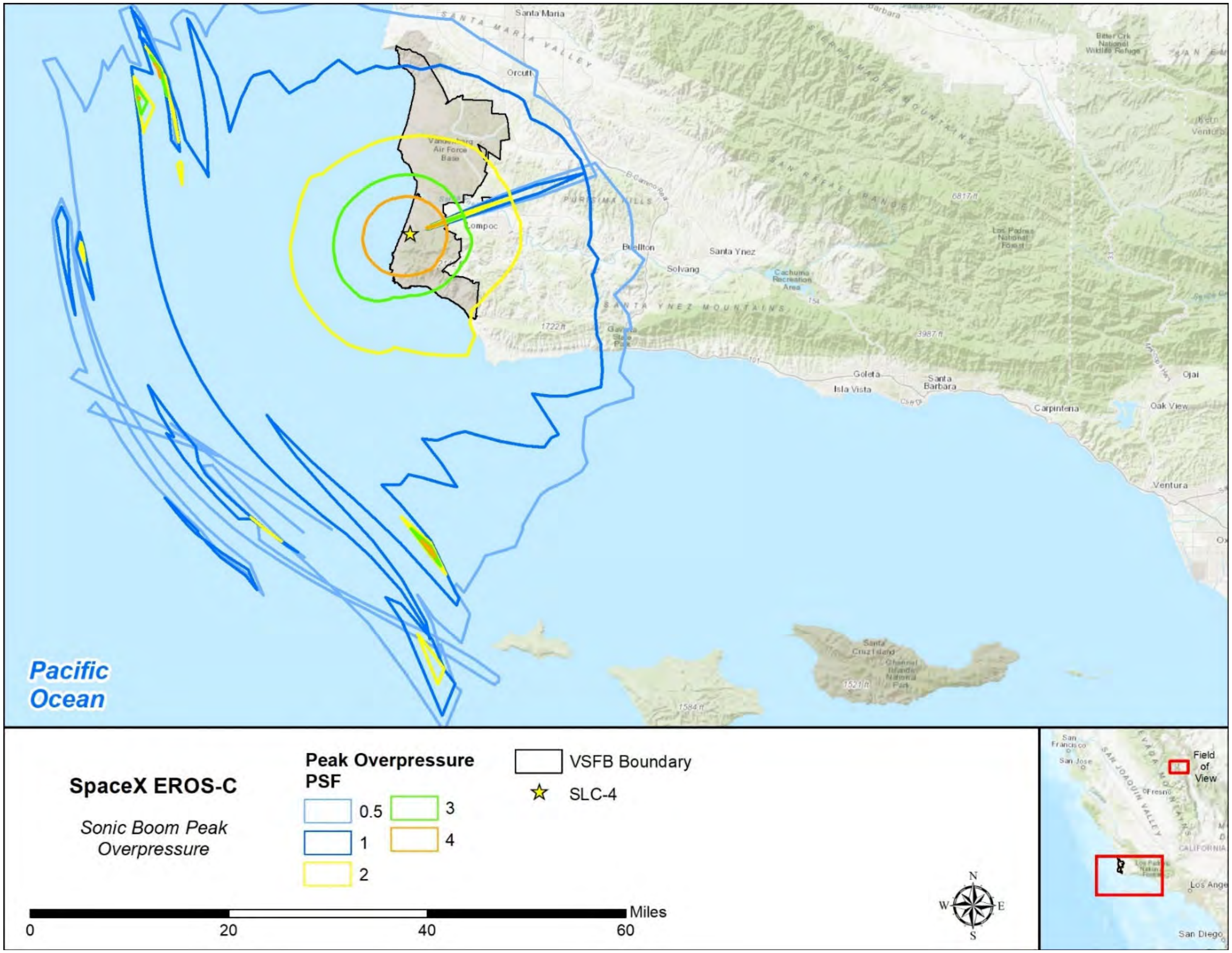

Figure 4-17. Falcon 9 first stage SLC-4W landing sonic boom results for the EROS-c mission with uncharacteristically higher levels over Lompoc.

4.2.4. Proposed Northerly Trajectories

As noted in Section 2.2, SpaceX proposes to add a northerly mission profile with launch azimuths between 301 and 325 degrees (Figure 1-2). MSRS performed modeling of a typical trajectory over numerous meteorological profiles for the most northerly proposed launch azimuth (325 degrees). The model results showed that the launch would not produce a sonic boom that would impact the surface of the earth. A sonic boom up to 5 psf is predicted to impact at the droneship landing location, but the sonic boom footprint would be entirely over open ocean and not impact land (Figure 4-19).

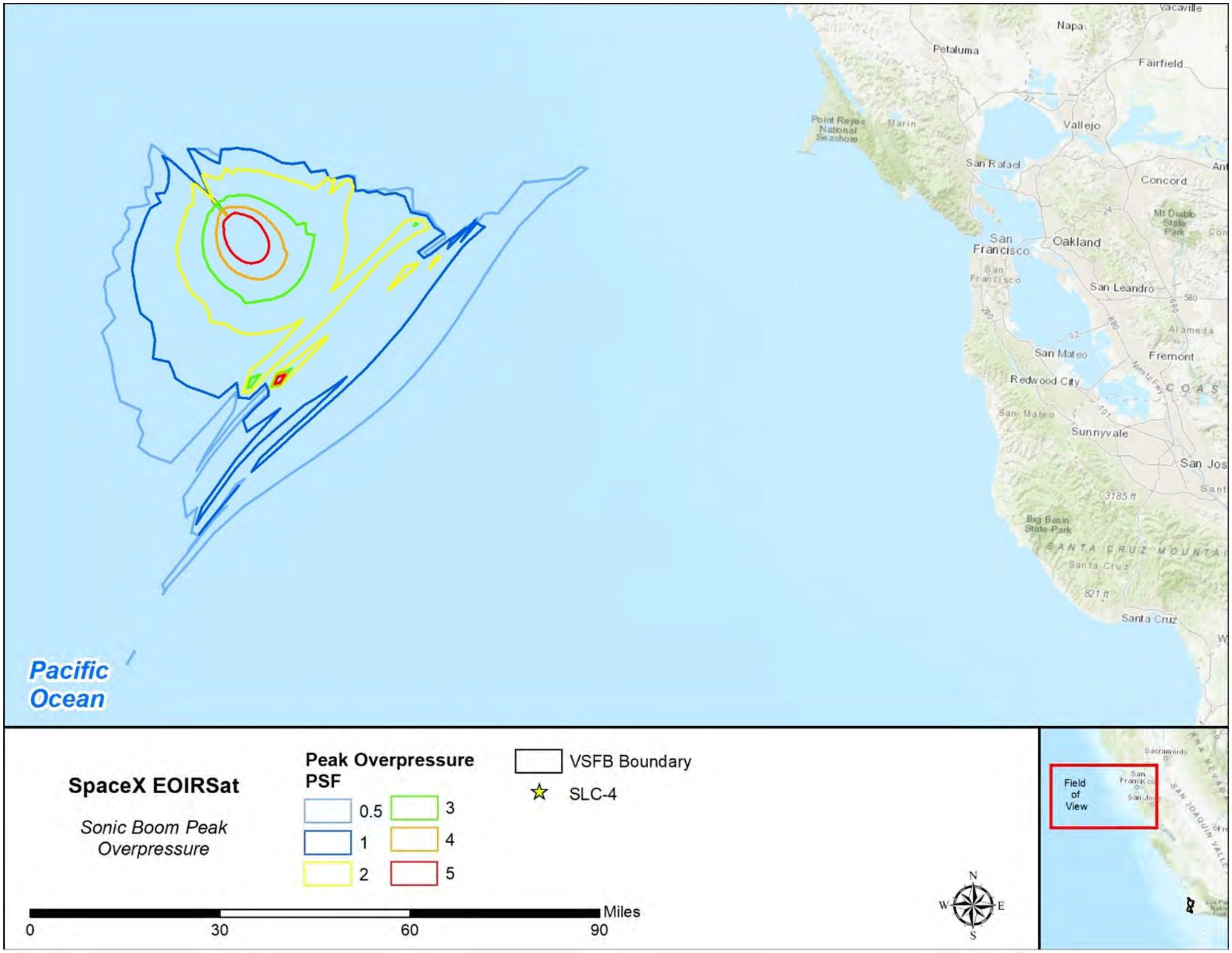

Figure 4-18. Example of a typical sonic boom profile for Falcon 9 First Stage landing on a droneship in the Proposed Landing Areas with a northerly mission profile.

5.0 Conclusions

The 115 dB L_{Amax} and 60 dBA CNEL noise contours produced by the Falcon 9 during launch, landing, and static fire operations at SLC-4 are entirely contained within VSFB boundaries. Based on analysis of an array of southerly trajectories, parts of the NCI would occasionally receive sonic booms of 2 psf or greater. Sonic booms created during first stage landing at SLC-4W would impact a variable area of land depending on mission profiles, occasionally ranging into areas adjacent to VSFB, with sonic booms at or above 2 psf. The 120 dB L_{max} noise contours for launch, landing, and static fire are entirely encompassed by VSFB.

The FAA uses the 120 dB L_{max} noise contour for engine noise and an overpressure contour of 2 psf or greater to define areas that may experience structural damage as a result of space launch vehicle noise (Fenton and Methold 2016; Guest and Slone 1972; Haber et al. 1989). SpaceX and the USSF have evaluated these results and are currently using them to assess the potential for any structural damage to historic properties on the NCI and the VSFB region under a separate effort.

6.0 List of Preparers

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7.0 References

Bradley, K.A., 2015. Sonic Boom Assessment of Falcon 9 (Longer, Full Thrust Vehicle) Landing at Vandenberg AFB. Wyle Technical Note TN 15-29. Prepared for Space Exploration Technologies. October 2015. 11 pp.

Bradley, K.A, C. Wilmer, V. San Miguel, M.M. James, A.R. Salton, and M.F. Calton. 2018. User guides for noise modeling of commercial space operations – RUMBLE and PCBoom. Airport Cooperative Research Program Research Report 183. Produced by Wyle Laboratories, Inc., Arlington, VA and Blue Ridge Research and Consulting, LLC, Asheville, NC. Available at: https://www.trb.org/Publications/Blurbs/177510.aspx.

Department of Defense (DoD). 2019. DoD Instruction 6055.12: Hearing Conservation Program. Office of the Under Secretary of Defense for Personnel and Readiness. 14 August 2019. 28 pp.

Federal Aviation Administration (FAA). 2015 Environmental Impacts: Policies and Procedures, Order 1050.1F. U.S. Department of Transportation. 16 July 2015. 132 pp.

Fenton, R., and R. Methold. 2016. Mod Shoeburyness and Pendine noise and vibration study criteria for the assessment of potential building damage effects from range activities. Southdowns Environmental Consultants, Lewes, East Sussex, UK. June 2016. 55 pp.

Guest, S., and R. M. Slone, Jr. 1972. Structural Damage Claims Resulting from Acoustic Environments Developed During Static Firing of Rocket Engines. Paper presented at the NASA Space Shuttle Technology Conference.

Haber, Jerry, David Nakaki, Craig Taylor, George Knipprath, Vijay Kopparam, and Mark Legg. 1989. Effects of Aircraft Noise and Sonic Booms on Structures: An Assessment of the Current State-of-Knowledge. BBN Systems and Technologies Corp., Canoga Park, Ca.

James, M., A. Salton, and M. Downing. 2017. Sonic Boom Study for SpaceX Falcon 9 Flybacks to CCAFS and VAFB. Blue Ridge Research and Consulting, LLC, Report Number: BRRC 17-05. Prepared for Space Exploration Technologies. March 2017. 11 pp.

Occupational Safety and Health Administration (OSHA). 2022. Occupational noise exposure. Federal Regulation Title 29 - Labor, Subtitle B, Chapter XVII, Part 1910 - Occupational Safety and Health Standards, Subpart G - Occupational Health and Environmental Control, 1910.95. Retrieved from https://www.ecfr.gov/current/title-29/subtitle-B/chapter-XVII/part-1910/subpart-G/section-1910.95, January 2022.

National Institute for Occupational Safety and Health (NIOSH). 1998. Criteria for a recommended standard, occupational exposure to noise, revised criteria 1998. NIOSH Publication No. 98-126. June 1998. 126 pp.

National Marine Fisheries Service. 2019. Letter of Authorization, issued to the U.S. Air Force, 30th Space Wing. Valid 10 April 2019 to 9 April 2024. Dated 10 April 2019. 8 pp.

National Oceanic and Atmospheric Administration. 2022. ESRL Radiosonde Database. Retrieved from https://ruc.noaa.gov/raobs/General_Information.html, January 2022.

U.S. Air Force. 2018. Final Supplemental Environmental Assessment for Launch, Boost-Back, and Landing of the Falcon 9 at Vandenberg Air Force Base, California and Offshore Landing Contingency Options. 24 January 2018.

Appendix C Native American Correspondence

DEPARTMENT OF THE AIR FORCE
UNITED STATES SPACE FORCE
SPACE LAUNCH DELTA 30

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Dear Ms. Zavalla

SpaceX proposes to increase launch cadence of their Falcon 9 vehicle at Vandenberg Space Force Base (VSFB) Space Launch Complex (SLC)-4 to expand its Starlink network and fill in coverage gaps and provide internet connectivity over the poles. SLC-4 is in the South Base portion of VSFB in Santa Barbara County. The proposed *SpaceX Increased Launch Cadence Project* is limited to increased launch activity from SLC-4 East pad and does not include any new construction, demolition, or physical alterations. The activity would increase the number of launches from 12 to 36, continue first-stage booster return landings at the existing landing pad at SLC-4 West, and include a new northerly trajectory over open ocean. This study considers noise vibrations and their potential effect on cultural resources on VSFB, Lompoc vicinity, and portions of Santa Rosa Island, Santa Cruz Island, and San Miguel Island.

VSFB determined the Project is an undertaking subject to compliance with Section 106 of the National Historic Preservation Act of 1966, as amended, and will comply with Section 106 using the implementing regulations [36 CFR Part 800]. VSFB has carried out a reasonable and good-faith cultural resources investigation that fulfills federal agency responsibilities pursuant to 36 CFR 800.4(a)-(d) and 36 CFR 800.5(a)-(d). With this letter and the accompanying report, VSFB is initiating consultation with the Tribe.

SpaceX contracted Dudek, Inc. to prepare an analysis specifically addressing potential impacts on cultural resources from rocket engine noise and sonic boom vibrations associated with static tests, launches and boost-back landings at SLC-4. A threshold of 120 decibels (dB) has been established, above which historic properties could be susceptible to damage. A noise analysis was performed to delineate an area where noise levels are expected to exceed 120 dB. Sonic booms associated with launches were also considered and are measured as pressure in pounds per square foot (psf). The threshold for potential damage resulting from sonic booms (atmospheric overpressure) is established at two psf or greater. The 120dB and greater and 2psf and greater noise vibration study area was delineated as the Area of Direct Impact (ADI).

Given the large number of recorded archaeological sites and buildings within the ADI, it was necessary to assess whether any would be susceptible to the effects of rocket engine noise and included in the Area of Potential Effect (APE). At VSFB, intact midden samples and compact sand cones have shown no visible effect after being exposed to short-duration launch noise of 150dB, and short-duration sonic boom from boost-back exceeding 5psf. Furthermore, monitoring of a sheer cliff-face midden deposit at CA-SBA-530 on South VSFB between SLC-4 and SLC-6 has indicated that while natural erosion from rain, wind, and pounding waves has a significant impact on sheer-cliff deposits, noise vibrations from launch and boost-back events has had no visible effect.

Therefore, VSFB cultural resources staff established that archaeological sites that consist of only surface artifacts and/or buried archaeological material would not be affected by rocket engine noise because soils would protect materials in place. Thus, those resources were excluded from the APE. Furthermore, all but one of the National Registerof Historic Places (NRHP)-eligible buildings located within the noise/sonic boom ADI on VSFB are associated with launch complexes and supporting infrastructure and therefore built to withstand concussive forces. They, too, were excluded from the APE. The only NRHP-eligible building situated within the VSFB portion of the noise/sonic boom ADI that is not associated with launch complexes or supporting infrastructure is the former U.S. Coast Guard Lifeboat Rescue Station (P-42-040495). Constructed in 1936 in the Colonial Revival style of architecture, the wood-frame Administrative Barracks and ancillary structures remaining in the complex have been subjected to decades of medium and heavy launches from SLC-4 and nearby SLC-6 with no effect. There has also been no effect from boost-back landings at SLC-4.

Four prehistoric archaeological sites with rock art were identified within the ADI of the noise vibration study. These include CA-SBA-550 (Honda Ridge Rock Art Site), -3686, -3687, and -3688. A condition assessment program has occurred continuously at these rock art sites since 2000. The program has found no evidence of effects to the rock art surfaces from heavy- and medium-payload rocket launches which have occurred from nearby SLC-3, SLC-4, and SLC-6 since the early 2000s. These sites have not been affected by noise vibrations created by SpaceX Falcon 9 launches and boost-backs in the past. Therefore, it is unlikely that these sites would be adversely affected by an increased launch cadence of the same Falcon 9 rocket. As a result, all rock art sites, rock shelters, rock cairns, and similar archaeological sites were excluded from the APE.

A total of 123 archaeological sites on VSFB have been identified in the noise study ADI as eligible for the NRHP. All 123 sites are archaeological deposits which are limited to artifacts laying on the surface or at depth, protected by soil. None of these sites has been affected by past SpaceX launches, nor has the potential to be affected by noise vibrations created by increased SpaceX launches and boost-back. As such, they were excluded from the APE. No other NRHP-eligible/listed archaeological sites identified within the Project ADI contain rock art or other features that could be damaged by rocket engine noise.

The sonic boom arc encompasses all of Santa Cruz Island, Santa Rosa Island, and San Miguel Island. Sonic boom overpressure may reach as much as 5psf over a thin sliver of land on the NCI, but the vast majority of the sonic boom arc over each of the islands is at 2–3psf. The San Miguel, Santa Rosa, and Santa Cruz Islands Archaeological Districts encompass the entirety of their respective islands, and the Districts are NRHP-listed. All contributing resources within the Districts are assumed eligible for the NRHP for the purposes of this Project. Historic properties on the NCI include historic ranches and archaeological deposits, and prehistoric Native American archaeological sites. Historic buildings include wood-frame, masonry, and adobe construction. The prehistoric sites consist of Native American shell middens, burials, habitation sites, and lithic scatters. None of these historic properties have been reported to be affected by noise vibrations created by SpaceX launches from SLC-4 since the first Falcon 9 launch in 2013, or any other medium or heavy-lift launches from SLC-4 or SLC-6 in decades passed.

A recent sand cone and midden chunk test by Smallwood showed that a 45-degree sloped sand cone and a chunk of midden soil was not affected by short-duration launch noise of 150dB, nor short-duration sonic boom from boost-back reaching 5psf. Furthermore, monitoring of the Honda Ridge Rock Art Site and the Historic U.S. Coast Guard Lifeboat Rescue Station Administration Barracks on VSFB have shown that rock art and wood-frame buildings in good condition are not affected by short-duration launch noise and sonic booms from medium and heavy-lift rockets launched from nearby SLC-4 and SLC-6. Therefore, it is highly unlikely that any of the historic properties in the Lompoc vicinity or the NCI has the potential to be affected. None of these resources has the potential to be affected by an increased cadence of launches and boost-back at SLC-4, therefore, none of these resources are included in the APE.

No other known historic properties exist within the Project ADI which could be affected by vibrations from increased launch and boost-back at SLC-4. Details of the investigation are provided in the attachment. Details of the investigation are provided in the attachment; however, briefly stated, VSFB has determined the following:

a. The APE for the SpaceX Increased Launch Cadence Project is adequately delineated; and

b. The undertaking will have *no effect* on any known historic properties.

In summary, VSFB has reached a Section 106 finding of *no historic properties affected* for this undertaking. The Base recognizes that the Santa Ynez Band of Chumash Indians may have concerns beyond the purview of the National Historic Preservation Act. Therefore, I am seeking any additional comments or concerns you may have about cultural resources. I would appreciate receiving any feedback as part of this consultation within the next 30 calendar days. Please feel free to let me know if you require additional time. I can be reached at (760) 419-0092 or via email at stacy.smallwood.1@spaceforce.mil. Thank you for your assistance with this undertaking.

Sincerely

JOSH SMALLWOOD, M.A., RPA
Base Archaeologist
Asset Management Flight

Attachment:
Identification of Historic Properties and Finding of No Effect, SpaceX Increased Launch Cadence Project (813-22-058)

Section 106 Update for SEA

WHITSITT-ODELL, TIFFANY A CIV USSF SSC 30 CES/CEIEA <tiffany.whitsitt-odell@spaceforce.mil>

Thu 4/27/2023 11:28 AM

To: LaBonte, John P <John.LaBonte@ManTech.com>;Katy Groom <Katy.Groom@spacex.com>;Brian Pownall <Brian.Pownall@spacex.com>
Cc: Kyle.Meade <Kyle.Meade@spacex.com>;YORK, DARRYL L CIV USSF SSC 30 CES/CEIE <darryl.york@spaceforce.mil>;KAISERSATT, SAMANTHA O CIV USSF SSC 30 CES/CEIEA <samantha.kaisersatt@spaceforce.mil>;SMALLWOOD, STACY J CIV USSF SSC 30 CES/CEIEA <stacy.smallwood.1@spaceforce.mil>

Hi All -

We have spoken with the SHPO and they have elected to let the 30-day review slip, citing 36CFR 800.3(c)4, "Failure of the SHPO/THPO to respond. If the SHPO/THPO fails to respond within 30 days of receipt of a request for review of a finding or determination, the agency official may either proceed to the next step in the process based on the finding or determination or consult with the Council in lieu of the SHPO/THPO." They explained to us that they feel there is no potential to effect due to the proposed action.

The Tribe also has not responded with comment within 30 days or receipt of request for review. Thus, we have no further Section 106 obligations, and we can proceed based on our delineation of the Area of Potential Effect and finding of no effect determination.

Please ensure this update is fully documented in the final version of the EA.

v/r,
Tiffany

____

Tiffany Whitsitt-Odell
Environmental Planner, 30 CES/CEIEA
1028 Iceland Ave B#11146
COMM: 805-606-2044/276-2044
Tiffany.Whitsitt-Odell@spaceforce.mil
(she, her, hers)

APPENDIX D
California Coastal Commission Consultation

DEPARTMENT OF THE AIR FORCE
UNITED STATES SPACE FORCE
SPACE LAUNCH DELTA 30

9 July 2024

Beatrice L. Kephart
30 CES/CEI
1028 Iceland Avenue
Vandenberg SFB CA 93437-6010

Cassidy Teufel
Federal Consistency Coordinator
Energy, Ocean Resources and Federal Consistency
California Coastal Commission
455 Market Street, Suite 228
San Francisco, CA 94105-2219

Dear Mr. Teufel,

Under the Federal Coastal Zone Management Act (CZMA) of 1972, as amended, Section 307c(1), and 15 Code of Federal Regulations Part 930, the Department of the Air Force (DAF) has determined that the Proposed Action, increased launch cadence for Space Exploration Technologies Corp. (SpaceX) operations at Space Launch Complex 4, on Vandenberg Space Force Base, California is consistent to the maximum extent practicable with the California Coastal Management Plan, pursuant to the requirements of the CZMA. We respectfully request that the Coastal Commission concur with our Consistency Determination (CD).

Attachment 1 to this letter serves as the analytical basis for the CD. The DAF is working on a draft Environmental Assessment in accordance with the National Environmental Policy Act and its implementing regulations. We have provided the Biological Assessment for this action per request as a part of the attached CD.

If you need additional information or have questions, please call me at (805) 605-7924 or email at beatrice.kephart@spaceforce.mil. You can also call Tiffany Whitsitt-Odell at (805) 606-2044 or email at tiffany.whitsitt-odell@spaceforce.mil.

Sincerely

BEATRICE L. KEPHART
Chief, Installation Management Flight

1 Attachment:
1. CZMA Consistency Determination for SpaceX Operations at Space Launch Complex 4

COASTAL ZONE MANAGEMENT ACT CONSISTENCY DETERMINATION FOR SpaceX Falcon Program at Vandenberg Space Force Base, California

July 2024

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ACRONYMS AND ABBREVIATIONS

ac.	acres
BCI	Bat Conservation International
BMPs	Best Management Practices
BNM	Broadcast Notice to Mariners
BO	Biological Opinion
CARB	California Air Resources Board
C.F.R.	Code of Federal Regulations
CCA	California Coastal Act
CCC	California Coastal Commission
CCMP	California Coastal Management Plan
CCSFS	Cape Canaveral Space Force Station
CD	Consistency Determination
CDFW	California Department of Fish and Wildlife
CNDDB	California Natural Diversity Database
CRLF	California red-legged frog
CTS	California tiger salamander
CZMA	Coastal Zone Management Act
DAPTF	Declining Amphibian Populations Task Force
dB	decibel(s)
dBA	A-weighted decibel(s)
DOD	Department of Defense
E	East
EPMs	Environmental Protection Measures
ESA	Endangered Species Act
FAA	Federal Aviation Administration
ft	foot or feet
Ft^2	square feet
km	kilometer(s)
KSC	Kennedy Space Center
LAA	May affect, likely to adversely affect
lbs	pounds
LC	Launch Complex
LEO	low-earth orbit
LETE	California least tern
Lmax	maximum sound level
LNM	Local Notice to Mariners
LOA	Letter of Authorization
m	meter(s)
mi	mile(s)
MMPA	Marine Mammal Protection Act
MOL	Manned Orbiting Laboratory
MSIB	Marine Safety Informational Bulletin
MSRS	ManTech SRS Technologies, Inc.
NA	Not Applicable
NCI	Northern Channel Islands
ND	Negative Determination
NE	No Effect
NL	Not Listed under the ESA
NLAA	May affect, not likely to adversely affect
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOTAM	Notices to Airmen
NOTMARs	Local Notices to Mariners
NRHP	National Register of Historic Places
NSSL	National Security Space Launch
psf	pounds per square foot
RORO	roll-on-roll-off
RWQCB	California Regional Water Quality Control Board
SBCAPCD	Santa Barbara County Air Pollution Control District
SECDEF	Secretary of Defense
SEL	sound exposure level
SLC	Space Launch Complex
SLD 30	Space Launch Delta 30
SMR	State Marine Reserve
SNPL	western snowy plover
SPCC	Spill Prevention, Contingency, and Countermeasures
SWFT	southwestern willow flycatcher
SWPT	southwestern pond turtle
TWG	tidewater goby
U.S.	United States
USACE	United States Army Corp of Engineers
U.S.C.	United States Code
USCG	U.S. Coast Guard
USFWS	U.S. Fish and Wildlife Service
USSF	United States Space Force
VSFB	Vandenberg Space Force Base

W	West

1 INTRODUCTION

Space Launch Delta 30 (SLD 30) of the Department of the Air Force (DAF), United States (U.S.) Space Force (USSF) submits this Consistency Determination (CD) for the California Coastal Commission's review. The Proposed Action would increase Space Exploration Technologies Corp. (SpaceX) Falcon 9 launch cadence at Space Launch Complex (SLC) 4 to up to 50 launches per year at SLC-4. SpaceX would maintain the currently approved 12 first stage landings per year at SLC-4.

The purpose of the Proposed Action is to provide greater mission capability to the Department of Defense (DOD), National Aeronautics and Space Administration (NASA) at the Western Range[1], as well as other government and commercial entities by increasing Falcon flight opportunities. This increase in flight opportunities would improve U.S. space capabilities by providing additional launch to support future U.S. Government and commercial missions, which require or benefit from a Falcon 9 vehicle. The Federal Aviation Administration (FAA) forecasts that commercial launch operations will increase in the United States (U.S.) from an all-time high in 2022 of 87 launches, to up to 186 launches by 2026. The DOD, NASA, and other Federal agencies obtain access to space through the procurement of commercial launch services. As such, commercial launch capability is critical to the national defense, American's national space objectives, and the National Space Policy of the United States (May 2020). The DOD issued the *Commercial Space Integration Strategy* (DOD 2024), providing a vision for prioritizing and aligning efforts to integrate commercial solutions into the U.S.'s national security space architecture. This strategy notes that integration will help deny adversaries the benefits of attacks against national security space systems and contribute to a safe, secure, stable, and sustainable space domain.

In furtherance of the National Space Policy and U.S. Government space launch requirements, this Proposed Action is needed to enable SpaceX to meet the increasing need to implement missions for the U.S. Government. SpaceX is currently one of *only* two U.S. launch service providers certified to launch national security missions for the USSF's National Security Space Launch (NSSL) program, which procures launches for all the military services as well as the intelligence community.

The USSF's mission to "secure our Nation's interests in, from, and to space" is enabled by Space Systems Command's largest organization, the Assured Access to Space Directorate. The Assured Access to Space Directorate procures launch services from the commercial space transportation industry at VSFB, one of only two Federal Ranges from which national security space launches can occur—and the only Federal Range on the West Coast. Space launch for the USSF, other DOD organizations, and the intelligence community is reliant on commercial space launch service providers, as DOD does not operate its own space launch vehicles. SpaceX supports, and is under contract for, the full spectrum of U.S. Government space mission requirements.

The Proposed Action fulfills Congress's grant of authority to the Secretary of Defense (SECDEF), pursuant to 10 United States Code (U.S.C.) § 2276(a), *Commercial Space Launch Cooperation*, that SECDEF is permitted to take action to:

> "(1) maximize the use of the capacity of the space transportation infrastructure of the [DOD] by the private sector in the U.S.;

[1] The Western and Eastern Ranges are U.S. Government managed space launch ranges on the western and eastern coasts. The Western Range includes VSFB, while the Eastern Range includes Kennedy Space Center and Cape Canaveral Space Force Station.

(2) maximize the effectiveness and efficiency of the space transportation infrastructure of the [DOD];

(3) reduce the cost of services provided by the [DOD] related to space transportation infrastructure at launch support facilities and space recovery support facilities;

(4) encourage commercial space activities by enabling investment by covered entities in the space transportation infrastructure of the [DOD]; and

(5) foster cooperation between the [DOD] and covered entities."

The Proposed Action is needed to meet current and anticipated near-term future U.S. Government launch requirements for national security, space exploration, science, and the Assured Access to Space process of the NSSL program. It is the policy of the U.S. to ensure that the U.S. has the capabilities necessary to launch and insert national security payloads into space whenever needed, as described in 10 U.S.C. § 2773. The Proposed Action is also needed so that SpaceX can continue to implement U.S. Government missions while simultaneously meeting its increasing commercial launch demands.

By increasing launch capacity at VSFB, the Proposed Action allows continued fulfillment of the 2020 National Space Policy, including promoting a "robust commercial space industry and strengthen United States leadership as the country of choice for conducting commercial space activities" (U.S. Government 2020). The Proposed Action ensures that U.S. space launch capability is not reduced or limited, and that the U.S. remains the world leader in space launch technology.

Several decades ago, the U.S. Government transitioned away from its historical approach of U.S. Government-developed and operated rockets to the use of commercial space launch vehicles, procured as a commercial service. Doing so has provided tremendous reduction in costs to U.S. taxpayers, significantly increased space launch vehicle reliability, and promoted innovative new technologies like rocket reusability. Lower launch costs are a direct value to the taxpayer and allows the DOD to field space systems more efficiently to counter increased adversary space threats and enhance U.S. space-based services to U.S. and allied warfighters. Cost benefits are realized through competitive commercial launch pricing, which is created in-part by efficient commercial launch operations. The viability and health of commercial launch services providers—enabled through a regular flight rate—is critical to the U.S. Government. This was emphasized by General Saltzman, Chief of Space Operations, and Secretary Kendall, Secretary of the Air Force, during the House of Representatives Armed Services Committee Meeting on April 17, 2024.

Through competitive acquisition of launch in the NNSL Program's Phase 2 procurement, the USSF saved $7 billion in taxpayer funds.[2] SpaceX has dramatically reduced the cost of access to space through the re-use of first stage rocket boosters and payload fairings. SpaceX is currently the only launch operator worldwide recovering, refurbishing, and reusing first-stage boosters and fairings—which means that SpaceX launch operations does not routinely expend rocket boosters or fairings into the ocean following launch. Launch system recovery and reuse has provided the U.S. Government the ability to rapidly launch and utilize new space systems architecture, such as satellite constellations in low-Earth orbit, quickly fielding new national security capability on orbit at substantially reduced cost.

2 https://www.af.mil/News/Article-Display/Article/2305576/space-force-awards-national-security-space-launch-phase-2-launch-service-contra/

SpaceX has developed Starlink and Starshield, satellite constellations in low-Earth orbit that require numerous launches to develop and maintain the constellation. Starlink is a critical national capability that is directly utilized by DOD and the intelligence community, which contracts directly for satellite communications services important to the national defense and in support of U.S. interests abroad. Here, Starlink is a services provider for the DOD under numerous contracting vehicles, including the U.S. Space Force Commercial Satellite Communications Office, the U.S. Air Force's Global Lightning program[3], the Department of the Navy[4], and other programs designed to enhance U.S. national security capability on-orbit and on the ground. Starlink services have also been directly procured by each of the U.S. military services, and by U.S. Special Operations Command. More broadly, Starlink is under contract with the Federal Emergency Management Agency, the Department of State, Department of Veterans Affairs, Department of Transportation, U.S. Coast Guard (USCG), Customs and Border Patrol, U.S. Geological Survey, U.S. Forest Service, the National Oceanic and Atmospheric Administration (NOAA), and many other government organizations at the state and local level. These agencies include emergency management personnel who are actively using Starlink to facilitate emergency response and recovery efforts. At any given point in time, Starlink can be activated and deployed globally to respond to various crises.

Starlink and Starshield are critical national capabilities that are directly utilized by DOD and the Intelligence Community, who contract directly for satellite communications services important to the national defense, as well as in support of U.S. interests abroad, including in Ukraine. Many of these capabilities are classified and cannot be discussed in the context of this CD. For many U.S. Government users, Starlink and Starshield are indistinguishable. The ability to consistently launch both Starshield *and* Starlink is critical to maintaining the highly reliable and stable services of both constellations for the U.S. Government and U.S interests to respond to urgent matters. Starshield contracts are so sensitive that the work under them is classified. It is critical that CCC generally understand that the distinction between Starshield and Starlink does not exist for some U.S. Government users, and Starlink itself is the basis for exclusive and specialized U.S. Government services and capability.

It is in the national interest to continuously enhance Starlink network capacity, particularly in furtherance of U.S. Government purposes and objectives. SpaceX's rapid launch capability and continuous deployment of Starlink satellites on orbit directly correspond to improved network performance that scales directly with network growth to meet escalating demand. Starlink launches are not incidental; each individual Starlink launch is part of a deliberate, planned effort to meet capacity needs to support specific requirements or demand, including the U.S. Government. The capability of new satellites allows SpaceX to add capacity more quickly and interconnect the Starlink constellation, to serve critical U.S. Government needs around the globe, and to launch critical communication services for aviation and maritime in the U.S. and the rest of the world's most remote locations.

SpaceX launches payloads for the USSF's Space Development Agency as part of the Proliferated Warfighter Space Architecture, a resilient layered network of military satellites designed to quickly deliver needed national security space capabilities to the joint warfighter. These missions require several launches in rapid succession given the scale of SDA's proliferated satellite architecture. Although initial SDA missions were procured directly from SpaceX, generally SDA missions moving forward will be conducted under the auspices of the USSF NSSL. In addition to missions for the DOD, SpaceX launches payloads from VSFB for

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[3] https://www.airandspaceforces.com/global-lightning-satcom-project-expanding-to-ac-130-kc-135/
[4] https://defensescoop.com/2024/04/11/starlink-terminals-navy-spacex-shipboard-c4i/

U.S. Government agencies, including NASA and NOAA, and allied foreign nations, including missions that directly benefit environmental monitoring and response.

On 5 May 2023 the Executive Director of the California Coastal Commission (CCC) concurred with a Negative Determination (ND; ND-0009-23) to increase the Falcon 9 launch cadence at SLC-4 to 36 launches per year, the number of SLC-4 first stage landings per year remained at 12, which CCC had reviewed in prior consultations. In the months following the Executive Director's concurrence, CCC staff stated that public coastal access was being adversely effected through other activities in addition to beach closures: (1) closures of the 14 mile long road between Highway 1 and Jalama Beach to incoming traffic in advance of scheduled SpaceX launches, even when a full closure and evacuation does not occur[5]; (2) email notices to those holding campground reservations during the time of a scheduled SpaceX launch; and (3) website notices to those seeking to secure a campsite reservation during the time of a scheduled SpaceX launch. The CCC stated that these launch activities prevent coastal access and recreation in greater numbers than the 12 closures at Jalama Beach, resulting in cancellations of campsite reservations and limited the number of reservations secured. Thus, the CCC advised that Jalama Beach had exceeded the number of closures analyzed in the ND. At the December 2023 public hearings, the Commissioners voted to revisit the ND and requested preparation of a CD. During preparation of the CD, SLD 30 and SpaceX coordinated with the CCC and County of Santa Barbara, to develop and implement measures to avoid and reduce future impacts of a similar nature. These measures were implemented well before the December 2023 public hearing and receipt of the Remedial Action Proposal in February 2024 and included: 1) reducing the potential for evacuations by shifting some missions to nighttime, when population levels are lower; and 2) revising the language in the potential evacuation notice emails sent to campers. Example emails from before and after these measures were implemented are included in Appendix C. Since the introduction of these measures, there was not an evacuation of Jalama Beach County Park and thus no associated closure of Jalama Road until May 2024. Additionally, seven contingency evacuation notices (out of 22 launches) have been sent to SBC resulting in email notifications to campers between mid-July 2023 and February 2024. Few campsite reservations (< 1 %) have been cancelled because of the contingency evacuation emails (pers comm L. Semenza, 2023).

1.1 AUTHORITY

This CD is being submitted by the DAF in accordance with the Federal Consistency Regulations (15 Code of Federal Regulations [C.F.R.] Part 930) pursuant to Section 307(c)(1)(A) of the Coastal Zone Management Act (CZMA; 16 U.S.C. 1456(c)(1)(A)), as amended, and the federally approved California Coastal Management Plan (CCMP) pursuant to the California Coastal Act (CCA) (California Public Resources Code, Division 20).

1.2 DETERMINATION

The project launch site (SLC-4) is located within the boundary of VSFB on land owned by the United States and under the administrative management and control of the DAF. Although the CZMA excludes federal lands from the definition of coastal zone, actions that may affect the coastal zone off federal lands are to be consistent, or it not consistent, then consistent to the maximum extent practicable with the enforceable policies of the CCMP. Launch and landing operations at SLC-4 have been developed to

[5] SLD 30 has confirmed with the County of Santa Barbara that the 14-mile-long road between Highway 1 and Jalama Beach only closes during full evacuation due to a launch or when road conditions are poor and unsafe to traverse which happens during rainy seasons that cause sink holes, downed trees and/or power lines. The road closures outside of launch times over the winter of 2022-2023 are related to weather events and unsafe conditions.

minimize and/or offset potential effects to coastal uses and/or resources to comply with the enforceable policies of the CCA. Based on review of the Proposed Action's compliance with the CZMA, the DAF has determined that the Proposed Action is consistent with the CCMP, pursuant to the requirements of the CZMA.

1.3 Consultations with other Resource Agencies and Tribal Entities

SLD 30 reinitiated Section 7 consultation with the National Marine Fisheries Service (NMFS) on March 21, 2024 and received a Letter of Concurrence on April 17, 2024 stating the Proposed Action would not adversely affect Endangered Species Act-listed and/or proposed critical habitat. The existing SLD 30 Letter of Authorization (LOA) issued by NMFS for Level B harassment of marine mammals incidental to launch activities covers the Proposed Action. The LOA allows launch programs to unintentionally take small numbers of marine mammals during launches and landings.

SLD 30 reinitiated Section 7 consultation with the United States Fish and Wildlife Service (USFWS) on March 7, 2024.

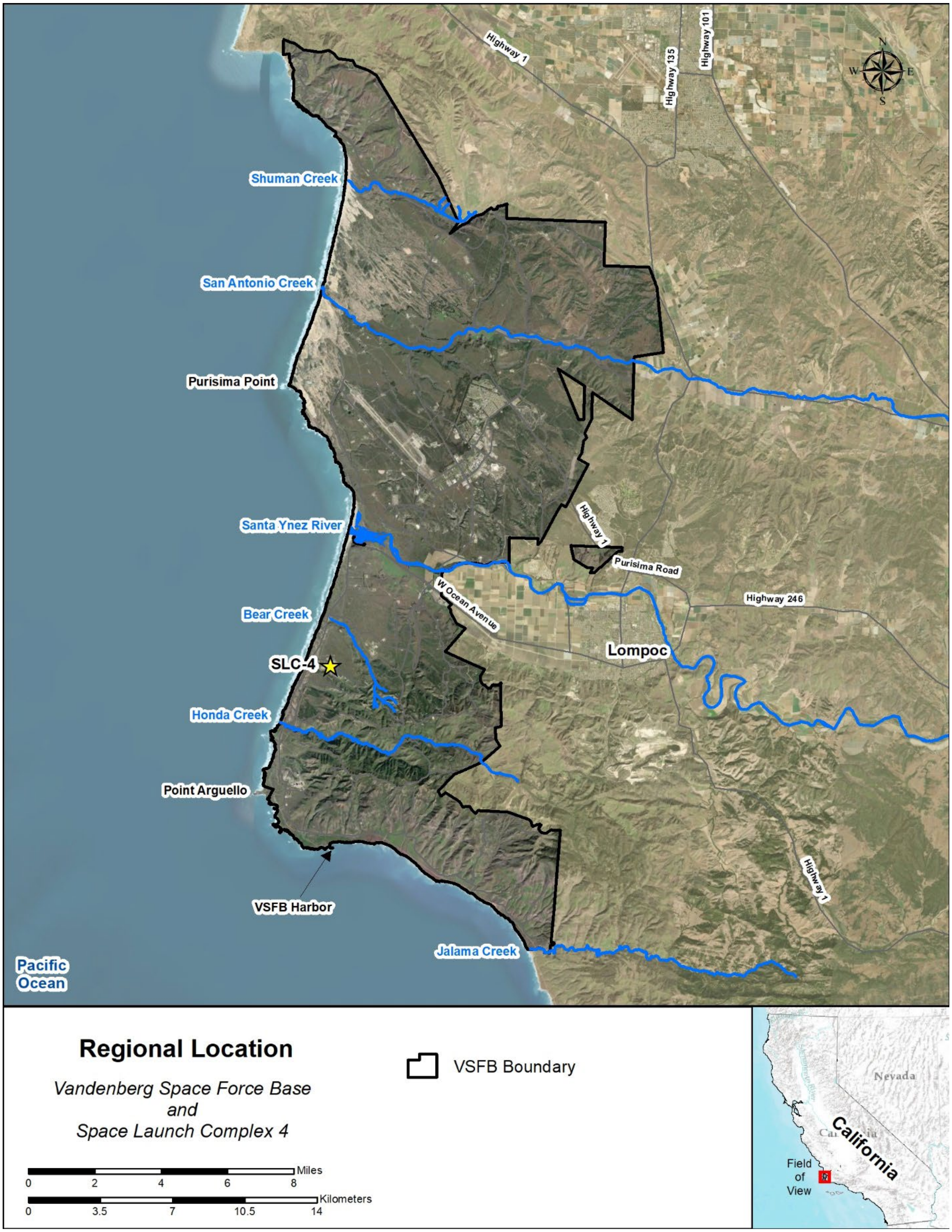

Figure 1.3-1. Regional Location of Proposed Action Area

2 DESCRIPTION OF PROPOSED ACTION

2.1 PROPOSED ACTION

The Proposed Action is to increase the annual Falcon 9 launch cadence up to 50 times per year from SLC-4. Following each launch, SpaceX would also perform a boost-back and landing of the first stage boosters up to 50 times, either downrange on a droneship or at landing zones at VSFB. As approved in prior environmental documents, no more than 12 first stage landings would occur at SLC-4 per year.

2.1.1 LAUNCH AND LANDING ACTIVITIES

One to 3 days before each launch, SpaceX may perform an engine static fire test, which lasts a few seconds. The need to conduct a static fire test depends on the mission, but there would be no more than 30 static fire events per year. Launch operations would occur day or night, at any time during the year. Following each launch, SpaceX would perform a boost-back and landing of the first stage or rocket boosters, either downrange on a droneship or at landing zones at VSFB. Mission objectives may occasionally require an expendable first stage or booster in the Pacific Ocean outside of California State waters. If expended, the first stage would break up upon atmospheric re-entry and there would be no residual propellant or explosion upon impact with the Pacific Ocean. The first stage remnants would sink to the bottom of the ocean. Fairing recovery would also occur within these recovery areas.

Launch trajectories from SLC-4 would remain within the previously analyzed azimuth range of 140 to 325 degrees. No more than 12 annual landings would occur at SLC-4, as previously analyzed.

SpaceX would land first stages and boosters either at VSFB or downrange on a droneship in the previously approved recovery areas outside of California State waters.

2.1.2 PAYLOAD FAIRING RECOVERY OPERATIONS

The Falcon 9 vehicle payload system includes a fairing that protects payloads (e.g. satellites). The fairing consists of two halves which separate, allowing the deployment of the payload at the desired orbit. Each fairing half contains a parachute system for recovery, which includes one drogue parachute and one parafoil. Parachutes, parafoils, and their assemblies are made of Kevlar and nylon, and sink quickly as they become waterlogged. The parachute system slows the descent of the fairing to enable a soft splashdown so that the fairing remains intact. The parachute canopy is approximately 110 square feet and the fairing parafoils are approximately 3,000 square feet.

SpaceX would attempt to recover both halves of the fairing after each launch. The fairing and parafoil would be recovered by a salvage ship stationed near the anticipated splashdown site, but no closer than 12 nautical miles offshore. Up to 200 parachutes and 200 parafoils would land in the ocean annually, within federal or international waters. SpaceX would attempt to recover all parafoils, but it is possible that some of the parafoils would not be recovered due to sea or weather conditions at the time of recovery. The recovery team would attempt to recover the parachute assembly if they can get a visual fix on the splashdown location. Because the parachute assembly is deployed at a high altitude, it is difficult to locate. In addition, based on the size of the assembly and the density of the material, the parachute assembly would be saturated and begin to sink. This would make recovering the parachute assembly difficult and unlikely. As a result, SpaceX has experienced limited success in recovering the parachutes but will continue to attempt recovery and improve the success rate. However, most parachutes would be deposited in the ocean.

2.1.3 Vehicle Refurbishment

SpaceX would continue to process vehicles at existing SpaceX facilities, including Building 398 and the SLC-4 hangar, on federal property. Operations include refurbishing the recovered first stage and fairing for reuse in future missions. Up to 50 boosters and 50 fairings would be refurbished each year. Solvents such as isopropyl alcohol, isopar, and Simple Green would be used during these operations, as well for launch pad operations, facility maintenance, and system flushing.

2.1.4 Harbor Operations

SpaceX would continue to transport first stage boosters and fairings from the Port of Long Beach to the VSFB harbor via a "roll-on-roll-off" (RORO) barge. The Proposed Action would include up to 5 RORO operations per year. Each harbor operation lasts for approximately four hours, or one tide window. Harbor operations could occur at any time of day, as they are dependent on the tide windows. The Proposed Action does not include additional dredging outside the amount allowed by VSFB's existing permit from the U.S. Army Corps of Engineers (USACE).

2.2 Consistency Analysis/Analysis of Effects

The effects test is a process where the federal agency determines which of its proposed activities affect any coastal use or resource in the state's coastal zone (off federal property) of states with approved management programs. The CCMP is such an approved program, and the DAF will determine such effects by reviewing the CCMP's relevant enforceable policies. Effects are determined by looking at reasonably foreseeable direct and indirect effects on any such coastal zone use or resource (15 CFR 930.33). As defined in Section 304 of the CZMA, the term "coastal zone" does not include "lands the use of which is by law subject solely to the discretion of or which is held in trust by the Federal Government." However, since the proposed activities may have an effect on the land, water, or natural resource of a coastal zone off such federal property, as per DAF policy guidance (AFMAN 32-7003, Section 3.26.2), the DAF undertakes federal actions in a manner consistent, or it not consistent then consistent to the maximum extent practicable with the enforceable policies[6] of the approved CCMP through the federal consistency process under the CZMA.

The relevant enforceable polices under the CCMP are the following: Article 2 – Public Access (Section 30210, 30213, and 30214); Article 3 – Recreation (Section 30220); Article 4 – Marine Environment (Section 30230, 30231, 30232, 30234, and 30234.5). Sections and Articles of the CCMP that are not relevant to the Proposed Action are presented in Section 3.1.

Prior to evaluating whether the Proposed Action complies with the CCMP's enforceable policies, the federal agency must first examine whether the Proposed Action would have a reasonably foreseeable effect on coastal zone uses or resources. Thus, the elements of the Proposed Action must first be examined to determine whether they have reasonably foreseeable effects before determining whether those effects are consistent with the CCMP's enforceable policies. Coastal zone resources include both resources permanently located in the coastal zone (e.g., benthic organisms) and mobile resources (e.g., marine mammals and sea turtles) that typically move into and out of the coastal zone as part of a natural cycle.

[6] DAF is using the term "enforceable policies" within the meaning contemplated in 15 C.F.R. 930.36. DAF does not concede that all aspects of California's coastal program are enforceable against the federal government.

The effects test evaluates the relative location of the Proposed Action to the coastal zone and the potential effects of stressors on coastal zone uses or resources. The DAF conducted the effects test and determined there are reasonably foreseeable effects to some coastal zone uses and resources. The effects test for the Proposed Action is based on the locations of the proposed activities relative to the coastal zone and the potential effects of stressors on coastal zone resources.

The Proposed Action at VSFB could have the potential to affect coastal resources from acoustics (launch engine noise and sonic booms) and potential impacts to public use and recreation at Jalama Beach County Park as follows:

- Contingency Evacuation Email – an email sent by the County of Santa Barbara to reservation holders of campgrounds at Jalama Beach County Park notifying them of a potential upcoming evacuation. Example email attached in Appendix C. Emails are sent several days in advance of the anticipated launch date. Updates are made to the County website.
- Evacuation Email – similar process as above, though text specifies that an evacuation will occur Example email attached in Appendix C. Updates are made to the County website.
- Evacuation – Removal of day-users and campers from Jalama Beach County Park due to safety requirements. Evacuation occurs approximately four hours prior to launch and users are able to return post-launch when the all-clear is issued by SLD 30 Range Safety.
- Road Closure – The closure of Jalama Road between Jalama Beach County Park and Highway 1 occurs when an evacuation is required. Santa Barbara County Sheriffs would place roadblocks along Jalama Road to enforce an evacuation.
- Acoustics – Noise effects from launch activities on marine and terrestrial biological resources.

3 POLICIES OF THE CALIFORNIA COASTAL MANAGEMENT PROGRAM

The DAF reviewed the CCMP to identify the policies relevant to the Proposed Action according to Division 20 of the California Public Resources Code, approved as part of the coastal program. Section 3.1 identifies the CCMP policies that are not relevant to the Proposed Action. Section 3.2 provides an analysis of the CCMP policies that are relevant to the Proposed Action.

3.1 Policies of the California Coastal Management Program That Are Not Relevant to the Proposed Action

The CCMP policies not applicable to the Proposed Action are provided in Table 3.1-1 below.

Table 3.1-1: Policies of the CCMP That Are Not Relevant to the Proposed Action

Article	Section	State Policy	Explanation of Non-Applicability
Article 2: Public Access	30211	Development not to interfere with access	The Proposed Action does not include any construction or ground disturbance that would block the public's right of access to the sea.
	30212	New development projects	The Proposed Action does not include any new development that would block or impede public access.
	30212.5	Public facilities; distribution	The Proposed Action does not include any public facilities.
Article 3: Recreation	30221	Oceanfront land; protection for recreational use and development	The Proposed Action does not include any development of oceanfront land that would reduce available areas for public use.
	30222	Private lands; priority of development purposes	The Proposed Action does not include any development of private lands within the Action Area.
	30222.5	Oceanfront lands; aquaculture facilities; priority	The Proposed Action does not affect coastal zone lands suitable for aquaculture.
	30223	Upland areas	The Proposed Action does not affect the availability of upland areas necessary to support coastal recreational uses.
	30224	Recreational boating use; encouragement; facilities	The Proposed Action does not include the development of any recreational boating facilities.
Article 4: Marine Environment	30233	Diking, filling, or dredging; continued movement of sediment and nutrients	The Proposed Action does not include any diking, filling, or dredging activities.
	30235	Construction altering natural shoreline	The Proposed Action does not include construction or ground disturbance that would alter natural shorelines processes.

Article	Section	State Policy	Explanation of Non-Applicability
	30236	Water supply and flood control	The Proposed Action does not alter any rivers or streams.
	30237	Repealed	
Article 5: Land Resources	30241	Prime agricultural land; maintenance in agricultural production	The Proposed Action would have no impact to prime agricultural lands.
	30241.5	Agricultural lands; determination of viability of uses; economic feasibility evaluation	The Proposed Action would have no impact to agricultural lands.
	30242	Lands suitable for agricultural use; conversion	The Proposed Action would have no impact to agricultural lands.
	30243	Productivity of soils and timberlands; conversion	The Proposed Action would have no impact to timberlands.
	30244	Archaeological or paleontological resources	The Proposed Action does not include construction or ground disturbance, thus would have no impacts archaeological or paleontological resources.
Article 6: Development	30250	Development location; existing developed areas	This policy only applies to actions that require permitting, which cannot be enforced against the DAF.
	30251	Scenic and visual qualities	The Proposed Action does not include any new permanent development that would affect public scenic or visual qualities within the coastal zone.
	30252	Maintenance and enhancement of public areas	The Proposed Action does not include any new development that would require maintenance or enhanced public access to the coast.
	30253	Minimization of adverse impacts	The Proposed Action does not include any development within the coastal zone.
	30254	Public works facilities	The Proposed Action does not include any new or expanded public works facilities.
	30254.5	Terms or conditions on sewage treatment plant development; prohibition	The Proposed Action does not include the development of a sewage treatment plant.
	30255	Priority of coastal-dependent developments	The Proposed Action does not include any development within the coastal zone.
Article 7: Industrial Development	30260	Location or expansion	The Proposed Action does not include the development of coastal-dependent industrial facilities.
	30261	Tanker facilities; use and design	The Proposed Action does not include the use of existing or new tanker facilities.

Article	Section	State Policy	Explanation of Non-Applicability
	30262	Oil and gas development	The Proposed Action does not include any oil and gas development.
	30263	Refineries or petrochemical facilities	The Proposed Action does not include new or expanded refineries or petrochemical facilities.
	30264	Thermal electric generating plants	The Proposed Action does not include new or expanded thermal electric generating plants.
	30265	Legislative findings and declarations; offshore oil transport	This section explains the legislative findings applicable to offshore oil transportation, and does not constitute a separate public access policy.
	30265.5	Governor or designee; co-ordination of activities concerning offshore oil transport and refining; duties	The Proposed Action does not include activities concerning offshore oil transport and refining.
Article 8: Sea Level Rise	30270	Sea level rise	The Proposed Action does not include activities at risk of sea level rise.

3.2 Policies of the California Coastal Management Program That Are Relevant to the Proposed Action

The CCMP policies that are relevant to the Proposed Action are policies where one or more of the Proposed Action components could affect a coastal use or resource within the coastal zone identified by the policy. The CCMP policies that are relevant to the Proposed Action are provided in Table 3.2-1.

Table 3.2-1: Policies of the CCMP That Are Relevant to the Proposed Action

Article	Section	State Policy
Article 2: Public Access	30210	Access; recreational opportunities; posting
	30213	Lower cost visitor and recreational facilities; encouragement and provision; overnight room rentals
	30214	Implementation of public access policies; legislative intent
Article 3: Recreation	30220	Protection of certain water-oriented activities
Article 4: Marine Environment	30230	Marine resources; maintenance
	30231	Biological productivity; water quality
	30232	Oil and hazardous substance spills
	30234	Commercial fishing and recreation boating facilities
	30234.5	Economic, commercial, and recreational importance of fishing
Article 5: Land Resources	30240	Environmentally sensitive habitat areas; adjacent developments

3.2.1 Article 2: Public Access

Policies

CCA Section 30210 – "Access; recreational opportunities; posting" states:

In carrying out the requirement of Section 4 of Article X of the California Constitution, maximum access, which shall be conspicuously posted, and recreational opportunities shall be provided for all the people consistent with public safety needs and the need to protect public rights, rights of private property owners, and natural resource areas from overuse.

CCA Section 30213 – "Lower cost visitor and recreational facilities; encouragement and provision; overnight room rentals" states:

Lower cost visitor and recreational facilities shall be protected, encouraged, and, where feasible, provided. Developments providing public recreational opportunities are preferred. The commission shall not: (1) require that overnight room rentals be fixed at an amount certain for any privately owned and operated hotel, motel, or other similar visitor-serving facility located on either public or private lands; or (2) establish or approve any method for the identification of low or moderate income persons for the purpose of determining eligibility for overnight room rentals in any such facilities.

CCA Section 30214 – "Implementation of public access policies; legislative intent" states

The public access policies of this article shall be implemented in a manner that takes into account the need to regulate the time, place, and manner of public access depending on the facts and circumstances in each case including, but not limited to, the following: (1) Topographic and geologic site characteristics. (2) The capacity of the site to sustain use and at what level of intensity. (3) The appropriateness of limiting public access to the right to pass and repass depending on such factors as the fragility of the natural resources in the area and the proximity of the access area to adjacent residential uses. (4) The need to provide for the management of access areas so as to protect the privacy of adjacent property owners and to protect the aesthetic values of the area by providing for the collection of litter. (b) It is the intent of the Legislature that the public access policies of this article be carried out in a reasonable manner that considers the equities and that balances the rights of the individual property owner with the public's constitutional right of access pursuant to Section 4 of Article X of the California Constitution. Nothing in this section or any amendment thereto shall be construed as a limitation on the rights guaranteed to the public under Section 4 of Article X of the California Constitution. (c) In carrying out the public access policies of this article, the commission and any other responsible public agency shall consider and encourage the utilization of innovative access management techniques, including, but not limited to, agreements with private organizations which would minimize management costs and encourage the use of volunteer programs.

Consistency Review

The DAF controls access to VSFB and on-Base recreation areas. Public access to VSFB is not permitted. Personnel and approved contractors may participate in outdoor activities on VSFB, such as camping, picnicking, sunbathing, hiking, bird watching, nature photography, fishing, and hunting. The closest public access beaches are Jalama Beach County Park, Surf Beach (federal property where VSFB voluntarily allows access to the public, but is not required to do so), and County of Santa Barbara Ocean Beach Park. Of these, Jalama Beach County Park is the only one with overnight accommodations, including 107 campsites (31 of which with electrical hookups) and seven equipped cabins.

Solely for the health and safety of park visitors, the County Parks Department and the County Sheriff currently close these parks upon request from the DAF in the event of launch activities that have been determined by SLD 30 Range Safety to have certain human health and safety risks. These evacuations are communicated at least 72 hours prior to evacuation and can be implemented a maximum of 48 hours per the agreement. Point Sal Road is not anticipated to be evacuated due to SpaceX launches.

Ocean Beach County Park and Surf Beach (Federal Property)

In the past, SLD 30 has restricted access to Ocean Beach County Park and Surf Beach for all launches from SLC-4. Based on updated modeling and safety considerations, SLD 30 Range Safety and the Security Forces Squadron have determined closures are only required if the first stage of the Falcon 9 launch vehicle will boost back to land at SLC-4. This action by DAF has resulted in a net-benefit to public access in northern Santa Barbara County by reducing the previous public access restrictions of prior launches based on past safety models and protocols. Now only a subset of launches include boost back to land at SLC-4. In addition to the parks remaining open, launch viewing opportunities attract more people to the coast thus providing coastal access to a larger number of users.

Access to the coastline from Surf Beach is available year-round. During the western snowy plover season, beach access is available from 0800-1800 and restricted during evening hours from 1800-0800. Access to the coastline from Ocean Beach County Park is available via a trail on federal property established by SLD 30 connecting this area to the coastal access available at nearby Surf Beach. Ocean Beach County Park is open from 0800 to dusk year-round. A portion of launches that boost back to land at SLC-4W would occur at night when these two locations are already closed. Accordingly, the Proposed Action would only restrict public access to Ocean Beach County Park and Surf Beach during daytime launches with boost back to SLC-4W. Surf Beach and County of Santa Barbara Ocean Beach Park would only be closed during SLC-4 landing events up to 12 times per year, for approximately four to eight hours each launch attempt.

Jalama Beach County Park

The County Parks Department and the County Sheriff may close Jalama Beach County Park for public safety for certain launch activities upon request from SLD 30 and under agreement between DAF and Santa Barbara County. Under this agreement, SLD 30 must provide notice of a launch at least 72 hours prior to the closure, and the closure is not to exceed 48 hours. SpaceX's proposed launches would comply with the closure agreement. These closures would be infrequent and would only last as long as necessary to assure the public are safe during a launch (approximately six to eight hours). The Commission has historically considered and analyzed the number of temporary evacuations to beaches in northern Santa Barbara County associated with launch activities and previously determined that a total of 12 evacuations per year at any of the beaches (Ocean Beach County Park, Surf Beach, and Jalama Beach County Park) is consistent with the public access and recreation policies of the CCMP (CD-049-98).

Impacts to coastal access and recreation at Jalama Beach County Park are dependent on risk analysis completed by SLD 30 Range Safety for each individual launch. The launch risk factors are estimated based on the probability of vehicle failure, population size in the high-risk area, day of launch weather, trajectory, and other factors. SLD 30 Range Safety considers the number of people within the Impact Limit Line; and thirty days prior to launch, conducts prelaunch debris risk assessments that determine high risk areas that contribute to the allowable risk criteria. If the risk of a Conditional Expected Casualty (CEc; a factor that estimates the risk of a multiple casualty event and assumes 100% vehicle failure) is greater than 0.01, Individual Risk is greater than 1/1,000,000, or the Expected Casualty risk is greater than 1/10,000, SLD 30 issues an evacuation requirement letter 25 days prior to launch. Generally, for launches from south VSFB, the population size in the Impact Limit Line determines the need for evacuation of Jalama Beach County Park and a CEc greater than 0.01 is typically triggered when the population exceeds

400 or more. Therefore, the number of users, including day users, campers, and staff, at Jalama Beach County Park may or may not exceed a level that triggers evacuation.

If evacuation is under consideration, SLD 30 notifies the County of Santa Barbara. The County then sends a contingency evacuation email (Appendix C) to reservation holders warning them that there may be a need to evacuate the park for the launch, providing them the opportunity to cancel the reservation. During early 2023 and before, only a full evacuation email was sent to reservation holders, this resulted in 3 to 4 reservations (typically 1 to 3, but up to 8 people maximum per site/reservation) typically being cancelled for each launch after the email announcement (L. Semenza, County of Santa Barbara, pers. comm.). In August 2023, SLD 30 and the County of Santa Barbara implemented improved messaging protocols to warn the public of potential evacuations at Jalama Beach County Park by developing a Contingency Evacuation Email (Appendix C). Santa Barbara County Parks and Recreation stated that after implementation of the new notification procedures, cancellations have become rarer, typically zero to one reservation per launch compared to 3 to 4 reservations in the past, where there are up to 8 people per reservation (L. Semenza, County of Santa Barbara, pers. comm.). The DAF and SpaceX have also minimized impacts at Jalama Beach by shifting to launches at night, discussed in more detail in the following paragraphs.

When an evacuation of Jalama Beach County Park is under consideration by SLD 30, Santa Barbara County reports the projected number of campers for the day of launch two to three days prior to the launch date. SLD 30 Range Safety compares the report to the maximum allowable number of people that would exceed the risk criteria and, if this number is exceeded, they will confirm the evacuation; if the population is less, the evacuation is rescinded. When an evacuation is confirmed, park staff request that all campers and day users leave the park. In addition, the Santa Barbara County Sheriff places roadblocks at the intersection of Highway 1 and Jalama Road to prevent the public from entering the affected area.

SpaceX flies a variety of trajectories from VSFB to support a wide range of missions, thus increasing to 50 launches per year does not mean that all 50 launches would have trajectories that impact Jalama Beach County Park. VSFB supports a unique range of trajectories, including launches to polar orbits, that are not available or practicable from CCSFS. Additionally, as launch vehicles become more reliable (e.g. a proven record of flight), impact limit lines decrease. The Commission has historically considered and analyzed the number of temporary evacuations to beaches in northern Santa Barbara County associated with launch activities and determined that a total of 12 evacuations per year is consistent with the public access and recreation policies of the CCMP. A launch attempt that could evacuate Jalama Beach County Park could be scrubbed due to weather, an issue with the vehicle, or another reason after an evacuation order has been issued. While some impacts to Jalama Beach County Park are unavoidable due to mission requirements, evacuations would not be issued for more than 12 launches, below the number of closures previously approved by the CCC (CD-049-98).

As previously stated, to reduce the potential for evacuations SpaceX has shifted launches with trajectories that would typically close the park to nighttime, when population levels are lower. Jalama Beach County Park Staff provide the number of people in the park in the hours leading up to launch, after which SLD 30 Range Safety determines if the CEc remains at or below the acceptable level. If population levels exceed acceptable risk criteria, the launch would be delayed to the following day and population levels reassessed to ensure total evacuations of Jalama Beach County Park do not exceed 12 per year. This delay process is known as scrubbing. While there is a substantial financial impact to launching at less-optimal times, the DAF will maintain these procedures when practicable to protect public access to Jalama Beach County Park. DAF and SpaceX evaluated a ‘dog leg’ trajectory to avoid impacting Jalama Beach County Park.

However, this trajectory would result in a significant performance hit to the vehicle due to the maneuver reducing the total mass able to be placed into orbit, thus requiring more launches to place the same amount of mass into orbit. Additionally, this could preclude certain missions from launching due to the mass of the payload.

DAF recognizes that potential evacuation notices can deter public access, through cancellation of scheduled reservations and/or fewer people making daily trips to Jalama Beach County Park. DAF will continue to coordinate with Santa Barbara County Parks and Recreation to better inform the public of potential evacuations.

To offset impacts to recreational access to the coast at Jalama Beach County Park due to past unaccounted for impacts and for potential impacts to future launch operations, the following measures have been or will be implemented:

- DAF, in coordination with SpaceX, has donated high-speed Starlink terminals to provide public internet coverage at Jalama Beach County Park. Cellular phone service in the area is limited, thus providing reliable internet coverage benefits emergency responders and provides overnight campers with reliable connectivity. Santa Barbara County Parks and Recreation stated that implementation of Starlink terminals at the park gate enhanced public access, as the prior online reservation system was slow and caused congestion and/or delays during the check in process at the controlled entrance as users enter the park (L. Semenza, County of Santa Barbara, pers. comm.).
- DAF, in coordination with SpaceX, is funding a variable messaging sign for use by Santa Barbara County Parks and Recreation to replace the prior sign at the intersection of Highway 1 and Jalama Road, enabling the County to inform the public if there is availability prior to driving down Jalama Road to the park. Santa Barbara County had indicated that a point of frustration for the public was not knowing whether the park or campground is full until they drove the length of Jalama Road and were forced to turn back if full. The ability for the County to utilize variable messaging reduces unnecessary vehicle trips to the park.
- DAF, in coordination with SpaceX, will provide a shuttle program to evacuate campers from the park to a safe location for missions that would result in an evacuation of Jalama Beach County Park. After launch, the shuttle(s) would bring campers back to the park.
- DAF, in coordination with SpaceX and the Lompoc Unified School District, will fund transportation for all 3rd graders in the Lompoc Unified School District to visit Surf Beach/Ocean Park on an annual basis.

Conclusion

DAF and SpaceX would continue to implement the following minimization measures for the launch increases previously discussed to reduce potential evacuations of Jalama Beach County Park:

- To reduce the potential for evacuation, SpaceX shifted launches with trajectories that would typically close the Jalama Beach County Park to nighttime, when population levels are lower. Jalama Beach County Park Staff provide the number of people in the park in the hours leading up to launch, after which SLD 30 Range Safety determines if the population level remains at or below the acceptable level for flight safety.
- If population levels at Jalama Beach exceed acceptable thresholds for flight safety during launches scheduled during hours of darkness and the number of evacuations previously deemed consistent by the CCC, the launch would be scrubbed (i.e. delayed) rather than require evacuation.

- SLD 30 and Santa Barbara County would continue to utilize improved messaging protocols to warn the public of potential evacuations at Jalama Beach County Park.

Through the implementation of offsets discussed above, the Proposed Action would not substantially diminish the protected activities, features, or attributes of Jalama Beach County Park. A summary of these offset measures would be included in DAF's annual report to the CCC. Similarly, the Proposed Action would not substantially diminish the protected activities, features, or attributes of Ocean Beach County Park and Surf Beach. The Proposed Action may draw additional people to these areas to view launches. The Proposed Action would be fully consistent with Sections 30210, 30213, and 30214 of the CCA.

3.2.2 Article 3: Recreation

Policies

CCA Section 30220 – "Protection of certain water-oriented activities" states:

> *Coastal areas suited for water-oriented recreational activities that cannot readily be provided at inland water areas shall be protected for such uses.*

Consistency Review

Water-oriented recreational activities occur offshore of VSFB; however, effects on offshore activities are unlikely other than temporary avoidance areas established during launch activities. Temporary avoidance areas for security and safety would not limit public access to adjacent areas. Areas would only be closed for the duration of the launch activity as required by SLD30 Range Safety. The USCG would issue a Notices to Mariners (NOTMAR) that defines public avoidance area for launch events. The avoidance area would be lifted as soon as the USCG determines it is safe to do so. Temporary closures of these areas for security and safety do not limit public access to or use of adjacent areas. Areas would be closed for the duration of the activity and reopened at the completion of the activity. A more detailed discussion of NOTMARs and maritime closures is included in Section 3.2.5.

Due to the short-term duration of the activities (50 total launches), broadcasting of NOTMARs, and the expansive offshore area that would still be available to the public, accessibility impacts associated with water-oriented recreational activities would remain negligible. Therefore, the Proposed Action would be fully consistent with Section 30220 of the CCA.

3.2.3 Article 4: Marine Environment (Marine Resources)

Policies

CCA Section 30230 – "Marine resources; maintenance" states:

> *Marine resources shall be maintained, enhanced, and where feasible, restored. Special protection shall be given to areas and species of special biological or economic significance. Uses of the marine environment shall be carried out in a manner that will sustain the biological productivity of coastal waters and that will maintain healthy populations of all species of marine organisms adequate for long-term commercial, recreational, scientific, and educational purposes.*

CCA Section 30231 – "Biological productivity; water quality" states (in part):

> *The biological productivity and the quality of coastal waters, streams, wetlands, estuaries, and lakes appropriate to maintain optimum populations of marine organisms and for the protection of human health shall be maintained and, where feasible, restored through, among other means …*

Consistency Review

As shown in Table 3.2-2, there are five species that occur in the marine environment off the VSFB coastline. One is federally listed as threatened under the Endangered Species Act (ESA) and four species are protected as defined under the Marine Mammal Protection Act (MMPA). The DAF determined these species may be potentially affected by the Proposed Action from noise effects during operation.

Table 3.2-2. Determination of Potential Effects to Marine Mammals

Species	Status	ESA Effects Determination	MMPA Determination
Southern sea otter (*Enhydra lutris nereis*)	FT	NLAA	NE
Steller sea lion - Eastern U.S. Stock (*Eumetopias jubatus*)	MMPA	NA	Level B
Northern elephant seal – California Breeding Stock (*Mirounga angustirostris*)	MMPA	NA	Level B
Pacific harbor seal – California Stock (*Phoca vitulina richardii*)	MMPA	NA	Level B
California sea lion – U.S. Stock (*Zalophus californianus*)	MMPA	NA	Level B

Notes: FE = Federally Endangered Species; FT = Federally Threatened Species; MMPA = Marine Mammal Protection Act, NA = not applicable; NE = no effect; NLAA = May affect, not likely to adversely affect; ESA = Endangered Species Act, MMPA = Marine Mammal Protection Act

In addition, there are up to 5 sea turtle species, 7 mysticetes (baleen whales), and 22 odontocetes (toothed cetaceans) that may be found within the region of influence. Sea turtles and cetaceans spend their entire lives in the water and spend most of their time (>90% for most species) entirely submerged below the surface. Additionally, when at the surface, sea turtle and cetacean bodies are almost entirely below the water's surface, with only the blowhole or head exposed for breathing. This minimizes exposure to in-air noise, both natural and anthropogenic, essentially 100% of the time because their ears are nearly always below the water's surface. As a result, in-air noise caused by sonic boom and engine noise would not affect sea turtle or cetacean species. Therefore, they were not considered further in the Environmental Assessment and are not considered further in this CD.

Southern Sea Otter (*Enhydra lutris nereis*)

Direct Effects. No ground disturbing activities or vegetation management activities would occur within southern sea otter habitat; therefore, these actions will have no effect on the southern sea otter.

Noise and Visual Effects. Areas directly offshore of SLC-4 would receive visual disturbance and noise levels of less than 130 unweighted decibels (dB) maximum sound level (Lmax) during up to 50 Falcon 9 launches from SLC-4 per year and approximately 110 dB Lmax during up to 12 first stage landing at SLC-4W. During static fire events, noise directly off the coast of SLC-4 would be less than 125 dB Lmax and there would be no associated visual disturbance. Landing at SLC-4W would also generate a sonic boom directly offshore that is expected to range from 1 to 5 pounds per square foot (psf). Otters are only occasionally observed along the coast between Purisima Point and Point Arguello transiting through the area between suitable habitat to the north and south. Beginning at the Boat Dock and continuing south along Sudden Flats, the inshore habitat supports expansive kelp beds and a relatively high density of otters. Noise levels would reach between 100 and 110 dB Lmax during up to 50 Falcon 9 launches from SLC-4 per year and less than 80 dB Lmax during up to 12 first stage landing each year at SLC-4W in these areas. Sonic booms during up to 12 SLC-4W landings per year would range from 1 to 3 psf along Sudden Flats.

Exceptionally little sound is transmitted between the air-water interface; thus, in-air sound would not have a significant effect on submerged animals (Godin 2008). In addition, according to Ghoul & Reichmuth (2014), "Under water, hearing sensitivity [of sea otters] was significantly reduced when compared to sea lions and other pinniped species, demonstrating that sea otter hearing is primarily adapted to receive airborne sounds." This study suggested that sea otters are less efficient than other marine carnivores at extracting noise from ambient noise (Ghoul & Reichmuth 2014). Therefore, the potential impact of underwater noise caused by in-air sound would be insignificant and discountable even with the launch increases from 36 to 50.

Extensive launch monitoring has been conducted for sea otters on both north and south VSFB, with pre- and post-launch counts and observations conducted at rafting sites immediately south of Purisima Point for numerous Delta II launches from SLC-2 and one Taurus launch from Launch Facility-576E and at the rafting sites near Sudden Flats for two Delta IV launches from SLC-6. Monitoring has also been conducted for Falcon 9 launch operations from SLC-4 with no abnormal behavior, mortality, or injury of effects on the population has ever been documented for sea otter because of launch-related disturbance. Otters were monitored during four Falcon 9 launches from SLC-4 during 2023 and there were no discernible effects on overall southern sea otter numbers at the monitoring site.

The lack of any demonstrated effects from launches on populations off the coast of Sudden Ranch is likely because there is little overlap in the hearing sensitivity of otters (primarily 2 to 22 kHz) and launch engine noise, which is primarily below 250 Hz, with moderate energy to 2 kHz range, and little energy above 2 kHz. While a 2-psf sonic boom is approximately equivalent to 135 dB Lmax, most of that acoustic energy from the sonic boom is not heard by sea otters. Most of the acoustic energy in a sonic boom is less than 250 Hz, well below the region of best sensitivity of the sea otter (2–22.6 kHz). While the sea otter would likely hear the sonic boom, it would only be responding to acoustic energy that is above 250 Hz and perceived sound levels would be much less than 135 dB Lmax. Additionally, if disturbed, otters typically dive under the water and therefore minimize potential noise exposure anyway. Landing engine noise follows launch by approximately 5 to 7 minutes and typically occurs slightly before the sonic boom effects land. Therefore, any individuals that flee into water as a result of launch disturbance would reduce their likelihood of being exposed to the landing engine noise and sonic boom due to the attenuation of sound in water. As a result, there would not be an opportunity for chronic noise exposure in otters.

Finally, otters have also been shown to quickly acclimate to disturbances from boats, people, and harassment devices (air horns). Davis et al. (1988) conducted a study of northern sea otter's reactions to various underwater and in-air acoustic stimuli. The purpose of the study was to identify a means to move sea otters away from a location in the event of an oil spill. Anthropogenic sound sources used in this behavioral response study included truck air horns and an acoustic harassment device (10 to 20 kHz at 190 dB Lmax) designed to keep dolphins and pinnipeds from being caught in fishing nets. The authors found that the sea otters often remained undisturbed and quickly became tolerant of the various sounds. When a fleeing response occurred as a result of the harassing sound, sea otters generally moved only a short distance (328 to 656 ft) before resuming normal activity (Davis et al. 1988).

Curland (1997) also found that southern sea otter may acclimate to disturbance. The author compared otter behavior in areas with and without human-related disturbance (e.g., kayaks, boats, divers, planes, sonic booms, and military testing at Fort Ord) near Monterey, California. Otters spent more time traveling in areas with disturbance compared to those without disturbance; however, there was no significant differences in the amount of time spent resting, foraging, grooming, and interacting, suggesting that the otters were becoming acclimated to regular disturbances from a variety of sources (Curland 1997). Extensive launch monitoring of sea otters on VSFB has shown that disturbance from rockets is not a primary driver of sea otter behavior or use of the habitat along Sudden Flats and has not had any apparent long-term consequences on populations, potentially indicating that this population has acclimated to launch activities. Therefore, any effects as a result of noise (launch, landing, and sonic boom) or visual disturbance are expected to be limited to minor behavioral disruption and insignificant.

Conclusion. Observations at VSFB have shown no abnormal behavior, mortality, or injury of otters during launch activities and noise studies have shown southern sea otters adapt to sound exposure. As a result, the Proposed Action would have an insignificant effect on southern sea otter. Therefore, VSFB has determined that the Proposed Action may affect, but is not likely to adversely affect, the southern sea otter.

Marine Mammals Protected under the MMPA

Under the MMPA, NMFS issued a Final Rule for taking marine mammals incidental to VSFB launches (NMFS 2024a), and a LOA (NMFS 2024b). The LOA allows launch programs to unintentionally take small numbers of marine mammals during launches. The Proposed Action would not result in exceedance of take thresholds as identified in the 2024 LOA. The DAF is required to comply with the LOA listed conditions and address NMFS concerns regarding marine mammals at VSFB. Under the current LOA, semi-monthly surveys (two surveys per month) must be conducted to monitor the abundance, distribution, and status of pinnipeds at VSFB. In addition, marine mammal monitoring and acoustic measurements must be conducted at the Northern Channel Islands (NCI) if the sonic boom model indicates that pressures from a boom will reach or exceed 7 psf from 1 January through 28 February, 5 psf from 1 March through 31. July, or 7 psf from 1 August through 30 September. No monitoring is required on NCI from 1 October through 31 December.

Direct Effects. No ground disturbing activities or vegetation management activities would occur within the habitat of marine mammals; therefore, these actions would not exceed Level B harassment to marine mammals, as authorized by NMFS, including during harbor operations.

Noise Effects. Noise and visual disturbance can cause variable levels of disturbance to pinnipeds that may be hauled out within the areas of exposure, depending on the species exposed and the level of the noise levels. NMFS has previously determined that the only potential stressors associated with the specified activities that could cause harassment of marine mammals (i.e., rocket engine noise, sonic booms) only have the potential to result in harassment of marine mammals that are hauled out of the water (NMFS 2024a). As a result, not all Falcon 9 first stage recoveries are expected to result in harassment of marine mammals. First stage recoveries throughout the majority of the proposed landing area will not result in landing engine noise or sonic booms greater than 1.0 psf impacting mainland or islands. Sonic booms greater than 1.0 psf would occasionally impact the NCI and pinniped haulouts in southeastern Santa Barbara and Ventura Counties. The DAF has monitored pinnipeds during launch-related sonic booms on the NCI during numerous launches over the past two decades and determined that there are generally no significant behavioral disruptions caused to pinnipeds by sonic booms less than 1.0 psf. Pinniped monitoring on VSFB during numerous launches over the past two decade has also found that generally only a portion of the pinnipeds present tend to react to rocket engine noise and sonic booms. Reactions between species are different. For instance, Pacific harbor seals and California sea lions tend to be more sensitive to disturbance and may react by entering the water while northern elephant seals raise their head or have no reaction. Normal behavior and numbers of hauled out pinnipeds typically return to pre-launch levels within 24 hours or less (often within minutes) after a launch event. The DAF has monitored pinnipeds on VSFB and the NCI during many launches to characterize the effects of noise and visual disturbance on pinnipeds over the past two decades and determined there are generally no substantial behavioral disruptions or anything more than temporary affects to the number of pinnipeds hauled out on VSFB and the NCI. Any impacts to Pacific harbor seals hauled out in eastern Santa Barbara and Ventura Counties are expected to be similar to what has been observed on VSFB and NCI – harbor seals would likely respond to sonic booms by entering the water but returning to normal behavior relatively quickly. Monitoring has not found additional or new effects on marine mammals as launch cadence at VSFB has increased and no observations of injury or mortality to pinnipeds during monitoring have been attributed to past launches.

MMPA-protected marine mammals have the potential to be disturbed during RORO barge operations. However, adverse effects are not anticipated because Environmental Protection Measures (EPMs), including entering the harbor to the extent possible at high tides when pinnipeds are not present, limiting, and restricting nighttime activities and using artificial lighting, and slowly starting any noisy activities, would help minimize and avoid any behavior disruptions.

Given the authorizations and EPMs in place (as described in Appendix A, Section A.3, Marine Biological Resources), including the required monitoring, the Proposed Action would result in insignificant effects on MMPA protected pinnipeds.

Consistency Review Conclusion

The DAF and USFWS initiated formal consultation for potential impacts resulting from the Proposed Action that may affect but are not likely to adversely affect the southern sea otter. The DAF will comply with the terms and conditions of the Biological Opinion (BO) for the 36, and the BO for the 50 when finalized. NMFS issued a new LOA to SLD 30 in April 2024 to allow Level B Harassment (behavioral disruption) of pinnipeds. The DAF will comply with the conditions of the LOA and will implement the necessary monitoring and mitigation activities to protect marine mammal species.

The DAF has determined that the Proposed Action would not result in population-level effects on any marine resources and biological productivity of coastal waters would be maintained for long-term commercial, recreational, scientific, and educational purposes. Therefore, the Proposed Action would be fully consistent with Sections 30230 and 30231 of the CCA.

3.2.4 ARTICLE 4: MARINE ENVIRONMENT (WATER QUALITY)

Policies

CCA Section 30231 – "Biological productivity; water quality" states (in part):

> *… minimizing adverse effects of waste water discharges and entrainment, controlling runoff, preventing depletion of ground water supplies and substantial interference with surface water flow, encouraging waste water reclamation, maintaining natural vegetation buffer areas that protect riparian habitats, and minimizing alteration of natural streams.*

CCA Section 30232 – "Oil and hazardous substance spills" states:

> *Protection against the spillage of crude oil, gas, petroleum products, or hazardous substances shall be provided in relation to any development or transportation of such materials. Effective containment and cleanup facilities and procedures shall be provided for accidental spills that do occur.*

Consistency Review

Wetlands

The Proposed Action does not involve construction or ground disturbance, therefore there would no impacts to wetlands in the coastal zone.

Surface Water

Activities during operations would include using hazardous materials and generating wastewater that if not properly controlled and managed could result in an adverse impact to water resources. However, EMPs would continue to be implemented to properly manage materials, and to reduce or eliminate project-associated runoff, which reduces the potential for adverse effects (see Appendix A). Commercial space companies are independently responsible for compliance to provisions of the Clean Water Act and its requirements for development of site-specific Spill Prevention, Contingency, and Countermeasures (SPCC) plan under 40 C.F.R. 112. Inspection and enforcement of each SPCC and any permitted tanks are delegated to the Santa Barbara County Certified Unified Programs Agency. The SPCC requirements for commercial space companies do not fall under the jurisdiction of SLD 30. SpaceX maintains and operates under an SPCC with Santa Barbara County CUPA. Under 40 C.F.R. 112, the SPCC includes elements that the Commission considers critical for these plans, including: an oil spill risk and worst-case scenario spill assessment, response capability analysis of the equipment, personnel, and strategies (both on-site and under contract) capable of responding to a worst-case spill, including alternative response technologies, oil spill preparedness training and drills, and evidence of financial responsibility demonstrating capability to pay for costs and damages from a worst-case spill. SpaceX's secondary containment is sized to capture all materials contained within any tanks present and the SPCC includes the necessary specifications on the spill response supplies needed at the site during operations.

Launch activities at SLC-4 would create exhaust clouds (plumes); however, Falcon does not use solid fuels, which have the potential to result in toxic plumes. Wastewater discharges would continue to follow the conditions of the Regional Water Quality Control Board (RWQCB) letter for Enrollment in the General Waiver of Waste Discharge Requirements for SLC-4E Process Water Discharges to eliminate potential adverse effects to water quality. Any water that remains after launches or stormwater that accumulates within the trench would be tested for contamination. If contamination is encountered, the contents would be pumped out and disposed of per the waiver/permit and state and Federal regulations. If the water is clean enough to go to grade, it would be discharged from the retention basin via a spray field. Currently, the water can be discharged to grade via the spray field approximately 90-95% of the time. It would then percolate into the groundwater system and flow down gradient. Therefore, impacts to surface water from launch operations under the Proposed Action would not be significant.

At maximum cadence, the Proposed Action would use up to 20.07 acre-feet of water per year. This would represent approximately 0.7 percent of the total annual water usage on VSFB; which would be negligible and not result in any measurable impacts to flow rates, hydration periods, or water levels in San Antonio Creek. Therefore, effects on surface water in San Antonio Creeks under the Proposed Action would not be significant. Therefore, effects to surface water from launch operations under the Proposed Action would be insignificant.

Ground Water

The Proposed Action does not involve construction or ground disturbance. At a maximum cadence of 50 launches per year, including static fires and landings, the Proposed Action, including water to support personnel and operational activities, would use up to 20.07 acre-feet of water per year.

Wastewater discharges that may occur during project activities, including accumulated stormwater and non-stormwater discharges, would continue to be managed IAW the RWQCB letter for Enrollment in the General Waiver of Waste Discharge Requirements for SLC-4E Process Water Discharges. After a launch, approximately 9,000 gallons of deluge water per Falcon 9 launch would remain in the existing retention basin after evaporation. Samples of the deluge water would be collected and analyzed. If the water is clean enough to discharge to grade, it would be discharged from the retention basin via the spray field as described in prior Environmental Assessments. It would then percolate into the groundwater system and flow down gradient into Spring Canyon. With adherence to federal, State, and local laws and regulations, impacts on groundwater would be less than significant.

Marine Debris

It is SpaceX's goal to land and recover all first-stage boosters for reuse. However, due to mission requirements (e.g., missions that require all available propellant due to heavier payloads or higher energy orbits), on rare occasions boosters may be unable to complete a boost-back burn and landing and would be expended in the broad open ocean well outside of State jurisdictional waters. When a first stage booster is intentionally expended, the first stage is expected to break up upon atmospheric reentry, and any residual fuel is dispersed and evaporated such that there's none left when the vehicle debris hits the ocean. Upon impact with the ocean's surface, the inert vehicle debris is expected to sink, like the fate of traditional non-reusable first stage boosters. However, these boosters would not have the potential to affect coastal water resources because they are made of inert materials that would not impact water quality, and they would be expended well outside of the coastal zone. SpaceX has not conducted an expendable booster mission from SLC-4E since 2018.

SpaceX attempts to recover potential debris where practicable. However, due to weather conditions, sea state, or other factors, a recovery attempt may be unsuccessful. SpaceX successfully completed all landing attempts in 2023, all attempted fairing recoveries (180 fairing halves) in both the Pacific and Atlantic Oceans and recovered approximately 75 percent of parafoils in the Pacific Ocean. Fairings, parachutes, and parafoils would land well outside of State jurisdictional and U.S. territorial waters but could land within the U.S. Exclusive Economic Zone. The fairings, parachutes/parafoils and their assemblies are all inert.

If a parachute or parafoil is not recovered, it would sink to the seafloor within a matter of hours. The degradation of parachute and parafoil materials would be a slow process that takes place after the materials have settled on the seafloor. It is possible that small fragments could temporarily resuspend in the water column, but the potential for this depends on local ocean floor conditions and the fragments are not expected to resuspend high in the water column where they would likely be encountered by ESA-listed species. Recovery operations typically take place far offshore (e.g. 300-500 NM) and any drogue parachutes or parafoils not recovered are expected to settle (> 3,000 m [9,800 ft]). Given the rapid rate parachutes and parafoils sink to the floor, the potential for adverse effects due to entanglement is low.

Weather balloons are 100% biodegradable and would split into pieces and quickly sink, along with the plastic radiosonde potentially within State jurisdictional waters. Both the weather balloon and radiosonde are inert. The final landing location of the weather balloon and radiosonde is dependent on wind conditions at the time of release, thus not every weather balloon released will land in the ocean.

As weather ballons rise, their volume increases to a point where the elastic limit is reached and the balloon bursts. The temperature at this altitude range can reach negative 40 degrees Fahrenheit and even colder. Under these conditions of extreme elongation and low temperature, the balloon undergoes “brittle fracture” where the resultant pieces of rubber are small strands comparable to the size of a quarter (Burchette 1989). This was confirmed by researchers at the University of Colorado and NOAA (University of Colorado and NOAA 2017). The small shreds then make their way back to the surface of the Earth and are expected to land in the ocean. Along the way, the pieces can be subject to movements in atmospheric pressure and wind as they sink through the air. This can cause the fragments to become scattered and disperse before landing on the surface of the ocean where they are subject to movement of surface currents, which can cause additional dispersion.

The balloon fragments would be positively buoyant, float on the surface, and begin to photo-oxidize due to UV light exposure. Studies have shown latex in water will degrade, losing tensile strength and integrity, though this process can require multiple months of exposure time (Pegram and Andrady 1989; Andrady 1990; Irwin 2012). Field tests conducted by Burchette (1989) showed latex rubber balloons are very degradable in the environment under a broad range of exposure conditions, including exposure to sunlight and weathering and exposure to water. The balloon samples showed significant degradation after six weeks of exposure (Burchette 1989).

The floating latex balloon fragments would provide substrate for algae and eventually be weighed down with growth of heavier epifauna, such as tunicates (Foley 1990). The degree to which such colonization may occur will correspond to the amount of time the balloon remains at or near the ocean’s surface. Additionally, an area’s geographic latitude (and corresponding climatic conditions) has a marked effect on the degree of biofouling on marine debris. Fouling of the latex shreds could be confused with organic matter while ESA-listed species are foraging. Green sea turtles are herbivorous and a large study of green sea turtles that stranded in Texas between 1987 and 2019, discovered 48% had ingested plastic, although there was no evidence of mortality related to the ingestion of the plastics (Choi et al. 2021). A study of latex balloon fragment ingestion by freshwater turtles and catfish found no significant impact on survival or blood measured indicators of stress response (Irwin 2012).

In addition to further degradation of the latex material, the embedded fouling organisms would cause the material to become negatively buoyant, making it slowly sink to the ocean floor. Studies in temperate waters have shown that fouling can result in positively buoyant materials (e.g., plastics) becoming neutrally buoyant, sinking below the surface into the water column after only several weeks of exposure (Ye and Andrady 1991; Lobelle and Cunliffe 2011), or descending farther to rest on the seafloor (Thompson et al. 2004).

SpaceX’s recovery efforts have reduced marine debris by approximately 74,804 lbs per launch. If SpaceX’s 2023 payload manifest for missions originating from SLC-4E was launched using expendable boosters and fairings, as all other launch providers currently operate, approximately 2,094,400 lbs of debris would have been deposited in the broad open water of the Pacific Ocean. For 2022 missions originating from VSFB, SpaceX achieved a 54 percent recovery rate for parafoils and recovered three drogue parachutes. SpaceX improved upon the parafoil recovery rate in 2023, recovering approximately 77 percent of all parafoils.

These recovery efforts have reduced marine debris by approximately 99.8 percent compared to a traditional launch provider. The continued recovery of the vast majority of the first stage and fairings offsets the rare occurrence that an ocean landing would occur.

To offset any effects from marine debris within State jurisdictional waters, SpaceX participates in the SLD 30 Adopt-A-Beach Program, which conducts quarterly beach cleanups at Surf Beach. SpaceX also makes an annual contribution to the California Lost Fishing Gear Recovery Project to offset the impacts from unrecoverable debris within State jurisdictional waters. Under nominal conditions, the first stage, fairing halves, parachutes, and parafoils impact the ocean well outside of State or Federal jurisdictional waters. For every pound of unrecovered debris landing in State jurisdictional waters, SpaceX would make a compensatory donation of $20.00 in a lump sum payment in the first quarter of the following year. This mitigation approach was agreed upon through coordination with NMFS in 2016 during consultation for potential impacts to Essential Fish Habitat from marine debris and was determined based on the USACE mitigation ratio checklist, as recommended by NMFS and in coordination with the University of California, Davis, which manages the California Lost Fishing Gear Recovery Project (SpaceX 2016). The mitigation ratio previously agreed upon with NMFS was $7.50 for every three pounds of debris; however, DAF has increased this ratio to further offset any potential impacts. SpaceX would provide annual reports on recovery efforts to DAF.

Water Supply

VSFB has two sources of drinking water; during normal operating conditions, the primary source comes from the State Water Project and the secondary source comes from four groundwater wells located on VSFB property. The VSFB wells are typically only used to augment State Water supplies and become the primary source during emergency repair or annual maintenance shutdowns on the State Water Project system. Over the past twenty years there have been several persistent drought periods affecting State Water Project supplies and VSFB has had to rely on its groundwater wells for extended periods to meet supply demands. At maximum cadence, the Proposed Action would use up to 20.07 acre-feet of water per year. This would represent approximately 0.7 percent of the total annual water usage on VSFB; which would be negligible and not result in any measurable impacts to the water supply or San Antonio Creek Groundwater Basin. The Proposed Action is within the normal fluctuation and water demand of VSFB. The Proposed Action's water usage would result in no effect to sensitive coastal resources in San Antonio Creek.

Conclusion

The Proposed Action avoids effects of interfering with surface water flow and would have insignificant effects on the quality of coastal waters, streams, wetlands, or estuaries. Therefore, the Proposed Action is fully consistent with Sections 30231 and 30232 of the CCA.

3.2.5 Article 4: Marine Environment (Commercial and Recreational Fishing)

Policies

CCA Section 30234 – "Commercial fishing and recreational boating facilities" states:

> *Facilities serving the commercial fishing and recreational boating industries shall be protected and, where feasible, upgraded. Existing commercial fishing and recreational boating harbor space shall not be reduced unless the demand for those facilities no longer exists or adequate substitute space has been provided. Proposed recreational boating facilities shall, where feasible, be*

> *designed and located in such a fashion as not to interfere with the needs of the commercial fishing industry.*

CCA Section 30234.5 – "Economic, commercial and recreational importance of fishing" states:

> *The economic, commercial, and recreational importance of fishing activities shall be recognized and protected.*

Consistency Review

Southern California's west coast is a leading recreational and commercial fishing area. SpaceX launches missions from VSFB with a launch azimuth between 140 and 325 degrees, supporting a wide range of U.S. Government missions. The maritime hazard area follows the path of the trajectory and is approximately 21 miles wide at its widest for Falcon 9 (Figure 3.2-1 and Figure 3.2-2). The maritime hazard area for any given mission would include up to approximately 16 to 20 California Commercial Fisheries Blocks as defined by the California Department of Fish and Wildlife. Southerly and northernly trajectories would cover more blocks than westerly trajectories, as the vehicle's trajectory is over state waters for longer. These launch azimuths also include multiple State Marine Reserves, which currently prohibit or significantly limit fishing. These are generally clustered around VSFB and the NCI.

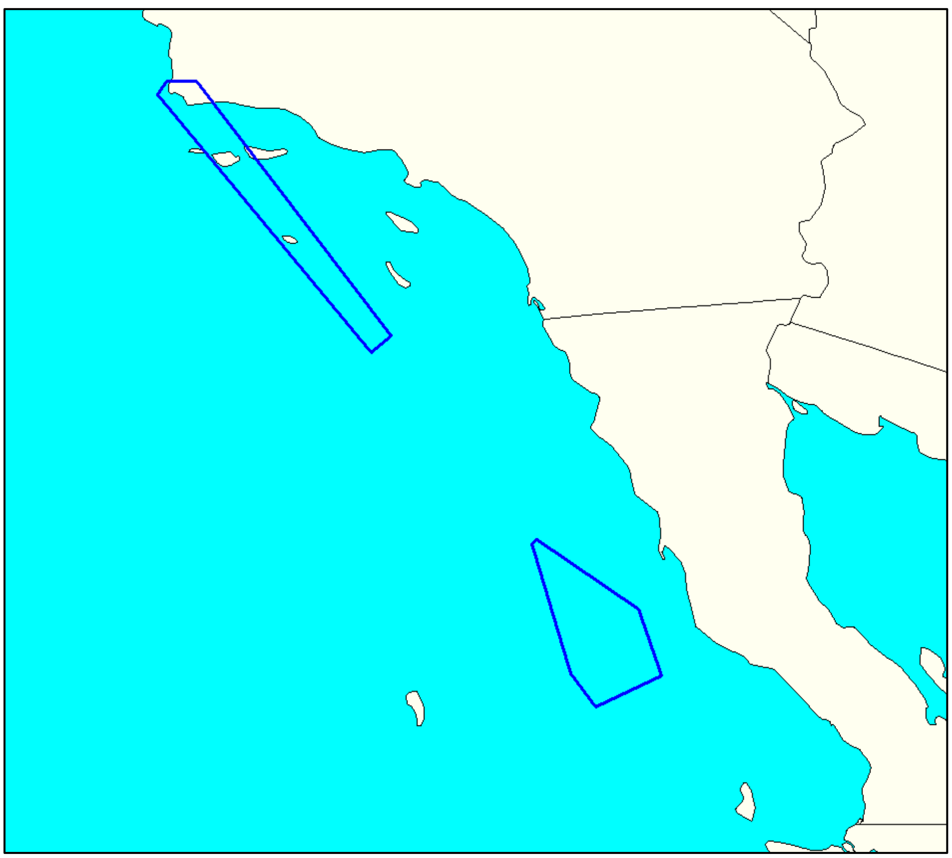

Figure 3.2-1. Example vehicle maritime hazard area (blue) for Falcon 9 launches. Note the maritime surveillance area is not shown because it does not extend off of land.

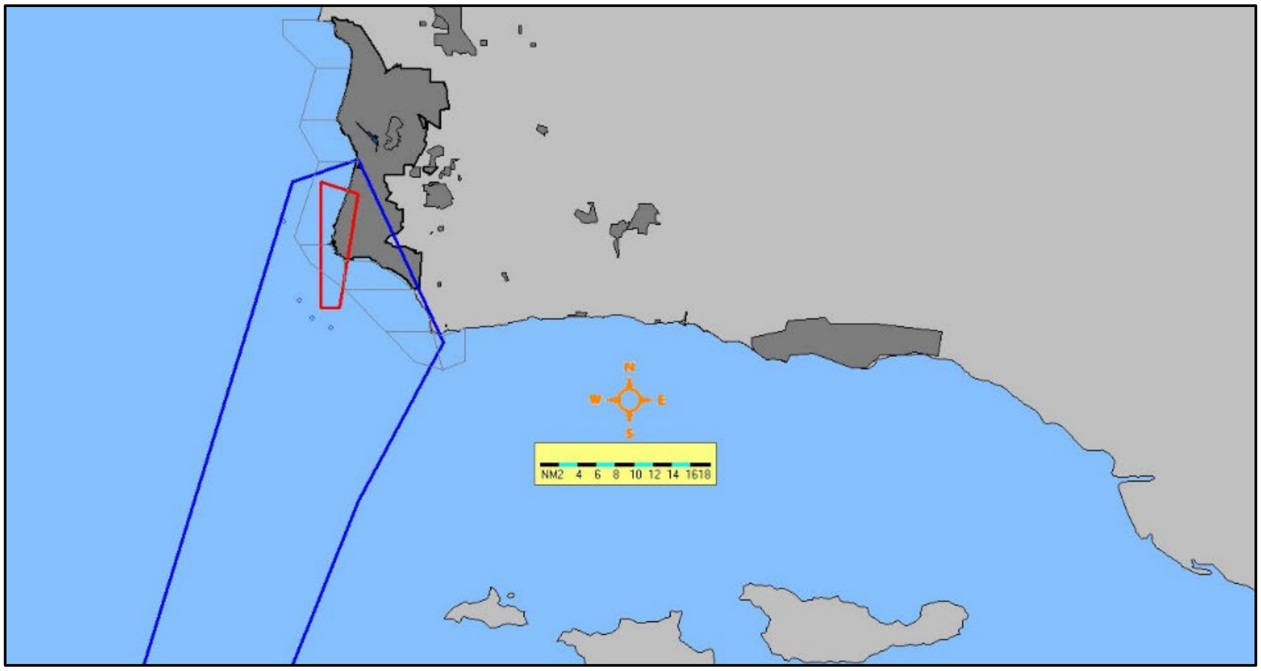

Figure 3.2-2. Example vehicle maritime hazard area (blue) and maritime surveillance area (red) for Falcon 9 launches

Fishing in these blocks varies and is largely conducted by vessels from the Santa Barbara Harbor, Port San Luis, and Morro Bay Harbor. Fishing in the blocks potentially affected by SpaceX VSFB launches is limited compared to other areas but is valuable for select species. The range of potential launch azimuths primarily overlays low producing fishing blocks and does not affect the high producing blocks that are further east around the Channel Islands (Figure 3.2-3). In 2023, the blocks overlaid by the range of SpaceX's potential azimuths landed a total of 10,949,361 pounds (lbs) worth $18,037,773, which is 9.9% of California's total landings, or 11.2% of the value of the state's total landings (Table 3.2-3; CDFW 2023).

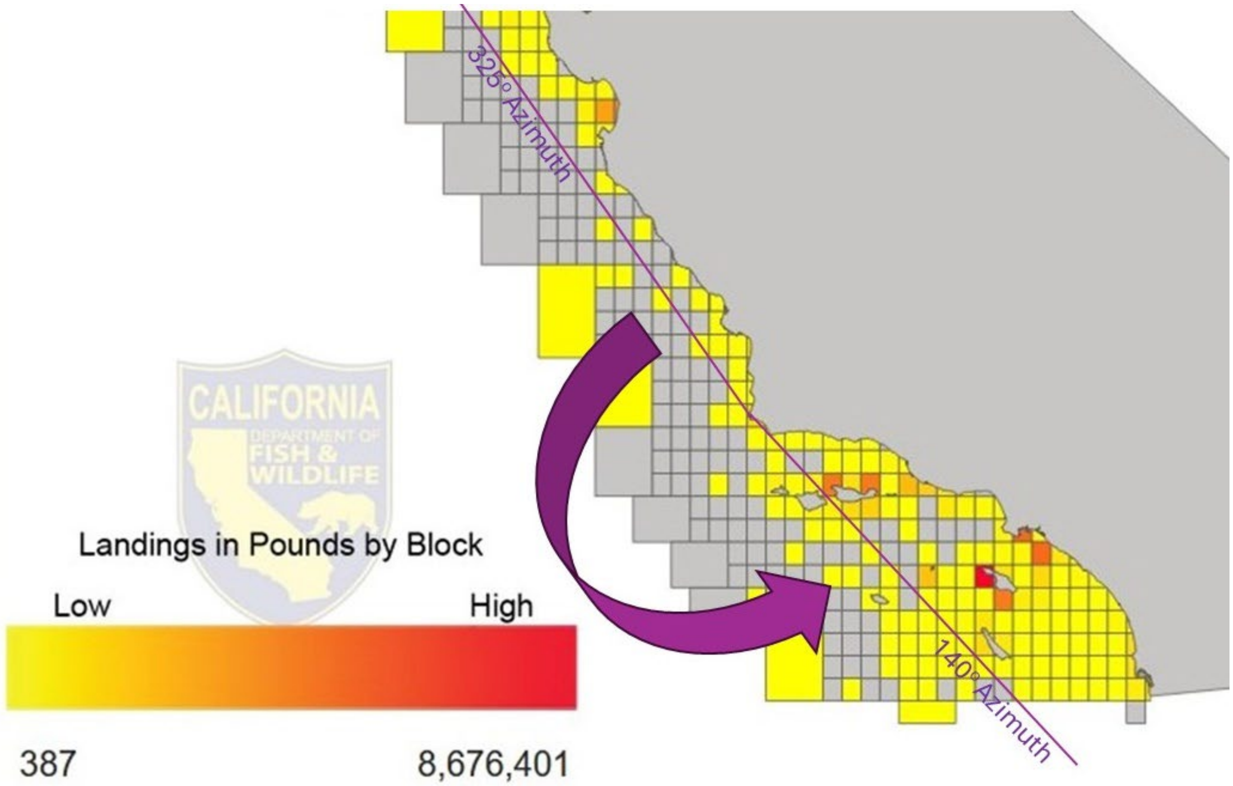

Figure 3.2-3. Productivity of fishing blocks in 2023 potentially affected by SpaceX launches

Table 3.2-3. Productivity of fishing blocks by species management group

Species Management Group	Pounds	Value	% of Selected Blocks		% of State Total	
			lbs	$	lbs	$
Coastal Pelagic Species (CPS)	7,946,236	$ 4,289,677.00	72.6%	23.8%	12.3%	13.2%
Groundfish	857,498	$ 2,480,089.00	7.8%	13.7%	6.1%	14.9%
Highly Migratory Species (HMS)	232,784	$ 1,325,434.00	2.1%	7.3%	8.7%	14.5%
Marine State Managed Fish	396,281	$ 792,260.00	3.6%	4.4%	12.4%	9.6%
Marine State Managed Invertebrates	1,478,625	$ 8,938,281.00	13.5%	49.6%	5.6%	9.5%
Nearshore Fishery Management Plan Species	37,937	$ 212,032.00	0.3%	1.2%	29.0%	28.4%
Total	**10,949,361**	**$18,037,773**				

The public's safety during launch operations is of upmost importance to SLD 30, FAA, USCG, and SpaceX, which includes the protection of maritime users near the launch vehicle's flight trajectory. Comprehensive safety measures, governed by federal regulations, are put into place for every launch to identify, communicate, and monitor areas that are at risk. Launch operations are conducted in a manner that is biased towards public safety and vessels that ignore hazard warnings near the launch trajectory may delay or cancel a launch if they present unacceptable public risk. While considerable formal planning and regulatory communications are accomplished during this process, successful implementation is dependent upon the good faith and collaboration of all maritime users.

The USCG supports launches from federal ranges by notifying the public of the maritime hazard upon request by the range authority or by the launch operator if a Letter of Intent has been signed by both parties. The USCG is not obligated to provide assets during commercial launch activities and maintains the discretion to determine how to employ its resources and manage maritime risks within their jurisdiction. The USCG issues various types of NOTMARs; including Local Notice to Mariners (LNM), Broadcast Notice to Mariners (BNM), and Marine Safety Informational Bulletin (MSIB), all of which include the predicted time and location of the hazard. These are notifications of potential hazardous operations and do not explicitly prohibit vessels from entering the identified areas. In determining the appropriate NOTMAR for the planned hazard areas, USCG District 11 reviews the risk assessments performed by SLD 30 for the launch or reentry activity and impacted commercial and recreational vessels on the high seas off the California Coast.

To ensure public safety, such warnings are issued for a window of time that includes the nominal launch duration plus the expected debris fall time in the event of a failure. The timing, duration, and direction of the launch is highly dependent upon the mission's requirements for accessing space. Akin to the ocean tides often dictating the best times for fishing, the earth's rotation and orbital mechanics dictate when and what direction to launch. For example, when needing to rendezvous with another spacecraft, the length of available times to launch can be as short as instantaneous and inflexible to move. Similarly, launch opportunities may only be available every few days or may only be available for a few weeks every so many years, which often is the case in launching to other planets or space objects. Alternatively, populating satellite constellations and launching prototype satellites are typically more flexible and may result in longer and adjustable times. Even with the most flexible orbital requirements, the length of the time window for launch, as well as the number of consecutive launch attempts, must be constrained to properly fit into other maritime operations as well as with the FAA-managed national airspace system and the efficient operations and movement across VSFB. In addition to mission requirements, launch days/times are adjusted to reduce range scheduling conflicts with SLD 30, national airspace impacts with FAA, radio frequency conflicts with U.S. Government users, and maritime impacts with USCG and U.S. Navy.

FAA regulations require the public to be notified of all maritime hazard areas for each launch. If the risk, as calculated by SLD 30, within a portion of the maritime hazard area exceeds a threshold determined by the FAA, access to this smaller area, known as the “surveillance area” may be restricted in order for launch to be allowed to proceed. Due to Falcon’s reliability, SpaceX’s surveillance areas for launches from VSFB have insignificant effects on maritime activities. For many missions, this closure area does not even leave land. Accordingly, only a small subset of fishing blocks within the vicinity of VSFB have the potential to be closed by each launch and for a relatively short period of time. The area within the hazard area, but not closed to vessel traffic, is approximately two blocks wide along each given trajectory. The size and shape of this area is described in the published NOTMAR and is specific to the mission and timing. As previously stated, this corridor is approximately 21 miles wide at its widest to a point where the risk is below safety thresholds. The size varies based on several factors including the launch flight trajectory and simulations of variations of the trajectory, expected seasonal winds, launch vehicle reliability, launch vehicle break-up modeling in case of an anomaly, anticipated vessel traffic, population data near the launch site, and other factors.

As noted above, since the NOTMARs are notices for unpatrolled hazard areas and not hard closures, vessels that enter the hazard area pose a safety risk for the launch. When an incursion of the NOTMAR occurs, SLD 30 or USCG personnel may contact the vessel and request confirmation of the number of passengers on-board, if the vessel cannot be contacted, a conservative estimate is assumed. SLD 30 range safety personnel then use this value to update risk safety calculations in real-time verify the safety requirements are not exceeded. For small vessels with only a few people, such as most recreational and commercial fishing vessels, the risk calculations often are not violated, and the launch may proceed. However, an increase in vessel traffic in the vehicle hazard area and/or a vessel (even a small one) close to the trajectory may violate the safety criteria and cause the launch to be delayed or cancelled. SpaceX has both delayed and cancelled launch attempts in order to protect the safety of vessels that did not heed the warning in the NOTMAR and proceeded to enter the hazard area. A launch delay or cancellation adds significant operations costs to a launch, including rescheduling of range assets and staffing, perishable launch commodities (e.g., liquid oxygen, nitrogen gas, helium gas), mission delay costs, and potential customer penalties. DAF and SpaceX are therefore highly motivated to work with other maritime users to avoid conflicts that could cause inadvertent delays.

Communication beyond the NOTMAR is key to successfully minimize and avoid impacts to recreational and commercial fishing stakeholders. DAF, in coordination with SpaceX, has established a communication protocol with maritime stakeholders in the region and maintains regular dialogue with a variety of commercial and recreational fishing stakeholders, including the Port San Luis Commercial Fishermen’s Association and similar fisherman associations, fish buyers and processors, harbor masters, and sport fishing companies. The chairmen of local fisherman’s associations are provided an email that includes the date and time of upcoming mission surveillance areas, and the vessel hazard areas that are also available in the NOTMARs, and for how long these will be in effect. Collaborative pre-planning and deeper understanding of the NOTMAR warning areas allows mariners to understand how small adjustments in their plans, such as adjusting port departure times or fishing areas, will meet their landing goals while also respecting DAF's responsibility for public safety in the maritime environment. Orbital mechanics and other competing demands, such as FAA commercial air traffic adjustments, may not fully satisfy fishermen requests. In these cases, additional coordination prior to and on launch day helps balance needs, including updated launch safety calculations and real-time radio communications. Therefore, effects on recreational and commercial fishing would be insignificant. The Proposed Action is fully consistent with Sections 30234 and 30234.5 of the CCA.

3.2.6 Article 5: Land Resources

Policies

CCA Section 30240 (b) – "Environmentally sensitive habitat areas, adjacent developments" states:

> *Development in areas adjacent to environmentally sensitive habitat areas and parks and recreation areas shall be sited and designed to prevent impacts which would significantly degrade those areas, and shall be compatible with the continuance of those habitat and recreation areas.*

CCA Section 30244 – "Archaeological or paleontological resources" states:

> *Where development would adversely impact archaeological or paleontological resources as identified by the State Historic Preservation Officer, reasonable mitigation measures shall be required.*

Consistency Review

It is the position of the DAF that ESHA policy, in particular Section 30240(a) of the Coastal Act, is not applicable to the activities only affecting VSFB property. While the CZMA allows the CCC to review federal agency activities and actions that have reasonably foreseeable effects on coastal uses or resources in the coastal zone (of VSFB property) affecting any land or water use or natural resource, Section 304 of the CZMA defines coastal zone to exclude "lands the use of which is by law subject solely to the discretion of or which is held in trust by the Federal Government, its officers or agents." SLD 30 is voluntarily analyzing some of the below species on VSFB property (no reasonably foreseeable affects off VSFB property) as well as those off VSFB property.

The Proposed Action does not involve any construction or ground disturbing activities. However, multiple federally listed species protected under the Endangered Species Act (ESA), potential habitat that supports these listed species, and several state special status species occur within the vicinity of SLC-4 and downrange that could experience effects due to launch and landing.

Table 3.2-4 contains the species that occur within the noise footprint that are federally listed as threatened or endangered under the ESA or proposed for listing under the ESA. The DAF determined these species may be potentially affected by the Proposed Action from noise and/or construction-related impacts on VSFB property. The DAF initiated formal consultation with the USFWS for these species and the Biological Assessment (Appendix D; MSRS 2024) has been shared with the CCC Staffers and is included in Appendix D. Full details of all analyses described below can be found in the Biological Assessment. In addition to ESA-listed species, VSFB reports, the California Natural Diversity Database, eBird, NMFS aerial pinniped count data, and Naval Base Ventura County Point Mugu pinniped count data were utilized to determine presence of sensitive species. The full list of sensitive species is included in Appendix B.

Table 3.2-4: Determination of Potential Impacts to Federally Listed and Proposed Threatened & Endangered Species

Common Name	Scientific Name	Federal Listing	Critical Habitat	Effects Determinations for the Proposed Action
Tidewater Goby	*Eucyclogobius newberryi*	Endangered	Designated, no overlap with Action Area	May affect, but is not likely to adversely affect.
Unarmored Threespine Stickleback	*Gasterosteus aculeatus williamsoni*	Endangered	Not designated	May affect, but is not likely to adversely affect.
California Tiger Salamander	*Ambystoma californiense*	Endangered	No Effect	May affect, but is not likely to adversely affect.
California Red-legged Frog	*Rana draytonii*	Threatened	No effect	May affect, and is likely to adversely affect.
Arroyo Toad	*Anaxyrus californicus*	Endangered	No Effect	May affect, not likely to adversely affect.
Western Spadefoot	*Spea hammondii*	Unlisted	N/A	May affect, but is not likely to adversely affect.
Southwestern Pond Turtle	*Actinemys pallida*	Unlisted	N/A	May affect, and is likely to adversely affect.
Marbled Murrelet	*Brachyramphus marmoratus*	Threatened	Designated, no overlap with Action Area	May affect, but is not likely to adversely affect.
Southwestern Willow Flycatcher	*Empidonax traillii extimus*	Endangered	No Effect	May affect, but is not likely to adversely affect.
Least Bell's Vireo	*Vireo bellii pusillus*	Endangered	Designated, no overlap with Action Area	May affect, but is not likely to adversely affect.

Common Name	Scientific Name	Federal Listing	Critical Habitat	Effects Determinations for the Proposed Action
Western Snowy Plover	*Charadrius nivosus*	Threatened	No effect	May affect, and is likely to adversely affect.
California Least Tern	*Sternula antillarum browni*	Endangered	Not designated	May affect, and is likely to adversely affect.
California Condor	*Gymnogyps californianus*	Endangered	Designated, no overlap with Action Area	May affect, but is not likely to adversely affect.
California Gnatcatcher	*Polioptila californica californica*	Threatened	No Effect	May affect, not likely to adversely affect.
Light-footed Clapper Rail	*Rallus obsoletus levipes*	Endangered	Not designated	May affect, not likely to adversely affect.

Launch monitoring conducted between 2017 and 2023 has not found significant effects to California red-legged frog (CRLF), California least tern (LETE), or western snowy plover (SNPL). Monitoring has not found launch noise to have an adverse effect on CRLF, including call frequency. Nesting terns and plovers have been found to hunker down or briefly flee during noise events, but no damage to eggs has been found that can be directly attributed to the noise event. A detailed discussion of potential effects to each ESA-listed species is included in Appendix F.

Note that sonic boom model results can vary in certain geographic locations and vary in intensity as a result of specific mission trajectories and meteorological conditions on the day of the launch. The sonic boom contours depicted in the figures included in Appendix B represent example predicted model results for median meteorological conditions, not actual measurements nor precise predictions. For easterly trajectories, sonic booms may affect southeastern Santa Barbara County, Ventura County, and Los Angeles County on the mainland (Figure 3.2-4). The majority of sonic booms that would affect these areas would be less than 1.0 psf. Even with identical trajectories, atmospheric conditions create considerable variation in where sonic booms effects occur and the level of affects. To account for this variation, PCBoom can utilize meteorological parameters in the model that effect where and at what level a sonic boom may impact the surface of the earth. In the late 1990's, SRS Technologies, Inc. assembled a series of daily meteorological profiles across 10 years (1984-1994, one per day for 10 years) from radiosonde data for weather balloons released by the VSFB weather squadron. The data include pressure, temperature, wind speed, and wind direction along an elevational profile from ground, every 1,000 feet (ft), to 110,000 ft. Figure 3.2-4 depicts the overlaid output from sonic boom modeling software (PCBoom) for four actual SpaceX easterly trajectories, each trajectory run between 29 and 34 times, each run representing 1 of between 29 and 34 randomly selected meteorological profiles that capture potential weather conditions throughout the year (125 model outputs total) overlaid in the image. In order to depict the potential variability in results from multiple model outputs under many potential conditions, these results have not been transformed into contours. This also enables an evaluation of the likelihood that specific areas within the overall potential impact area, may be affected at different sonic boom intensities. 15% of model runs predicted any affects in eastern Santa Barbara County; 50% of these sonic boom levels were less than 0.25 psf, 87% were less than 1.0 psf, and 0.3% were greater than 2.0 psf. The highest level predicted for eastern Santa Barbara County was 2.13 psf. 97% of the model runs predicted sonic boom affects within Ventura County; 65% were less than 0.25 psf, 86% were less than 1.0 psf, and 0.04% were greater than 2.0 psf. The highest predicted boom level predicted for Ventura County 2.03 psf. 94% of model runs predicted affects in western Los Angeles County; 95% were less than 0.25 psf, and 100% were less than 0.75 psf. For sensitive species occurring in eastern Santa Barbara, Ventura, and Los Angeles Counties, the likelihood of sonic boom affects are evaluated using this approach in the discussion below.

Sensitive species in the coastal zone of eastern Santa Barbara County, Ventura County, and western Los Angeles County may experience a sonic boom during ascent of southeasterly launches. A noise-induced startle response could occur but would vary by species and intensity of the sonic boom. As discussed above, these sonic booms are expected to be of generally low levels and would be infrequent. The exact location and intensity of a sonic boom would vary launch to launch. There is no expectation of long-term or permanent affects to sensitive species or their reproductive success rates. A species may experience a brief startle response but would be expected to resume normal behavior quickly. Sensitive species that live underwater would be expected to see no effect, as little sound travels through the air-water interface. There would be no adverse effect to habitat as a result of sonic booms.

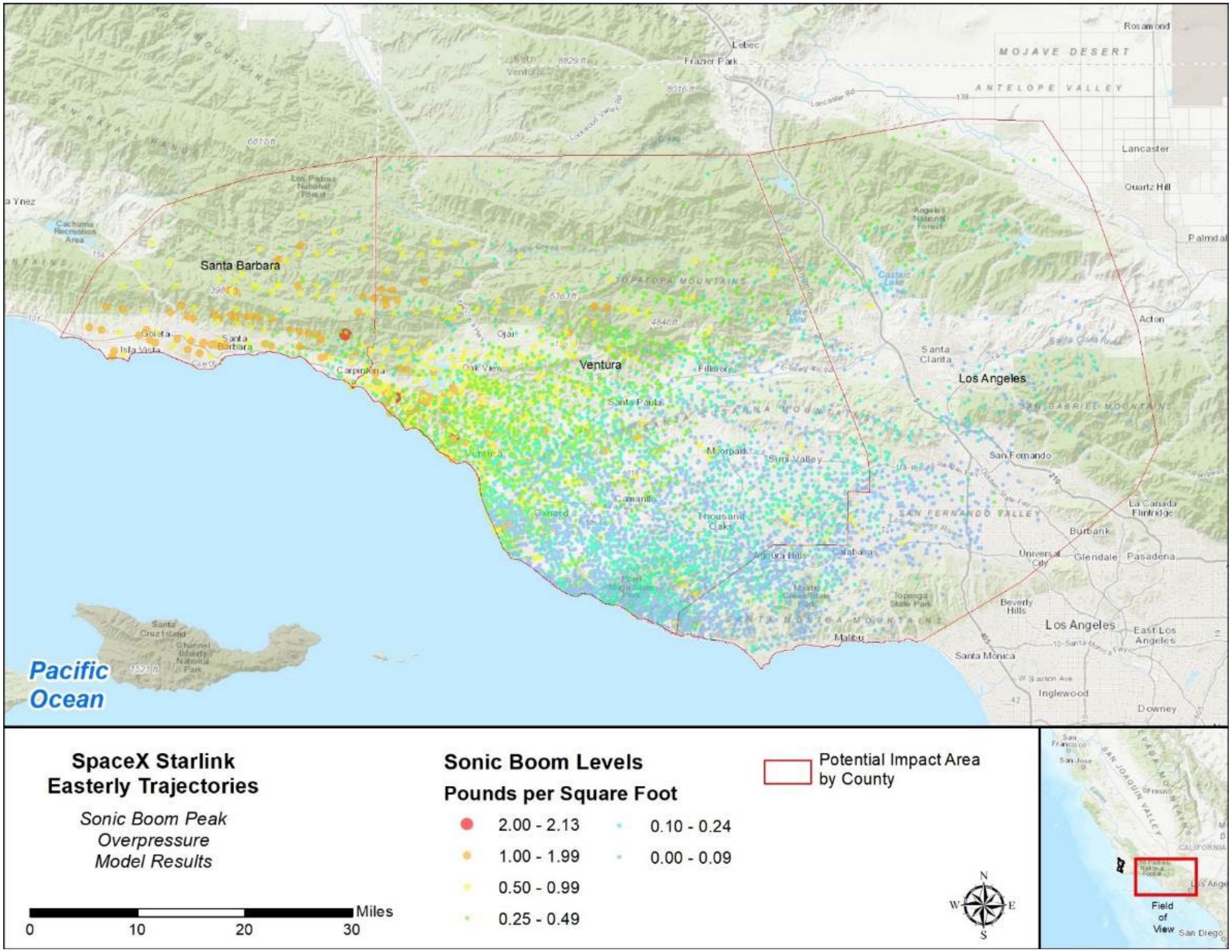

Figure 3.2-4. Potential sonic boom impact areas in eastern Santa Barbara, Ventura, and Los Angeles Counties

Reporting

The DAF would send an annual report to the Commission on all monitoring work conducted for biological resources and outline the data and results collected to date, and any initial conclusions regarding potential effects to the species resulting from the Proposed Action. The report will include the annual reports prepared for the USFWS for SNPL, LETE, and CRLF, and bat monitoring. In addition, the DAF would provide a report to the Commission 5 years from project implementation on how the Proposed Action is, or is not, affecting the surrounding special-status species and their habitats.

Consistency Review Conclusion

The DAF and USFWS initiated formal consultation for effects resulting from the Proposed Action that may affect, but are not likely to adversely affect the tidewater goby, unarmored threespine stickleback, California tiger salamander, western spadefoot, marbled murrelet, southwestern willow flycatcher, least bell's vireo, California condor, California gnatcatcher, and light-footed clapper rail. The Proposed Action may affect and are likely to adversely affect the California red-legged frog, southwestern pond turtle, western snowy plover, and California least tern and have implemented and will continue to implement the measures in the BO for the 36, and will also implement any additional measures that USFWS may add in the BO issued under the reinitiation of consultation for the increase to 50 launches annually. As such, in applying such measures, the DAF has determined that the Proposed Action would result in population-level effects on any biological resource.

Therefore, the Proposed Action with the implementation of such measures would be fully consistent with Section 30240 (b) and Section 30244 of the CCA.

4 STATEMENT OF CONSISTENCY

The DAF has reviewed the CCMP and has determined that the policies identified in Section 3.1 of this CD do not apply to the Proposed Action. In addition, the DAF has determined that all or parts of the policies reviewed in Section 3.2 of this CD are relevant for purposes of assessing whether the project would be fully consistent with the CCMP. These policies include Sections 30210, 30213, 30214, 30220, 30230, 30231, 30232, 30234, 30234.5, and 30240 (limited as not applicable on federal property).

An effects test was conducted by the DAF to analyze how and to what degree the Proposed Action would affect California coastal zone uses and resources, as defined and/or described in the relevant policies. The results of the effects test demonstrate that some components of the Proposed Action may have short-term, temporary effects to California coastal zone uses and resources. While some biological species may be temporarily affected, the Proposed Action would not have population-level permanent effects. The DAF would implement offsets, minimization measures, standard operating procedures and EPMs for the Proposed Action (Appendix A), to be fully consistent with the enforceable policies. The DAF initiated formal consultation with the USFWS and completed informal consultation with NMFS for potential effects on species listed under the ESA. NMFS has issued a LOA to the DAF for potential Level B Harassment of marine mammals due to rocket, missile, or aircraft activities from VSFB. Therefore, the Proposed Action is fully consistent with the enforceable policies of the CCMP.

The DAF requests the CCC concur that launch operations at SLC-4 on VSFB would be consistent with CCA enforceable policies.

5 REFERENCES

Andrady, A.L. 1990. Environmental Degradation of Plastics under Land and Marine Exposure Conditions. In R.S. Shomura and M.L. Godfrey (Eds.), Proceedings of the 2nd International Conference on Marine Debris, vol. 1 (pp. 848–869). United States Department of Commerce, Honolulu, Hawaii, USA.

Applegate, T.E., and S.J. Schultz. 1998. Snowy Plover Monitoring on Vandeberg Space Force Base. Launch monitoring report for the May 13, 1998 Titan II Launch from SLC-4W. Point Reyes Bird Observatory, Stinson Beach, California.

Barry, S., and B. Shaffer. 1994. The Status of the California Tiger Salamander (*Ambystoma californiense*) at Lagunita: A 50-Year Update. The Journal of Herpetology: 28(2): 159-164.

Bellefleur, D., P. Lee, and R.A. Ronconi. 2009. The impact of recreational boat traffic on Marbled Murrelets (*Brachyramphus marmoratus*). Journal of Environmental Management 90(1): 531-538.

Brattstrom, B.H., and M.C. Bondello. 1983. Effects of off-road vehicle noise on desert vertebrates. Pages 167-206 in R.H. Webb and H.G. Wilshore, eds. Environmental effects of off-road vehicles. Impacts and management in arid regions. Springer-Verlag, New York.

Burchette, D., 1989. A study of the effect of balloon releases on the environment. National Association of Balloon Artists, p.20.

California Department of Fish and Wildlife [CDFW]. 2023. Marine Fisheries Data Explorer. Available at: https://wildlife.ca.gov/Conservation/Marine/Data-Management-Research/MFDE

Capranica, R.R., and A.J.M. Moffat. 1975. Selectivity of the peripheral auditory system of spadefoot toads (*Scaphiopus couchi*) for sounds of biological significance. Journal of Comparative Physiology 100: 231-249.

Choi, D.Y., Gredzens, C. and Shaver, D.J., 2021. Plastic ingestion by green turtles (*Chelonia mydas*) over 33 years along the coast of Texas, USA. *Marine pollution bulletin*, *173*, p.113111

Curland, J. M. 1997. Effects of disturbance on sea otters (Enhydra lutris) near Monterey, California. Master's Thesis. San Jose State University, California. 47 pp.

Davis, R., T. Williams, and F. Awbrey. 1988. Sea Otter Oil Spill Avoidance Study. Minerals Management Service: 76.

Delay, S.J., O. Urquhart, and J.D. Litzgus. 2023. Wind farm and wildfire: spatial ecology of an endangered freshwater turtle in a recovering landscape. Canadian Journal of Zoology 00: 1-22. https://doi.org/10.1139/cjz-2023-0100

Dimmitt, M.A., and R. Ruibal. 1980. Environmental correlates of emergence in spadefoot toads (*Scaphiopus*). Journal of Herpetology 14:21–29.

DOD. *Commercial Space Integration Stategy*. (2024). Available at: https://media.defense.gov/2024/Apr/02/2003427610/-1/-1/1/2024-DOD-COMMERCIAL-SPACE-INTEGRATION-STRATEGY.PDF

eBird. 2021. eBird: An online database of bird distribution and abundance [web application]. eBird, Cornell Lab of Ornithology, Ithaca, New York. Available: http://www.ebird.org. (Accessed: 15 October 2022).

Foley, A.M. 1990. A Preliminary Investigation on Some Specific Aspects of Latex Balloon Degradation. Florida Department of Natural Resources, Florida Marine Research Institute. St. Petersburg, FL. August 3. 4 pp.

Francis, C.D., and J.R. Barber. 2013. A framework for understanding noise impacts on wildlife: an urgent conservation priority. Fronteirs in Ecology and the Environment 11(6): 305-313.

Geomatrix Consultants, Inc. 2005. Phase I Environmental Site Assessment, Delta IV/Evolved Expendable Launch Vehicle (EELV) Program Space Launch Complex 6 (SLC-6), Vandenberg Air Force Base. Prepared for The Boeing Company, 13 September 2005.

Ghoul, A., and C. Reichmuth. 2014. Hearing in the sea otter (Enhydra lutris): auditory profiles for an amphibious marine carnivore. Journal of Comparative Physiology. doi:10.1007/s00359-014-0943-x.

Godin, O. 2008. Sound transmission through water–air interfaces: new insights into an old problem. Contemporary Physics 49(2): 105-123.

Irwin, S.W. 2012. Mass Latex Balloon Releases and the Potential Effects on Wildlife. Doctoral Dissertation. Clemson University Department of Wildlife and Fisheries Biology, Clemson, SC. August. 73 pp.

Konishi, M. 1970. Comparative neurophysiological studies of hearing and vocalizations in songbirds. Zeitschrift fur vergleichend Physiologie 66: 257-272.

Lewis, E., and P. Narins. 1985. Do Frogs Communicate with Seismic Signals? Science 227(4683): 187-189.

Lobelle, D., and M. Cunliffe. 2011. Early microbial biofilm formation on marine plastic debris. Marine Pollution Bulletin, 62(1):197–200.

ManTech SRS Technologies, Inc. 2007a. Biological Monitoring of Southern Sea Otters, California Brown Pelicans, Western Snowy Plovers, and California Least Terns for the 7 June 2007 Delta II COSMO-1 Launch from Vandenberg Space Force Base, California. ManTech SRS Technologies, Inc., Lompoc, California. 24 pp.

ManTech SRS Technologies, Inc. 2007b. Biological Monitoring of California Brown Pelicans and Southern Sea Otters for the 14 December 2006 Delta II NROL-21 Launch from Vandenberg Space Force Base, California. SRS Technologies Systems Development Division, Lompoc, California. 21 pp.

ManTech SRS Technologies, Inc. 2007c. Biological Monitoring of Southern Sea Otters and California Brown Pelicans for the 18 September 2007 Delta II WorldView-1 Launch from Vandenberg Space Force Base, California. ManTech SRS Technologies, Lompoc, California. 18 pp.

ManTech SRS Technologies, Inc. 2008a. Biological Monitoring of Southern Sea Otters, California Brown Pelicans, Western Snowy Plovers, and California Least Terns for the 20 June 2008 Delta II OSTM Launch from Vandenberg Space Force Base, California. ManTech SRS Technologies, Inc., Lompoc, California. 29 pp.

ManTech SRS Technologies, Inc. 2008b. Biological Monitoring of Southern Sea Otters and California Brown Pelicans for the 6 September 2008 Delta II GeoEye-1 Launch from Vandenberg Space Force Base, California. Lompoc, California: ManTech SRS Technologies, Inc., Lompoc, California.

ManTech SRS Technologies, Inc. 2009a. Status of the unarmored threespine stickleback (Gasterosteus aculeatus williamsoni) in San Antonio and Cañada Honda creeks, Vandenberg Air Force Base, California. 10 February 2009.

ManTech SRS Technologies, Inc. 2009b. Biological Monitoring of Southern Sea Otters and California Brown Pelicans for the 8 October 2009 Delta II Worldview-II Launch from Vandenberg Air Force Base, California. ManTech SRS Technologies, Inc., Lompoc, California. 22 pp.

ManTech SRS Technologies, Inc. 2016. California Red-Legged Frog Habitat Assessment, Population Status, and Chytrid Fungus Infection in Cañada Honda Creek and San Antonio West Bridge Area on Vandenberg Space Force Base, California. Unpublished report. 51 pp.

ManTech SRS Technologies, Inc. 2018a. California red-legged frog habitat assessment, population status, and chytrid fungus infection in Cañada Honda Creek, Cañada del Jolloru, and seasonal pools on Vandenberg Air Force Base, California. Submitted to 30th Civil Engineer Squadron, Environmental Flight, Natural Resources Section (30 CES/CEIEA), Vandenberg Air Force Base, California.

ManTech SRS Technologies, Inc. 2018b. Biological Monitoring of Southern Sea Otters and California Red-legged Frogs for the 7 October 2018 SpaceX Falcon 9 SAOCOM Launch and Landing at Vandenberg Space Force Base, California. Prepared for 30 CES/CEIEA. 27 December 2018. 15 pp.

ManTech SRS Technologies, Inc. 2021b. California Red-Legged Frog Habitat Assessment, and Population Status on San Antonio Terrace and Assessment of Select Aquatic Features on Vandenberg Space Force Base, California in 2020. October 2021. 85 pp.

ManTech SRS Technologies, Inc. 2021c. Biological Monitoring of Southern Sea Otters and California Red-legged Frogs for the 21 November 2020 SpaceX Falcon 9 Sentinel 6A Mission at Vandenberg Space Force Base, California. January 2021. 12 pp.

ManTech SRS Technologies, Inc. 2022. Biological Monitoring of California Red-legged Frogs for the 2 February 2022 SpaceX Falcon 9 NROL-87 Mission at Vandenberg Air Force Base, California.

ManTech SRS Technologies, Inc. 2024. Biological Assessment for Falcon 9 Cadence Increase and SLC-6 Modifications at Vandenberg Space Force Base, California. Prepared for Space Launch Delta 30, Installation Management Flight Environmental Assets. 217 pp.

NMFS. 2022. Programmatic Concurrence Letter for Launch and Reentry Vehicle Operations in the Marine Environment and Starship/Super Heavy Launch Vehicle Operations at SpaceX's Boca Chica Launch Site, Cameron County, TX.

NMFS. 2024a. Takes of Marine Mammals Incidental to Specified Activities; Taking Marine Mammals Incidental to U.S. Space Force Launches and Supporting Activities at Vandenberg Space Force Base, Vandenberg, California. Dated 10 April 2024. Federal Register, Vol. 89, No. 70, pp 25163-25185.

NMFS. 2024b. Letter of Authorization, issued to the U.S. Space Force. Valid 10 April 2024, through 9 April 2029. Dated 10 April 2024. 9 pp.

Oelze, M.L., W.D. O'Brien, and R.G. Darmody. 2002. Measurement of Attenuation and Speed of Sound in Soils. Soil Science Society of America Journal (66): 788-796.

Parris, K.M., M. Velik-Lord, and J.M.A. North. 2009. Frogs call at a higher pitch in traffic noise. Ecology and Society 14(1): 25. Available at http://www.ecologyandsociety.org/vol14/iss1/ art25/.

Pegram, J.E., and A.L. Andrady. 1989. Outdoor weathering of selected polymeric materials under marine exposure conditions. Polymer Degradation and Stability, 26(4):333–345.

Robinette, D., and R. Ball. 2013. Monitoring of Western Snowy Plovers on South Surf Beach, Vandenberg Space Force Base, Before and After the 29 September 2013 SpaceX Falcon 9 Launch. Point Blue Conservation Science. Vandenberg Field Station. 22 October 2013.

Robinette, D.P., J.K. Miller, and A.J. Howar. 2016. Monitoring and Management of the Endangered California Least Tern and the Threatened Western Snowy Plover at Vandenberg Space Force Base, 2016. Petaluma, California: Point Blue Conservation Science.

Robinette, D. and E. Rice. 2019. Monitoring of California Least Terns and Western Snowy Plovers on Vandenberg Space Force Base during the 12 June 2019 SpaceX Falcon 9 Launch with "Boost-Back". Petaluma, California: Point Blue Conservation Science.

Robinette, D., E. Rice, A. Fortuna, J. Miller, L. Hargett, and J. Howar. 2021. Monitoring and management of the endangered California least tern and the threatened western snowy plover at Vandenberg Space Force Base, 2021. Unpublished Report, Point Blue Conservation Science, Petaluma, CA.

Robinette, D., E. Rice, S. Gautreaux, and J. Howar. 2024. Monitoring of California Least Terns and Western Snowy Plovers on Vandenberg Space Force Base during 11 SpaceX Falcon 9 Launches in 2023. Unpublished Report, Point Blue Conservation Science, Petaluma, CA.

Seavy N.E., M.A. Holmgren, M.L. Ball, and G. Geupel. 2012. Quantifying riparian bird habitat with orthophotography interpretation and field surveys: Lessons from Vandenberg Air Force Base, California. Journal of Field Ornithology.

Semenza, L. 2023. Personal communication via email between L. Semenza (County of Santa Barbara) and T. Whitsitt-Odell (CEIEA) on impacts of email announcements regarding Vandenberg launches on Jalama Beach County Park camping reservation holders. 28 September 2023.

Simmons, D.D., R. Lohr, H. Wotring, M.D. Burton, R.A. Hooper, and R.A. Baird. 2014. Recovery of otoacoustic emissions after high-level noise exposure in the American bullfrog. Journal of Experimental Biollogy 217(9): 1626–1636. doi: 10.1242/jeb.090092.

Space Exploration Technologies, Inc. 2016. EFH Mitigation Plan for Landing of the Falcon 9 First Stage Vandenberg Air Force Base, California. Prepared for 30th Space Wing, Installation Management Flight, Vandenberg Air Force Base, California. 12 pp.

SRS Technologies, Inc. 2002. Analysis of Behavioral Responses of California Brown Pelicans and Southern Sea Otters for the 18 October 2001 Delta II Quickbird2 Launch from Vandenberg Space Force Base, California. SRS Technologies technical report submitted to the United States Space Force.

SRS Technologies, Inc. 2006a. Biological Monitoring of Southern Sea Otters, California Brown Pelicans, and Western Snowy Plovers for the 28 April 2006 Delta II Cloudsat & CALIPSO Launch from Vandenberg Space Force Base, California. SRS Technologies technical report submitted to the United States Space Force and the U.S. Fish and Wildlife Service, 11 October 2006.

SRS Technologies, Inc. 2006b. Results from Water Quality and Beach Layia Monitoring, and Analysis of Behavioral Responses of Western Snowy Plovers to the 19 October 2005 Titan IV B-26 Launch from Vandenberg Space Force Base, California. SRS Technologies technical report submitted to the United States Space Force.

SRS Technologies, Inc. 2006c. Analysis of Behavioral Responses of Southern Sea Otters, California Least Terns, and Western Snowy Plovers to the 20 April 2004 Delta II Gravity Probe B Launch from Vandenberg Space Force Base, California. SRS Technologies technical report submitted to the United States Space Force. 12 pp.

SRS Technologies, Inc. 2006d. Analysis of Behavioral Responses of California Brown Pelicans, Western Snowy Plovers and Southern Sea Otters to the 15 July 2004 Delta II AURA Launch from Vandenberg Space Force Base, California. SRS Technologies technical report submitted to the United States Space Force. 13 pp.

SRS Technologies, Inc. 2006e. Analysis of Behavioral Responses of Southern Sea Otters, California Brown Pelicans, and Western Snowy Plovers to the 20 May 2005 Delta II NOAA-N Launch from Vandenberg Space Force Base, California. SRS Technologies technical report submitted to the United States Space Force. 15 pp.

SRS Technologies, Inc. 2006f. Biological Monitoring of Southern Sea Otters, California Brown Pelicans, and Western Snowy Plovers for the 28 April 2006 Delta II Cloudsat & CALIPSO Launch from Vandenberg Space Force Base, California. SRS Technologies technical report submitted to the United States Space Force and the U.S. Fish and Wildlife Service, 11 October 2006. 18 pp.

SRS Technologies, Inc. 2006g. Biological Monitoring of Southern Sea Otters, California Brown Pelicans, Gaviota Tarplant, and El Segundo Blue Butterfly, and Water Quality Monitoring for the 4 November 2006 Delta IV DMSP-17 Launch from Vandenberg Space Force Base, California. SRS Technologies Systems Development Division, Lompoc, California. 40 pp.

Stebbins, R.C. 1972. California amphibians and reptiles. Univ. California Press, Berkeley. 152 pp.

Strachan, G., M. McAllister, and C.J. Ralph. 1995. Marbled murrelet at-sea and foraging behavior. Chapter 23 in Ralph, C. J., Hunt, G.L., Jr., Raphael, M.G., Piatt, J.F. (eds.): Ecology and conservation of the marbled murrelet. USDA Forest Service General Technical Report PSW-152.

Sun, J.W.C., and P.M. Narins. 2005. Anthropogenic sounds differentially affect amphibian call rate. Biological Conservation 121: 419-427.

Tennessen, J.B., S.E. Parks, and T. Langkilde. 2015. Traffic noise causes physiological stress and impairs breeding migration behaviour in frogs. Conservation Physiology 2(1): cou032. Available at https://doi.org/10.1093/conphys/cou032.

U.S. Fish and Wildlife Service. 1996. California Condor Recovery Plan, Third Revision. Portland, Oregon: U.S. Fish and Wildlife Service.

U.S. Fish and Wildlife Service. 1997. Marbled Murrelet Recovery Plan. Retrieved from U.S. Fish and Wildlife Service, Portland, Oregon.

U.S. Fish and Wildlife Service. 2002. Recovery Plan for the California red-legged frog (Rana aurora draytonii). Portland Oregon.

U.S. Fish and Wildlife Service. 2003. Final Revised Recovery Plan for the Southern Sea Otter (Enhydra lutris nereis). Portland, Oregon.

U.S. Fish and Wildlife Service. 2007. Recovery Plan for the Pacific Coast Population of the Western Snowy Plover (Charadrius alexandrinus nivosus). Sacramento, California.

U.S. Fish and Wildlife Service. 2009. Marbled Murrelet (Brachyramphus marmoratus) 5-Year Review. Lacy, Washington.

U.S. Fish and Wildlife Service. 2014. 2014 Summer Window Survey Results for Snowy Plovers on the U.S. Pacific Coast.

U.S. Fish and Wildlife Service. 2015. Southern Sea Otter (Enhydra lutris nereis) 5-Year Review: Summary and Evaluation. Ventura, California: U.S. Fish and Wildlife Service.

U.S. Fish and Wildlife Service. 2017a. 2016 Summer Window Survey for Snowy Plovers on U.S. Pacific Coast with 2005-2016. Available at https://www.fws.gov/arcata/es/birds/WSP/plover.html.

U.S. Fish and Wildlife Service. 2017b. California Condor Recovery Program. Retrieved from Our Programs Pacific Southwest Region: https://www.fws.gov/cno/es/CalCondor/Condor.cfm

U.S. Fish and Wildlife Service and National Marine Fisheries Service. 1998. Endangered Species Consultation Handbook Procedures for Conducting Consultation and Conference Activities Under Section 7 of the ESA. U.S. Fish and Wildlife Service and National Marine Fisheries Service.

U.S. Government. 2020. National Space Policy of the United States of America. 9 December 2020. 40 pp.

University of Colorado and National Oceanic and Atmospheric Administration (NOAA). 2017. Pop Goes the Balloon! What Happens when a Weather Balloon Reaches 30,000 m asl? Cooperative Institute for Research in Environmental Sciences, University of Colorado, Boulder. NOAA, Boulder, Colorado. American Meteorological Society. Available: http://journals.ametsoc.org/doi/pdf/10.1175/BAMS-D-16-0094.1

Ventana Wildlife Society. 2017. California Condor #760 aka "Voodoo". Retrieved 28 March 2017, from MYCONDOR.ORG: http://www.mycondor.org/condorprofiles/condor760.html.

Ventre, C.S., Myles, M.M., and I.L. Ver. 2002. Measurements of the Reflection Factor of Flat Ground Surfaces. Prepared for National Aeronautics and Space Administration, Cambridge Massachusetts

Ye, S., and A.L. Andrady. 1991. Fouling of floating plastic debris under Biscayne Bay exposure conditions. Marine Pollution Bulletin, 22(12):608–613.

APPENDIX A – ENVIRONMENTAL PROTECTION MEASURES

Implementing the environmental protection measures (EPMs), outlined in Tables A.1-1 through A.5-1, would avoid or minimize potential adverse effects to various environmental resources during executing of the Preferred Alternative. Qualified SpaceX personnel or contractor staff would oversee fulfilling EPMs.

A.1 AIR QUALITY

The Santa Barbara County Air Pollution Control District (SBCAPCD) and California Air Resources Board (CARB) requires the dust control measures described in Table A.1-1 to decrease fugitive dust emissions, as applicable to the Proposed Action.

Table A.1-1: Control Measures to Decrease Emissions

Environmental Protection Measures – Air Quality
✓ Any portable equipment powered by an internal combustion engine with a rated horsepower of 50 brake horsepower or greater used for this project shall be registered in the California State-wide Portable Equipment Registration Program or have a valid SBCAPCD Permit to Operate.
✓ Ultra-low sulfur diesel fuel (15 parts per million by volume) will be used for all diesel equipment.
✓ CARB-developed idling regulations will be followed for trucks during loading and unloading.
✓ When feasible, equipment will be powered with Federally mandated “clean” diesel engines.
✓ The size of the engine in equipment and number of pieces of equipment operating simultaneously for the project should be minimized.
✓ Engines should be maintained in tune per manufacturer or operator’s specification.
✓ U.S. Environmental Protection Agency (USEPA) or CARB-certified diesel catalytic converters, diesel oxidation catalysts, and diesel particulate filters may be installed on all diesel equipment.
✓ SpaceX shall adhere to the CARB In-Use Off-Road Diesel-Fueled Fleets Regulation (CARB 2024) for fleet management and fuel selection.
✓ CARB diesel will be the only fuel combusted in the engines while in California Coastal Waters

A.2 Terrestrial Biological Resources

The EPMs listed below would be implemented to avoid, minimize, or characterize the effects of the Proposed Action on terrestrial biological resources. These EPMs require various levels of biological competency from personnel completing specific tasks, as defined in Table A.2-1.

Table A.2-1: Biological monitoring qualifications

Biologist Level	Necessary Qualifications
Permitted Biologist	Biologist with a valid and current USFWS section 10(a)(1)(A) Recovery Permit or specifically named as an approved biologist in a project-specific BO. The DAF will coordinate with the USFWS prior to assigning permitted biologists to this project
USFWS Approved Biologist	Biologist with the expertise to identify species listed under the Endangered Species Act (ESA) and species with similar appearance. The DAF will review and approve the resumes from each individual, and then submit them to the USFWS for review and approval no less than 15 days prior to the start of the Proposed Action. Each resume will list their experience and qualifications to conduct specific actions that could potentially affect listed species and their habitats. A USFWS-approved biologist could train other biologists and personnel during surveys and project work; in some cases, a USFWS-approved biologist could also provide on-site supervision of other biologists.
Qualified Biologist	Biologist trained to accurately identify specific federally listed species and their habitats by either a Permitted or USFWS-approved biologist. This person could perform basic project monitoring but would need to have oversight from a permitted or USFWS-approved biologist. Oversight will require a permitted or USFWS-approved biologist to be available for phone/email consultation during the surveys and to have the ability to visit during monitoring/survey activities if needed.

A.2.1 General Measures

The measures described in Table A.2-2 would be implemented to minimize the potential impacts on terrestrial biological resources.

Table A.2-2: General Measures

Environmental Protection Measures – Terrestrial Biological Resources
✓ All erosion control materials used will be from weed-free sources and, if left in place following project completion, constructed from 100 percent biodegradable erosion control materials (e.g., erosion blankets, wattles).
✓ All human-generated trash at the project site shall be disposed of in proper containers and removed from the work site and disposed of properly at the end of each workday. Large dumpsters can be maintained at staging areas for this purpose.
✓ Heavy equipment and vehicles (mowers, etc.) shall be cleaned of weed seeds prior to use in the project area to prevent the introduction of weeds and be inspected by a qualified biological

Environmental Protection Measures – Terrestrial Biological Resources
monitor to verify weed free status prior to use. Prior to site transport, any skid plates shall be removed and cleaned. Equipment should be cleaned of weed seeds daily especially wheels, undercarriages, and bumpers. Prior to leaving the project area, vehicles with caked-on soil or mud shall be cleaned with hand tools such as bristle brushes and brooms at a designated exit area; vehicles may subsequently be washed at an approved wash area. Vehicles with dry dusted soil (not caked-on soil or mud), prior to leaving a site at a designated exit area, shall be thoroughly brushed; alternatively, vehicles may be air blasted on site.
✓ Qualified biological monitors, approved by USFWS and 30 CES/CEIEA, including personnel who are familiar with and possess necessary qualifications to be approved for capture, handle, and release California red-legged frog (CRLF; *Rana draytonii*) and southwestern pond turtle (SWPT; *Actinemys pallida*), shall be present to monitor activities at all times deemed necessary by the DAF throughout the length of the project to minimize impacts on these species. The biological monitors shall be responsible for delineating areas where special-status species are located or concentrated, relocating special-status species in jeopardy of being killed or injured by construction, and inspecting equipment and equipment staging areas for fluid leaks. Prior to the onset of maintenance activities, resumes of qualified biologist(s), who would conduct the monitoring, surveying, species relocation, and other biological field activities shall be submitted by 30 CES/CEIEA to the USFWS for approval. ✓ Qualified biologists shall brief all project personnel prior to participating in project implementation activities. At a minimum, the training would include a description of the listed species and sensitive biological resources occurring in the area, the general and specific measures and restrictions to protect these resources during project implementation, the provisions of the ESA and the necessity of adhering to the provisions of the ESA, and the penalties associated with violations of the ESA. ✓ Disturbances shall be kept to the minimum extent necessary to accomplish project objectives. ✓ All erosion control materials used (i.e., gravel, sand, fill material, wattles, etc.) would be from weed-free sources. Only nonplastic, 100 percent biodegradable erosion control materials (e.g., erosion blankets, wattles) would be left in place following project completion. ✓ Portable toilets would only be placed over paved surfaces or within staging areas. ✓ All human-generated trash at the project site shall be disposed of in proper containers and removed from the work site and properly secured in a suitable trash container at the end of each workday. Special attention will be paid to ensure any food waste is properly contained. All construction debris and trash shall be removed from the work area upon completion of the project. ✓ A qualified biologist shall inspect any equipment left overnight prior to the start of work. Equipment would be checked for presence of special-status species in the vicinity and for fluid leaks. ✓ The DAF would continue to remove nonnative, invasive predators encountered during survey efforts (i.e., bullfrogs [*Lithobates catesbeianus*]). ✓ To avoid transferring disease or pathogens between aquatic habitats during the course of surveys and handling of amphibians, the biologist(s) shall follow decontamination procedures

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described in the Declining Amphibian Population Task Force's (DAPTF) Code of Practice (USFWS 2002a). ✓ To avoid potential project-related impacts on nesting migratory birds, if vegetation clearing is initiated during avian nesting season (15 February through 15 August), a qualified biologist would conduct nesting bird surveys within 250 ft of the Action Area prior to project initiation and vegetation-clearing activities. If nesting migratory birds are found within the Action Area, a buffer of adequate size to prevent disturbance from project-related activities (to be determined by the biological monitor) would be marked with flagging tape to avoid disturbance. The nest would be monitored to determine impacts, if any, from project-related disturbance. In addition to ensuring compliance with the Migratory Bird Treaty Act (MBTA), this measure would ensure any undetected ESA-listed birds are not present during vegetation removal. If work occurs during nesting season, a qualified biologist would conduct bird nest surveys prior to project activities. ✓ The DAF will continue to sample water quality in lower Spring Canyon once annually when ponded water is present to ensure no project-related byproducts (i.e., launch combustion residue, operations-related run-off, etc.) have entered the waterway in a manner not previously considered in this analysis. The DAF will continue to perform sampling a minimum of once a year until 2026, as required under BO 2022-0013990-S7-001 (USFWS 2023a). The DAF will design water quality sampling to detect potential project related byproducts and any resulting associated changes in aquatic habitat (i.e., salinity, pH, etc.). Sampling will consider and utilize the most recent applicable advances in water quality sampling technology. The DAF will include maps depicting sampling locations during annual reporting. The DAF will collect and clearly present data including any associated chemical and nutrient presence, dissolved oxygen, water temperature, turbidity, and any other pertinent observations regarding ecosystem condition for purposes of annual comparison. If the DAF finds that project related water contamination occurs, the DAF will coordinate with the USFWS, address sources of input, and remediate. ✓ The DAF has established a pre-project baseline for hydrodynamic data within San Antonio Creek. During project operations the DAF will continue to collect hydrodynamic data annually using consistent data collection methodologies for purposes of comparison against the established baseline. The DAF will use these data to ensure that the proposed project's water extraction, when viewed in addition to the unknown total water extraction amount of permitted launch projects, is not measurably affecting flow rate or water level within San Antonio Creek.
Vegetation Management Area
✓ One day prior to vegetation removal from Spring Canyon, a qualified biologist will conduct surveys for CRLF within the area to be mowed. Any CRLF present will be captured by the USFWS-approved or permitted biologist, if possible, and released at the nearest suitable habitat within Spring Canyon outside of the vegetation management area, as determined by the biologist. All biologists will follow the DAPTF fieldwork code of practice (DAPTF 2019) to avoid conveying diseases between work sites and will clean all equipment between use following protocols that are also suitable for aquatic reptiles. The USFWS-approved or permitted biologist will also be present during vegetation removal

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to capture and relocate CRLF to the extent that safety precautions allow. This biologist will also search for injured or dead CRLF after vegetation removal to document take. ✓ A qualified biologist will perform one CRLF survey annually during peak breeding season in Spring Canyon when individuals are most likely to be present and detectable. If CRLF are not encountered at the time of this survey, no subsequent pre/post launch surveys would occur. If CRLF is found to be present during the annual survey, pre- and post-launch surveys and relocation of any CRLF encountered would occur for each subsequent launch event. ✓ The annual report will include methodology used (i.e., survey time, date, duration, weather conditions, and a depiction of the survey area).

A.2.2 SPECIAL STATUS SPECIES

The DAF and qualified SpaceX personnel or contractor staff would ensure that all non-discretionary measures included in the USFWS BO issued for the Proposed Action, listed in Tables A.2-3 through A.2-8 would be implemented.

Table A.2-3: California Red-legged Frog Measures

✓ The DAF will maintain exhaust ducts and associated v-ditch at SLC-4 to be free of standing water to the maximum extent possible between launches to help minimize the potential to attract CRLF to SLC-4. ✓ The DAF will continue to require that a biologist survey the SLC-4 v-ditch feature for CRLF prior to any maintenance activities and relocate any encountered individuals. ✓ CRLF Baseline and Launch Monitoring: o The DAF will continue implementing a long-term monitoring plan of annual population and distribution trends associated with CRLF populations within Jalama Creek, Honda Creek, Bear Creek, and the Santa Ynez River. Through further coordination with the USFWS, the DAF will update the monitoring plan to adequately addresses potential effects on CRLF populations in Jalama Creek and other potential effects associated with the Proposed Action. ▪ The monitoring plan will clearly establish a pre-project baseline of the CRLF average population level within each impacted breeding feature (Jalama Creek, Honda Creek, Bear Creek, and Santa Ynez River) and clearly define the survey area and methodology. Following project implementation, the DAF will conduct annual surveys utilizing the same methodology within each impacted breeding feature during the breeding season when CRLF are most likely to be encountered. ▪ The monitoring plan will include passive bioacoustics monitoring (Wildlife Acoustics Song-Meter 4 or similar technology) and will establish frog calling behavior baseline within each impacted breeding feature (Jalama Creek, Honda Creek, Bear Creek, and Santa Ynez River) and any necessary appropriate control sites for purposes of signal characteristic comparison. CRLF calling behavior baseline will include applicable call characteristics (e.g., changes in signal rate, call frequency, amplitude, call timing, call duration, etc.). The DAF will ensure that bioacoustic monitoring conducted is designed to best address confounding factors in order to appropriately characterize impacts of launch,

static fire, and landing events on calling behavior. Results will be analyzed in conjunction with long term population data to ensure any observed changes in signal characteristics are not resulting in observable declines in population.

- The DAF will conduct quarterly night surveys for CRLF and spring or early summer tadpole surveys of Jalama Creek, Honda Creek, Bear Creek, and the Santa Ynez River to compare baseline CRLF occupancy data collected over the past 10 years and assess if there are any changes in CRLF habitat occupancy, breeding behavior (calling), and breeding success (egg mass and tadpole densities) within these sites. The following will be recorded and measured during the surveys:
  - CRLF detection density (number of frogs per survey hour), following the same survey methods conducted previously at these sites and throughout VSFB.
  - CRLF locations and breeding evidence (e.g., calling, egg masses).
  - Environmental data during surveys (temperature, wind speed, humidity, and dewpoint) to determine if environmental factors are affecting CRLF detection or calling rates.
  - Annual habitat assessments to measure flow rates, stream morphology, depths, and sediment to determine if any changes in CRLF metrics are associated with other environmental factors, such as drought.
- Bioacoustic monitoring will continue to be conducted during CRLF breeding season (typically November through April, depending on rainfall) to characterize the noise environment and determine if there are changes in calling behaviors as the Proposed Action commences. Passive noise recorders and environmental data loggers (temperature, relative humidity, dew point) would be placed at up to two suitable breeding locations within Jalama Creek, Honda Creek, Bear Creek, and the Santa Ynez River. Passive bioacoustic recording would occur throughout the entirety of the breeding season using the Wildlife Acoustics Song-Meter 4 (or similar technology) with software that enables autodetection of CRLF calling. The DAF will use bioacoustic monitoring to characterize and analyze impacts of launch, static fire, and landing events on calling behavior during the breeding season to assess whether Falcon noise events affect CRLF calling frequency.
- To address potential population declines that may be a result of the Proposed Action, the specified threshold criteria are described below:
  - CRLF occupancy, calling rate, or tadpole densities decline from baseline by 15 percent or more and,
  - The 15 percent decline from baseline is maintained for two consecutive years.
- If any of these threshold criteria are met and cannot confidently be attributed to other natural- or human-caused catastrophic factors, not related to the Proposed Action, that may eliminate or significantly degrade suitable habitat (see potential scenarios described below), the DAF will mitigate these impacts as discussed under CRLF Mitigation section below. Examples of potential catastrophic scenarios include the following:
  - Fire, unrelated to project activities or launch operations, that directly impacts Jalama Creek, Honda Creek, Bear Creek, or the Santa Ynez River and is demonstrated to degrade or eliminate breeding habitat.
  - Landslides or significant erosion events, unrelated to project activities or launch operations, in Jalama Creek, Honda Creek, Bear Creek, or the Santa Ynez River that results in the elimination or degradation of CRLF breeding habitat.

  - Drought or climate impacts that quantifiably reduce available aquatic habitat further than what was available during existing baseline.
  - Flash flood events during the breeding season that are more significant than what was documented during the existing baseline.
- The DAF will review the purported cause of decline with the USFWS and reach agreement. If cause of declines is determined to be inconclusive, the DAF will implement proposed mitigation.

- ✓ CRLF Mitigation
  - The DAF will create new CRLF breeding habitat at a 2:1 ratio (habitat enhanced: habitat affected) for adverse effects to occupied CRLF habitat, as determined above, at the San Antonio Creek Oxbow Restoration Area, an established wetland mitigation site on VSFB. Historically occupied by riparian vegetation, restoration efforts will focus on enhancing this abandoned tract of agricultural land to improve sensitive species habitat in San Antonio Creek and expand breeding habitat for CRLF.
  - Additional restoration will be conducted in the "expansion area" adjacent to the existing restoration area (where restoration has already been conducted in support of other projects). Restoration will involve digging a channel that reaches ground water. Spoils generated during excavation will be used to create a berm bordering the channel that will be planted with willows. This method is already being used at this site and has been proven to successfully create deep water aquatic habitat, that supports CRLF reproduction, bordered by riparian woodland. The restored habitat mirrors naturally occurring high-flow channels in San Antonio Creek.
- ✓ Actions taken within this area will include site preparation via herbicide application, plowing, container plant installation, seeding, willow pole planting (via water jet, hand-held power auger, or manually driving a steel rod into the ground), and watering via water truck. The mitigation actions for CRLF are included under the existing USFWS Programmatic Biological Opinion PBO (8-8-12-F-49R) and all applicable avoidance, minimization, and monitoring measures required under the PBO would be implemented.

Table A.2-4: Southwestern Pond Turtle Measures

- ✓ SWPT Baseline Monitoring:
  - The DAF will implement long-term monitoring of annual population and distribution trends associated with SWPT populations within Jalama Creek, Honda Creek, Bear Creek, and the Santa Ynez River. The DAF will develop a monitoring plan that adequately addresses potential short- and long-term project effects that may result from sensory pollutants. The DAF will coordinate with the USFWS during plan development and provide the USFWS the monitoring plan for review and approval within three months of project implementation to ensure that potential project related short and long-term effects are detectable and clearly defined.
    - The monitoring plan will clearly establish methods to estimate average population levels within each impacted breeding feature (Jalama Creek, Honda Creek, Bear Creek, and the Santa Ynez River) and clearly define the survey area and methodology. Mark-recapture techniques will be used to monitor population sizes and movements of individuals.
  - Annual habitat assessments to measure flow rates, stream morphology, depths, and sediment to determine if any changes in SWPT metrics are associated with other environmental factors, such as drought.

- To address potential declining trends that may be a result of the proposed project, the specified threshold criteria are described below:
  - SWPT population estimates decline by 15 percent or more and,
  - The 15 percent decline from baseline is maintained for two consecutive years.
- If any of these threshold criteria are met and cannot confidently be attributed to other natural- or human-caused catastrophic factors, not related to the Proposed Action, that may eliminate or significantly degrade suitable habitat (see potential scenarios described below), the DAF will mitigate these impacts as discussed under SWPT Mitigation section below. Examples of potential catastrophic scenarios include the following:
  - Fire, unrelated to project activities or launch operations, that directly impacts Jalama Creek, Honda Creek, Bear Creek, or the Santa Ynez River and is demonstrated to degrade or eliminate breeding habitat.
  - Landslides or significant erosion events, unrelated to project activities or launch operations, that result in the elimination or degradation of SWPT habitat.
  - Drought or climate impacts that quantifiably reduce available aquatic habitat further than what was available during existing baseline.
  - Flash flood events during the breeding season that are more significant than what was experienced during the existing baseline.
- The DAF will review the purported cause of decline with the USFWS and reach agreement. If cause of declines is determined to be inconclusive, the DAF will implement proposed mitigation.

✓ SWPT Mitigation

- The DAF will create new SWPT habitat at a 2:1 ratio (habitat enhanced: habitat affected) for adverse effects to occupied SWPT habitat, as determined above, at the San Antonio Creek Oxbow Restoration Area, an established wetland mitigation site on VSFB. Historically occupied by riparian vegetation, restoration efforts will focus on enhancing this abandoned tract of agricultural land to improve San Antonio Creek and provide habitat for SWPT.
- Additional restoration will be conducted in the “expansion area” adjacent to the existing restoration area (where restoration has already been conducted in support of other projects). Restoration will involve digging a channel that reaches ground water. Spoils generated during excavation will be used to create a berm bordering the channel that will be planted with willows. This method is already being used at the site and has proven successful at creating deep water aquatic habitat, suitable for SWPT, with adjacent riparian woodland that simulates naturally occurring high-flow channels.

✓ Actions taken within this area will include site preparation via herbicide application, plowing, container plant installation, seeding, willow pole planting (via water jet, hand-held power auger, or manually driving a steel rod into the ground), and watering via water truck. The mitigation actions for SWPT are included under the existing USFWS PBO (8-8-12-F-49R) and all applicable avoidance, minimization, and monitoring measures required under the PBO would be implemented.

Table A.2-5: Least Bell's Vireo Measures

✓ The DAF will require that a Qualified Biologist conduct point-count surveys for least Bell’s vireo (LBVI; *Vireo bellii pusillus*) on VSFB and at potential breeding habitats at the Santa Ynez River

adjacent to Buellton, California during the breeding season (15 May through 15 August) concurrent with routine riparian bird surveys on VSFB, conducted once every three years. The DAF will require that Permitted Biologists conduct any required protocol level surveys.

Table A.2-6: Western Snowy Plover Measures

SNPL Monitoring

- ✓ The DAF will continue to implement a long-term monitoring plan of annual population and distribution trends associated with western snowy plover along Surf Beach. The DAF will update the monitoring plan to adequately address potential short- and long-term project effects that may result from the Proposed Action in coordination with the USFWS. The SNPL monitoring plan will include a clear, established baseline annual variation and decline threshold that would trigger proposed mitigation (see below).
  - o The DAF will continue augmenting the current SNPL monitoring program on VSFB by performing acoustic monitoring and geospatial analysis of nesting activity on South Surf Beach to assess potential adverse effects from Falcon noise events.
  - o The current Base-wide SNPL monitoring program estimates breeding effort, nest fates, and fledging success while recording patterns of habitat use through the season. This program has been augmented for the Proposed Action by placing sound level meters (SLMs) immediately inland of South Surf Beach to characterize the noise environment and any related launch and landing associated disturbance.
  - o The DAF will perform geospatial analysis annually to identify declines in the SNPL population, nesting activity, and reproductive success that may result from cumulative effects of multiple Falcon launches and landings from SLC-4.
- ✓ To address potential declining trends that may be a result of the Proposed Action, the specified threshold criteria are described below.
  - o Geospatial analysis shows a statistically significant decline (defined as a decline greater than the baseline annual variation in these variables over the past 10 years at South Surf Beach) in population or reproductive success, and
  - o the decline from baseline maintains over two consecutive years within the areas impacted by noise from the Falcon program.
- ✓ If any of these threshold criteria are met and cannot confidently be attributed to other natural- or human-caused catastrophic factors, not related to the proposed action, that may eliminate or significantly degrade suitable habitat (see potential scenarios described below), the DAF will mitigate for these impacts as discussed under the SNPL Mitigation section below. Examples of potential catastrophic scenarios include the following:
  - o Significantly higher levels of tidal activity, predation, etc. as compared with the existing baseline and demonstrable across remainder of base population.
  - o Significant avian disease demonstrable across the recovery unit.
  - o Separate work activities (i.e., restoration efforts) not related to project.
- ✓ The DAF will review the purported cause of decline with the USFWS and reach agreement. If the cause of declines is determined to be inconclusive, the DAF will implement proposed mitigation.
- ✓ Motion triggered video cameras will be used during the breeding season (1 March through 30 September) to determine nest fates and potential impacts to nests due to launches and landings to reduce disturbance associated with human activity within breeding habitat.

- The DAF will monitor active nests at South Surf Beach with motion triggered video cameras during the breeding season at whichever of the following is greater within the modeled 4.0 pounds per square foot (psf) zone to assess potential novel effects that may result from frequent launching: (i) 10 percent of active SNPL nests, or (ii) 4 active SNPL nests. The DAF will monitor at whichever the following is greater within the modeled 3.0 to 4.0 psf zone: (iii) 10 percent of active SNPL nests, or (iv) 2 active SNPL nests. The DAF will monitor at whichever the following is greater within the modeled 2.0 to 3.0 psf zone: (v) 5 percent of active SNPL nests, or (vi) 4 active SNPL nests. - Cameras will be placed in a manner to minimize disturbance to nesting plovers; this will be determined in the field based on the best judgement of a permitted biologist. - The DAF will employ camera technology that is capable of long-term recording and time marking the moment of disturbance events. - The DAF will implement landscape level camera monitoring in conjunction with individual nest cameras to document SNPL response to launch and sonic boom noise and overpressures. The landscape level camera(s) will be capable of long-term recording, time marking the moment of disturbance events, and deployed adjacent to areas of highest density nesting to best capture population level reaction. The DAF will coordinate camera installation and placement with a USFWS approved biologist to ensure no additional effects would occur (i.e., perching for raptors). - The DAF will review SNPL nest camera recordings as soon as possible after potential disturbance events. ✓ The DAF will rescue any SNPL eggs abandoned on Surf Beach during disturbance events. The DAF will develop and/or fund a program to incubate any rescued abandoned eggs and release fledglings. ✓ SNPL Mitigation - The DAF will increase predator removal efforts to include the non-breeding season, particularly focusing on raven removal at and adjacent to VSFB beaches. - Given that all available SNPL nesting habitat on VSFB has already or will soon (under current planning) be restored, the biggest factor reducing nest success is predation with significant impacts from ravens. Ravens, which have historically been absent to rare in the region, are now common, and the population has increased substantially over the past two decades. Raven population increases are due to human activities which have allowed their numbers to increase and range to expand each year. Off-season raven control efforts will help reduce the population on Base prior to the breeding season which should increase nest success. ✓ Predator control actions will include trapping, shooting, and tracking SNPL predators from VSFB beaches and surrounding areas on Base. The mitigation actions for SNPL are permitted under an existing USFWS BO (8-8-12-F-11R; USFWS 2015a) and all applicable avoidance, minimization, and monitoring measures required under BO 8-8-12-F-11R will be implemented. CEIEA also maintains a USFWS depredation permit

Table A.2-7: California Least Tern Measures

LETE Monitoring
✓ The DAF will continue to implement a long-term monitoring plan of annual population and distribution trends associated with California least tern at Purisima Point. The DAF will update

the monitoring plan that adequately addresses potential short- and long-term project effects of the Proposed Action in coordination with the USFWS. The LETE monitoring plan will include a clear, established baseline annual variation and decline threshold that would trigger proposed mitigation (see below).

- ✓ The DAF has augmented the current LETE monitoring program on VSFB by performing acoustic monitoring and geospatial analysis of nesting activity at the Purisima LETE colony to assess potential adverse effects from Falcon 9 noise events.
  - o The current Base-wide LETE monitoring program estimates breeding effort, nest fates, and fledging success while recording patterns of habitat use through the season. This program has been augmented for the Proposed Action by placing SLMs immediately inland of the LETE colony at Purisima Point to characterize the noise environment and any related launch and landing associated disturbance.
  - o The DAF will perform geospatial analysis annually to identify declines in the LETE population, nesting activity, and reproductive success that may result from cumulative effects of multiple launches and landings from SLC-4.
- ✓ To address potential declining trends that may be a result of the Proposed Action, the specified threshold criteria is described below.
  - o Geospatial analysis shows a statistically significant decline (defined as a decline greater than the baseline annual variation in these variables over the past 10 years at Purisima Point) in population or reproductive success, and
  - o the decline from baseline maintains over two consecutive years within the areas impacted by noise from the Falcon program.
- ✓ If any of these threshold criteria are met and cannot confidently be attributed to other natural- or human-caused catastrophic factors, not related to the Proposed Action, that may eliminate or significantly degrade suitable habitat (see potential scenarios described below), the DAF will mitigate for these impacts as discussed under the LETE Mitigation section below. Examples of potential catastrophic scenarios include the following:
  - o Significantly higher levels of predation, lower prey availability, etc. as compared with the existing baseline and demonstrable across remainder of base population.
  - o Significant avian disease demonstrable across the recovery unit.
  - o Separate work activities (i.e., restoration efforts) not related to project.
- ✓ The DAF will review the purported cause of decline with the USFWS and reach agreement. If the cause of declines is determined to be inconclusive, the DAF will implement proposed mitigation.
- ✓ Motion triggered video cameras will be used during the breeding season (typically 15 April to 15 August) to determine nest fates and potential impacts to nests due to launches and landings to reduce disturbance associated with human activity within breeding habitat.
  - o The DAF will monitor at whichever of the following is greater within the Purisima Point colony: (i) 10 percent of active LETE nests, or (ii) 4 active LETE nests.
  - o Cameras will be placed in a manner to minimize disturbance to nesting terns; this will be determined in the field based on the best judgement of a permitted biologist.
  - o The DAF will employ camera technology that is capable of long-term recording and time marking the moment of disturbance events.
  - o The DAF will implement landscape level camera monitoring in conjunction with individual nest cameras to document LETE response to launch and sonic boom noise

and overpressures. The landscape level camera(s) will be capable of long-term recording, time marking the moment of disturbance events, and deployed adjacent to areas of highest density nesting to best capture population level reaction. The DAF will coordinate camera installation and placement with a USFWS approved biologist to ensure no additional effects would occur (i.e., perching for raptors). o The DAF will review LETE nest camera recordings as soon as possible following disturbance events. ✓ The DAF will rescue any LETE eggs abandoned at the Purisima Point colony during disturbance events. The DAF will develop and/or fund a program to incubate any rescued abandoned eggs and release fledglings. ✓ LETE Mitigation o The DAF will increase predator removal efforts to include the non-breeding season, particularly focusing on raven removal at and adjacent to VSFB beaches. o One factor reducing nesting success is nest predation. Off-season predator control will help reduce the population on Base prior to the breeding season which should increase nest success. ✓ Predator control actions will include trapping, shooting, and tracking LETE predators from VSFB beaches and surrounding areas on Base. The mitigation actions for LETE are permitted under an existing USFWS BO (8-8-12-F-11R; USFWS 2015a) and all applicable avoidance, minimization, and monitoring measures required under BO 8-8-12-F-11R will be implemented. CEIEA also maintains a USFWS depredation permit.

Table A.2-8: California Condor Measures

✓ The DAF will continue to coordinate with the USFWS on a quarterly basis to determine if any California condors are present at VSFB. The DAF will contact the USFWS if California condors appear to be near or within the area affected by a launch from SLC-4. In the unlikely event that a California condor is nearby, qualified biologists will monitor California condor movements in the vicinity of VSFB and coordinate with the USFWS to analyze data before, during, and after launch events to determine whether any changes in movement occur. ✓ The DAF will continue to coordinate with current USFWS personnel, including Arianna Punzalan, Supervisory Wildlife Biologist (arianna_punzalan@fws.gov, (805) 377-5471); Joseph Brandt, Wildlife Biologist (joseph_brandt@fws.gov, 805-677-3324 or 805-644-1766, extension 53324), or Steve Kirkland, California Condor Field Coordinator, USFWS California Condor Recovery Program (steve_kirkland@fws.gov, 805-644-5185, extension 294). The Space Force will also coordinate with current Ventana Wildlife Society personnel, Joe Burnett (joeburnett@ventanaws.org, 831-800-7424).

A.3 Marine Biological Resources

The DAF and qualified SpaceX personnel or contractor staff would ensure that all applicable minimization, monitoring, and avoidance measures listed in Tables A.3-1 and A.3-2 would be implemented during operation of the Proposed Action.

Table A.3-1 Minimization, Monitoring, and Avoidance Measures

✓ Sonic boom modeling (commercially available modeling software [PCBoom] or an acceptable substitute) would be completed prior to each launch to verify and estimate the overpressure levels and footprint.
✓ Semi-monthly surveys (two surveys per month) must be conducted to monitor the abundance, distribution, and status of pinnipeds at VSFB. Whenever possible, these surveys are timed to coincide with the lowest afternoon tides of each month when the greatest numbers of animals are usually hauled out. ✓ Marine mammal monitoring and acoustic measurements will be conducted at the NCI if the sonic boom model indicates that pressures from a boom will reach or exceed 7 psf from 1 January through 28 February, 5 psf from 1 March through 31. July, or 7 psf from 1 August through 30 September. No monitoring is required on NCI from 1 October through 31 December.
✓ The USSF will ensure that a USFWS-approved biologist monitors southern sea otters from a monitoring location within occupied habitat on VSFB where landing events at SLC-4 West (W) generate sonic booms of 2.0 psf or greater (i.e., Sudden Flats). Upon establishment of any new southern sea otter populations within areas of potential impact from project-related activities, the USSF will consider additional monitoring locations; ✓ A USFWS-approved biologist will conduct daily counts of sea otters from the monitoring location when otters are most likely rafting (between 09:00AM and 12:00PM) beginning 3 days before and continuing 3 days after and landing events, noting any mortality, injury, or abnormal behavior. Personnel will use both binoculars (10X) and a high-resolution (50–80X) telescope for monitoring; and ✓ Acoustic recording equipment will be deployed at or near the monitoring location to document and quantify sonic boom levels.
✓ The USSF will submit a report, detailing results of the monitoring program, to the Office of Protected Resources, NMFS, and the West Coast Regional Administrator, NMFS, in compliance with the requirements of the current LOA. ✓ Discoveries of injured or dead marine mammals, irrespective of cause, would be reported to the Office of Protected Resources, NMFS, and the West Coast Regional Stranding Coordinator, NMFS. Specific protocol would be followed depending on the cause of the event, if cause is unknown, and whether injury or death was relatively recent.
To reduce the risk of injury or mortality of ESA-listed species in the marine environment, the following EPMs will be implemented during first stage and fairing recovery operations: ✓ The USSF will ensure that all personnel associated with vessel support operations are instructed about marine species and any critical habitat protected under the ESA that could be present in the proposed landing area. Personnel will be advised of the civil and criminal penalties for harming, harassing, or killing ESA-listed species. ✓ Support vessels will maintain a minimum distance of 150 ft from sea turtles and a minimum distance of 300 ft from all other ESA-listed species. If the distance ever becomes less, the vessel will reduce speed and shift the engine to neutral. Engines would not be re-engaged until the animal(s) are clear of the area. ✓ Support vessels will maintain an average speed of 10 knots or less.

✓ Support vessels will attempt to remain parallel to an ESA-listed species' course when sighted while the watercraft is underway (e.g., bow-riding) and avoid excessive speed or abrupt changes in direction until the animal(s) has left the area. ✓ The USSF will immediately report any collision(s), injuries, or mortalities to ESA-listed species to the appropriate NMFS contact.
✓ To offset the impacts from unrecoverable debris, SpaceX would make an annual contribution to the California Lost Fishing Gear Recovery Project. This includes the weather balloon and radiosonde; parachute and assembly; and parafoil and assembly. For every 3 lbs of unrecovered debris, SpaceX would make a compensatory donation of $20.00, which is sufficient to recover 1 lb. of lost fishing gear.
✓ Vessels will enter the harbor, to the extent possible, only when the tide is too high for pinnipeds to haul-out on the rocks. The vessel will reduce speed to 1.5 to 2 knots once the vessel is within 3 mi of the harbor. The vessel will enter the harbor stern first, approaching the wharf and mooring dolphins at less than 0.75 knots.
✓ Vessels using the harbor will follow a predetermined route that limits crossing kelp beds.
✓ No vessels will anchor within kelp beds or hard-bottom habitat outside of the dredge footprint, and no vessel anchors within the dredge footprint will be placed in kelp or hard bottom habitat.
✓ If nighttime activities are to occur at any time from dusk to dawn, the required lighting will be turned on before dusk and left on the entire night. Lights will not be turned on or off between dusk and dawn.
✓ Activities that could result in the startling of wildlife in the vicinity of the harbor will be allowed so long as they are initiated before dusk and not interrupted by long periods of quiet (in excess of 30 minutes). If such activities cease temporarily during the night, they will not be reinitiated until dawn.
✓ Starting-up of activities (either initially or if activities have ceased for more than 30 minutes) will include a gradual increase in noise levels if pinnipeds are in the area.
✓ The restrictions on access to the intertidal area will be included in the personnel orientations provided at project startup and for new employees.
✓ The tug vessels and barge will be periodically cleaned as necessary to avoid impacts related to the transfer of non-native invasive pests and vegetation to VSFB Harbor.

Table A.3-2 Southern Sea Otter Measures

✓ The DAF will continue to monitor southern sea otters during landing events at SLC-4W whenever a sonic boom of 2 psf or greater is predicted to be generated by the landing that would impact southern sea otter habitat. The monitoring locations are selected based on where pressure waves greater than 2 psf are predicted to impact and the relation of these locations to occupied sea otter habitat, which is commonly Sudden Flats on south VAFB. However, no monitors are allowed within the "Impact Limit Line" during launch or landing. If otter counts by the United States Geological Survey, or other non-related survey efforts, show the establishment of new populations within the action area, new survey locations would be considered for landing events. o A USFWS-approved biologist would conduct daily counts of sea otters at the selected monitoring location beginning 3 days before and continuing 3 days after the landing. The monitor would note any mortality, injury, or abnormal behavior observed during these counts. Weather permitting; the counts would be conducted between 09:00 AM

and 12:00 PM when otters are most likely to be rafting to help maintain daily consistency in detectability. Monitors would use both binoculars (10X) and a high-resolution 50—80X telescope to conduct counts; and o Acoustic recording equipment would be deployed at or near the monitoring location to document and quantify sonic boom levels. ✓ If no long term effects on sea otter populations are observed after three years of full launch cadence the monitoring will be discontinued after review of data and concurrence of the USFWS.

A.4 WATER RESOURCES

The following measures, as described in Table A.4-1, would be implemented to minimize impacts on water resources and stormwater:

Table A.4-1: Water Resources and Stormwater Measures

✓ The Proposed Action shall comply with storm water management plans, including Best Management Practices (BMPs) following the latest California Stormwater Quality Association's Stormwater Best Management Practices Handbook.
✓ Spring Canyon will be routinely monitored for erosion where vegetation management occurs. BMPs would be utilized as needed to reduce erosion.
✓ SpaceX will continue to ensure that water ejected from the flame bucket during launches does not result in any overland surface flow reaching Spring Canyon by maintaining current v-ditches within the SLC-4 fenceline and routinely assessing whether any additional diversion structures are necessary.
✓ All equipment will be properly maintained and free of leaks during operation, and all necessary repairs carried out with proper spill containment.
✓ Fueling equipment will only occur in pre-designated areas with spill containment materials placed around the equipment before refueling. Stationary equipment will be outfitted with drip pans and hydrocarbon absorbent pads.
✓ Adequate spill response supplies will be maintained at the site during operation for immediate response and clean-up of any fuel spills.
✓ Hazardous materials will be stored in proper containers, placed in proper containment facilities covered prior to rain events.
✓ Trash disposal containers will be covered at all times.
✓ SpaceX and its contractors will implement best management practices to prepare for and respond to a spill. These practices include fueling equipment at least 100 ft from the water, fueling only in areas designed to capture runoff or spilled fuel, and maintaining spill response kits.

A.5 Cultural Resources

SpaceX personnel or contractor staff will ensure the following measures, described in Table A.5-1, would be implemented to minimize impacts on sensitive archaeological resources:

Table A.5-1: Cultural Resources Measures

Cultural Resources Measures
✓ If previously undocumented cultural resources are discovered during maintenance activities, work would stop, and the procedures established in 36 C.F.R. 800.13 and the VSFB Integrated Cultural Resources Management Plan shall be followed.

A.6 Hazardous Materials and Waste Management

SpaceX personnel or contractor staff will ensure the following measures, described in Table A.6-1, would be implemented to minimize impacts on minimize impacts on hazardous materials and waste management:

Table A.6-1: Hazardous Materials and Waste Management Measures

✓ Proper disposal of hazardous waste would be accomplished through identification, characterization, sampling (if necessary), and analysis of wastes generated.
✓ All hazardous materials would be properly identified and used IAW manufacturer's specifications to avoid accidental exposure to or release of hazardous materials required to operate and maintain construction equipment.
✓ Hazardous materials would be procured through or approved by the Vandenberg Hazardous Materials Pharmacy (HazMart). Monthly usage of hazardous materials would be reported to the HazMart to meet legal reporting requirements.
✓ All equipment would be properly maintained and free of leaks during construction and maintenance activities. All necessary equipment maintenance and repairs would be performed in pre-designated controlled, paved areas to minimize risks from accidental spillage or release. Prior to construction, a Spill Prevention Plan would be submitted to SLD 30 Environmental Compliance Section for approval.
✓ SpaceX would ensure employees and contractor staff are trained in proper prevention and cleanup procedures.
✓ SpaceX would store liquids, petroleum products, and hazardous materials in approved containers and drums and would ensure that any open containers are covered prior to rain events.
✓ Per 40 C.F.R. Part 112, Spill Prevention, Control, and Countermeasure Plan, Phantom would place chemicals, drums, or bagged materials on a pallet and, when necessary, secondary containment.

APPENDIX B – SENSITIVE SPECIES AND WILDLIFE OCCURRENCE WITHIN THE PROPOSED ACTION AREA

Table B-0-1 through Table B.0-4 includes all special status species records and survey locations from multiple sources in the noise footprint. Figures B.0-1 through Figure B.0-8 include localities of additional special status species within the noise footprint, gathered from DAF long-term monitoring and annual survey efforts and the CNDDB.

Table B.0-1: Federal and State Special Status Species Occurrence Within the Proposed Action Area

Species	Status		Occurrence within the Coastal Zone of the Proposed Action Area[1, 2]
	USFWS	CDFW	
Invertebrates			
Crotch bumble bee (*Bombus crotchii*)	-	SSC	Present in the noise footprint on VSFB, in eastern Santa Barbara, Ventura, and western Los Angeles Counties.
Monarch butterfly (*Danaus plexippus*)	Proposed	Special Animal*	Overwintering stands within noise footprint on VSFB, in eastern Santa Barbara, Ventura, and western Los Angeles Counties.
Fish			
Tidewater goby (*Eucyclogobius newberryi*)	FT	-	Historic occurrence in Honda Creek on VSFB; surveys have not detected since 2001. Present in San Antonio Creek and Jalama Creek on VSFB. Present in coastal streams within the noise footprint in eastern Santa Barbara, Ventura, and western Los Angeles Counties.
Unarmored Threespine Stickleback (*Gasterosteus aculeatus*)	FE	SE	Currently extirpated on Honda Creek on VSFB; historic introduction in Honda Creek in 1984. No individuals have been detected in Honda Creek since the late 1990's. Present in San Antonio Creek on VSFB.
Arroyo chub (*Gila orcuttii*)	-	SSC	Not present on Honda Creek and San Antonio Creek on VSFB. Present within the noise footprint on Malibu and Calleguas Creeks in Ventura and western Los Angeles Counties.
steelhead - southern California DPS (*Oncorhynchus mykiss*)	FE	Candidate	Present within the noise footprint in coastal streams and rivers of Santa Barbara and western Los Angeles Counties.
Amphibians			

Species	Status		Occurrence within the Coastal Zone of the Proposed Action Area[1, 2]
	USFWS	CDFW	
California red-legged frog (*Rana draytonii*)	FT	SSC	Documented within noise footprint on VSFB and coastal Santa Barbara County.
Coast range newt (*Taricha torosa*)	-	SSC	Present within the noise footprint in coastal streams of Santa Barbara, Ventura, and western Los Angeles Counties
Reptiles			
Northern legless lizard (*Anniella pulchra*)	-	SSC	Present within the noise footprint in Santa Barbara County.
Southern legless lizard (*Anniella stebbinsi*)	-	SSC	Present within the noise footprint in Ventura and western Los Angeles Counties.
Coastal whiptail (*Aspidoscelis tigris stejnegeri*)	-	SSC	Present within the noise footprint in western Los Angeles County.
Coast horned lizard (*Phrynosoma blainvillii*)	-	SSC	Present within the noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.
Southwestern pond turtle (*Actinemys pallida*)	-	SSC	Present within the noise footprint in coastal streams and wetlands of Santa Barbara, Ventura, and western Los Angeles Counties.
Two-striped garter snake (*Thamnophis hammondii*)	-	SSC	Present within the noise footprint in Honda Creek on VSFB and the noise footprint in western Santa Barbara County. Potential occurrence in the noise footprint in eastern Santa Barbara and western Los Angeles Counties.
Birds			
Allen's hummingbird (*Selasphorus sasin*)	BCC	-	Present within noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.
Bald eagle (*Haliaeetus leucocephalus*)	BCC; BGEPA	SE; Fully Protected	Documented occasional flyovers on VSFB; foraging habitat within noise footprint. Rarely present within the noise footprint in eastern Santa Barbara, Ventura, and western Los Angeles Counties.
Bank swallow (*Riparia riparia*)	-	ST	Present within noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.

Species	Status		Occurrence within the Coastal Zone of the Proposed Action Area[1, 2]
	USFWS	CDFW	
Belding's savannah sparrow (*Passerculus sandwichensis beldingi)*	-	SE	Present in coastal plains within the noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.
Black oystercatcher (*Haematopus bachmani*)	BCC	-	Present on sandy beaches and cliffs of VSFB shoreline and within the noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.
Black skimmer (*Rynchops niger*)	BCC	-	Present in nearshore ocean waters within the noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.
Brant (*Branta bernicla*)	-	SSC	Present in nearshore ocean waters within the noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.
Burrowing owl (*Athene cunicularia*)	BCC	SSC	Winters in burrows in grassland areas impacted by noise. Breeding on VSFB has not been documented in optimal breeding habitat on Base since 1984 (reflects a well-documented county-wide decline of the species). Present in coastal plains and agricultural lands within the noise footprint in eastern Santa Barbara, Ventura, and western Los Angeles Counties.
California brown pelican (*Pelecanus occidentalis californicus*)	-	Fully Protected	Present in nearshore ocean waters and roosts on beaches and rocks within the noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.
California condor (*Gymnogyps californianus*)	FE	SE	Unlikely on VSFB: may stray into noise footprint on VSFB on occasion. One documented brief occurrence on VSFB in 2017.
California least tern (*Sterna antillarum browni*)	FE	SE	Present in noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.
Costa's hummingbird (*Calypte costae*)	BCC	-	Present within the noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.

Species	Status		Occurrence within the Coastal Zone of the Proposed Action Area[1, 2]
	USFWS	CDFW	
Golden eagle (*Aquila chrysaetos*)	BGEPA	Fully Protected	Present within noise footprint on VSFB and Santa Barbara County. Rare in Ventura and western Los Angeles Counties.
Grasshopper sparrow (*Ammodramus savannarum*)	-	SSC	Present in coastal plains within the noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.
Lawrence's goldfinch (*Spinus lawrencei*)	BCC	-	Present in shrub and riparian habitat within noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.
Least Bell's vireo (*Vireo bellii pusillus*)	FE	SE	Documented within noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.
Light-footed Ridgeway's rail (*Rallus obsoletus levipes*)	FE	SE	Present in coastal salt marshes within the noise footprint of Ventura County.
Loggerhead shrike (*Lanius ludovicianus*)	BCC	SSC Nesting	Documented in shrub and riparian habitat within noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.
Long-billed curlew (*Numenius americanus*)	BCC	-	Present on rocky coastline at low tide and beaches within noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.
Marbled godwit (*Limosa fedoa*)	BCC	-	Present on sandy beaches and rocky coastline at low tide within noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.
Marbled murrelet (*Brachyramphus marmoratus*)	FT	SE	Present in nearshore ocean waters within noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.
Northern harrier (*Circus hudsonius*)	-	SSC Nesting	Present in grassland within noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.

Species	Status		Occurrence within the Coastal Zone of the Proposed Action Area[1, 2]
	USFWS	CDFW	
Nuttall's woodpecker (*Dryobates nuttallii*)	BCC	-	Present in riparian habitat within noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.
Oak titmouse (*Baeolophus inornatus*)	BCC	-	Present in riparian and non-native tree habitat within noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.
Peregrine falcon (*Falco peregrinus anatum*)	BCC Nesting	Fully Protected Nesting	Present in coastal habitat within noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.
Short-billed dowitcher (*Limnodromus griseus*)	BCC	-	Present on rocky coastline at low tide and beaches within noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.
Whimbrel (*Numenius phaeopus*)	BCC	-	Present on rocky coastline at low tide and beaches within noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.
Western snowy plover (*Charadrius nivosus nivosus*)	FT; BCC	SSC Nesting	Present on rocky coastline at low tide, nests on sandy beaches within noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.
Willet (*Tringa semipalmata*)	BCC	-	Present on rocky coastline at low tide and beaches impacted by noise in Santa Barbara, Ventura, and western Los Angeles Counties.
White-tailed kite (*Elanus leucurus*)	-	Fully Protected Nesting	Present in riparian and non-native tree habitat within noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.
Yellow warbler (*Setophaga petechia*)	BCC	SSC Nesting	Present in riparian habitat within noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.
Terrestrial Mammals			

Species	Status		Occurrence within the Coastal Zone of the Proposed Action Area[1, 2]
	USFWS	CDFW	
Pallid bat (*Antrozous pallidus*)	-	SSC	Present within the noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.
Spotted bat (*Euderma maculatum*)	-	SSC	Present within the noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.
Townsend's big-eared bat (*Corynorhinus townsendii*)	-	SSC	Present within the noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.
Western red bat (*Lasiurus blossevillii*)	-	SSC	Present within the noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.
Western mastiff bat (*Eumops perotis californicus*)	-	SSC	Present within the noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.
San Diego desert woodrat (*Neotoma lepida intermedia*)	-	SSC	Present within the noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.
South coast marsh vole (*Microtus californicus stephensi*)	-	SSC	Present within the noise footprint in Ventura County.
Southern California saltmarsh shrew (*Sorex ornatus salicornicus*)	-	SSC	Present in coastal salt marshes of Ventura County.
American badger (*Taxidea taxus*)	-	SSC	Present within noise footprint in Santa Barbara, Ventura, and western Los Angeles Counties.

Notes: BGEPA = Bald and Golden Eagle Protection Act; FE = Federally Endangered Species; FT = Federally Threatened Species; SE = State Endangered Species; SSC = California State Species of Special Concern; SE = State Endangered Species; SSC = State Candidate Species; BCC = Federal Bird of Conservation Concern

[1] Source: California Natural Diversity Database (CNDDB; 2024); eBird (2024; https://ebird.org/); and various Vandenberg Space Force Base natural resources reports.

[2] Potential presence for CNDDB species in the action area was determined by comparing spatial overlap of CNDDB records with potential noise footprint, and the Coastal Zone.

Table B.0-2:ESA-listed fish species occurrence within the Action Area

Common Name	Scientific Name	DPS or ESU	Federal Status	Presence in Action Area
Steelhead	*Oncorhynchus mykiss*	Southern California Coast	FE	Documented in the nearshore and offshore waters.[3]

Chinook salmon	*Oncorhynchus tshawytscha*	5 ESUs[1]	FT	Specific ESUs present or potentially present in the nearshore and offshore waters.[4, 5, 6, 7, 8]
Coho salmon	*Oncorhynchus kisutch*	4 ESUs[2]	FT	Documented in the nearshore and offshore waters.[9]
Green sturgeon	*Acipenser medirostris*	Southern	FT	Likely present primarily along continental shelf waters of the West Coast
Oceanic whitetip shark	*Carcharhinus longimanus*	-	FT	Present in open ocean waters from Southern California to Peru[10]
Scalloped hammerhead shark	*Sphyrna lewini*	Eastern Pacific	FE	Present in coastal and semi-oceanic water in temperate and tropical regions.[11]

Notes: ESU = Evolutionarily Significant Unit, DPS = Distinct Population Segment; FE = federally endangered; FT = federally threatened

[1] Chinook salmon ESUs include California Coastal (FT), Central Valley Spring-Run (FT), Lower Columbia River (FT), and Sacramento River Winter-Run (FT)

[2] Coho salmon ESUs include Central California Coast (FT) and Southern Oregon and Northern California Coasts (FT).

[3] Good, T.P., R.S. Waples, and P. Adams, (Eds.). 2005. Updated Status of Federally Listed ESUs of West Coast Salmon and Steelhead. Seattle, WA: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Fisheries Science Center.

[4] Quinn, T.P., and K.W. Myers. 2005. Anadromy and the marine migrations of Pacific salmon and trout: Rounsefell revisited. Reviews in Fish Biology and Fisheries 14: 421–442.

[5] Sharma, R. 2009. Survival, Maturation, Ocean Distribution and Recruitment of Pacific Northwest Chinook Salmon (*Oncorhynchus tshawytscha*) in Relation to Environmental Factors, and Implications for Management. (Unpublished doctoral dissertation). University of Washington, Seattle, WA.

[6] Bellinger, M.R., M.A. Banks, S.J. Bates, E.D. Crandall, C.G. Garza, and P.W. Lawson. 2015. Geo-Referenced, Abundance Calibrated Ocean Distribution of Chinook Salmon (*Oncorhynchus tshawytscha*) Stocks across the West Coast of North America. PLoS One 10(7): e0131276.

[7] Satterthwaite, W.H., J. Ciancio, E.D. Crandall, M.L. Palmer-Zwahlen, A.M. Grover, M.R. O'Farrell, E.C. Anderson, M.S. Mohr, and C. Garza. 2015. Stock composition and ocean spatial distribution inference from California recreational Chinook salmon fisheries using genetic stock identification. Fisheries Research 170: 166-178.

[8] Hendrix, N., A.-M. K. Osterback, E. Jennings, E. Danner, V. Sridharan, C. M. Greene, and S.T. Lindley. 2019. Model Description for the Sacramento River Winter-run Chinook Salmon Life Cycle Model. Seattle, WA: National Marine Fisheries Service.

[9] Fisher, J.P., L.A. Weitkamp, D.J. Teel, S.A. Hinton, J.A. Orsi, E.V. Farley Jr., J.F.T. Morris, M.E. Thiess, R.M. Sweeting, and M. Trudel. 2014. Early Ocean Dispersal Patterns of Columbia River Chinook and Coho Salmon. Transactions of the American Fisheries Society 143(1): 252–272.

[10] Baum, J., E. Medina, J.A. Musick, and M. Smale. 2015. *Carcharhinus longimanus*. The International Union for Conservation of Nature Red List of Threatened Species 2015: e.T39374A85699641.

[11] Compagno, L.J.V. 1984. FAO Species Catalogue. Sharks of the World. An Annotated and Illustrated Catalogue of Shark Species Known to Date. Part 2. Carcharhiniformes (FAO Fisheries Synopsis No. 125). Tiburon, CA: San Francisco State University.

Table B.0-3: ESA-listed turtle species occurrence within the Action Area

Common Name	Scientific Name	DPS or ESU	Federal Status	Presence in Action Area
Green sea turtle	*Chelonia mydas*	East Pacific Central North Pacific	FT	Present in offshore and nearshore subtropical waters.[1]
Leatherback sea turtle	*Dermochelys coriacea*	-	FE	Present in offshore and nearshore waters.[2]
Olive ridley sea turtle	*Lepidochelys olivacea*	Mexico Pacific Coast	FE	Present in offshore and nearshore waters.[3]

Common Name	Scientific Name	DPS or ESU	Federal Status	Presence in Action Area
Hawksbill sea turtle	*Eretmochelys imbricata*	-	FE	Present in offshore and nearshore waters of Mexico.[4]
Loggerhead turtle	*Caretta caretta*	North Pacific	FE	Present in small numbers in offshore waters generally north of Point Conception.[5]

Notes: ESU = Evolutionarily Significant Unit; DPS = Distinct Population Segment; FE = federally endangered; FT = federally threatened

[1] Cliffton, K., D.O. Cornejo, and R.S. Felger. 1995. Sea turtles of the Pacific coast of Mexico. In K. A. Bjorndal (Ed.), Biology and Conservation of Sea Turtles (Revised ed., pp. 199-209). Washington, DC: Smithsonian Institution Press.

[2] Conant, T.A., P.H. Dutton, T. Eguchi, S. P. Epperly, C.C. Fahy, M. H. Godfrey, S.L. MacPherson, E.E. Possardt, B.A. Schroeder, J.A. Seminoff, M.L. Snover, C.M. Upite, and B.E. Witherington. 2009. Loggerhead sea turtle (*Caretta caretta*) 2009 status review under the U.S. Endangered Species Act (Report of the loggerhead biological review team to the National Marine Fisheries Service, August 2009). Silver Spring, MD: Loggerhead Biological Review Team.

[3] National Marine Fisheries Service and U.S. Fish and Wildlife Service. 2007. Olive Ridley Sea Turtle (*Lepidochelys olivacea*) 5-year Review: Summary and Evaluation. (pp. 64). Silver Spring, MD: National Marine Fisheries Service.

[4] National Marine Fisheries Service, and U.S. Fish and Wildlife Service. 2013. Hawksbill sea turtle (*Eretmochelys imbricata*) 5-year review: summary and evaluation. Jacksonville, FL: Jacksonville Ecological Services Field Station.

[5] Bailey, H., S.R. Benson, G.L. Shillinger, S.J. Bograd, P.H. Dutton, S.A. Eckert, S.J. Morreale, F.V. Paladino, T. Eguchi, D.G. Foley, B.A. Block, R. Piedra, C. Hitipeuw, R.F. Tapilatu, and J.R. Spotila. 2012. Identification of distinct movement patterns in Pacific leatherback turtle populations influenced by ocean conditions. Ecological Applications 22(3): 735–747.

Table B.0-4: Marine Mammals within the Action Area

Common Name	Scientific Name	DPS or ESU	Federal Status	Presence in Action Area
Blue whale	*Balaenoptera musculus*	-	FE; MMPA	Present with high densities in summer/fall; single individuals in winter/spring.[1]
Fin whale	*Balaenoptera physalus*	-	FE; MMPA	Present year-round with higher densities in the summer and fall.[2]
Gray whale	*Eschrichtius robustus*	Western North Pacific	FE; MMPA	Present during seasonal migration in the winter and spring.[3,4]
Humpback whale	*Megaptera novaeangliae*	Mexico	FT; MMPA	Individuals present year-round with higher seasonal presence during the summer migrations from Mexico and Central America.[5, 6, 7]
		Central America	FE; MMPA	
Killer whale	*Orcinus orca*	Southern Resident	FE; MMPA	Occasionally present offshore of Central and Southern California.[8, 9]
Sei whale	*Balaenoptera borealis*	-	FE; MMPA	Present year round with more likely presence in the winter and spring.[10]
Sperm whale	*Physeter macrocephalus*	-	FE; MMPA	Present year round with a preference for deep waters and the continental shelf break and slope.[11]
Steller sea lion	*Eumetopias jubatus*	-	MMPA	Present in California coastal waters and haulouts within the noise footprint on VSFB and the NCI.[12]
Northern elephant seal	*Mirounga angustirostris*	-	MMPA	Present in California coastal waters and haulouts within the noise footprint on VSFB and the NCI.[12]
Pacific harbor seal	*Phoca vitulina richardii*	-	MMPA	Present in California coastal waters and haulouts within the noise footprint on VSFB, the NCI, and the south coast of Santa Barbara and Ventura Counties.[12]

Common Name	Scientific Name	DPS or ESU	Federal Status	Presence in Action Area
California sea lion	*Zalophus californianus*	-	MMPA	Present in California coastal waters and haulouts within the noise footprint on VSFB and the NCI.[12]
Guadalupe fur seal	*Arctocephalus townsendi*	-	FT; MMPA	Present in California coastal waters and haulouts within the noise footprint on the NCI.[12]
Southern sea otter	*Enhydra lutris nereis*	-	FT; MMPA	Present along coast of California from Santa Barbara County and north.[13]

Notes: ESU = Evolutionarily Significant Unit; DPS = Distinct Population Segment; FE = federally endangered; FT = federally threatened; NCI = Northern Channel Islands

Sources:

[1] Becker, E.A., K.A. Forney, P.C. Fiedler, J. Barlow, S.J. Chivers, C.A. Edwards, A.M. Moore, and J.V. Redfern. 2016. Moving Towards Dynamic Ocean Management: How Well Do Modeled Ocean Products Predict Species Distributions? Remote Sensing 8(2): 149.

[2] Mizroch, S.A., D.W. Rice, D. Zwiefelhofer, J.M. Waite, and W.L. Perryman. 2009. Distribution and movements of fin whales in the North Pacific Ocean. Mammal Review 39(3): 193–227.

[3] Jefferson, T.A., M.A. Webber, and R.L. Pitman. 2008. Marine Mammals of the World: A Comprehensive Guide to Their Identification. London, United Kingdom: Elsevier.

[4] Jones, M.L., and S.L. Swartz. 2009. Gray whale, *Eschrichtius robustus*. In W. F. Perrin, B. Wursig, & J. G. M. Thewissen (Eds.), Encyclopedia of Marine Mammals (2nd ed., pp. 503–511). Cambridge, MA: Academic Press.

[5] Dohl, T.P., R.C. Guess, M.L. Duman, and R.C. Helm. 1983. Cetaceans of Central and Northern California, 1980-1983: Status, Abundance, and Distribution (OCS Study MMS 84–005). Los Angeles, CA: U.S. Department of the Interior, Minerals Management Service, Pacific Outer Continental Shelf Region.

[6] Forney, K.A., and J. Barlow. 1998. Seasonal patterns in the abundance and distribution of California cetaceans, 1991–1992. Marine Mammal Science 14(3): 460–489.

[7] Campbell, G.S., L. Thomas, K. Whitaker, A.B. Douglas, J. Calambokidis, and J.A. Hildebrand. 2015. Inter-annual and seasonal trends in cetacean distribution, density and abundance off southern California. Deep Sea Research Part II: Topical Studies in Oceanography 112: 143–157.

[8] Hanson, M.B., E.J. Ward, C.K. Emmons, and M.M. Holt. 2018. Modeling the occurrence of endangered killer whales near a U.S. Navy Training Range in Washington State using satellite-tag locations to improve acoustic detection data. Seattle, WA: National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Fisheries Science Center.

[9] Hanson, M.B., E.J. Ward, C.K. Emmons, M.M. Holt, and D.M. Holzer. 2017. Assessing the Movements and Occurrence of Southern Resident Killer Whales Relative to the U.S. Navy's Northwest Training Range Complex in the Pacific Northwest. Seattle, WA: National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Fisheries Science Center.

[10] Smultea, M.A., T.A. Jefferson, and A.M. Zoidis. 2010. Rare sightings of a Bryde's whale (*Balaenoptera edeni*) and Sei whales (*B. borealis*) (Cetacea: Balaenopteridae) northeast of Oahu, Hawaii. Pacific Science 64(3): 449–457.

[11] Smultea, M. 2014. Changes in Relative Occurrence of Cetaceans in the Southern California Bight: A Comparison of Recent Aerial Survey Results with Historical Data Sources. Aquatic Mammals 40(1): 32–43.

[12] National Marine Fisheries Service pinniped count data; Naval Base Ventura County pinniped count data; and various Vandenberg Space Force Base natural resources reports

[13] USGS count data and various Vandenberg Space Force Base natural resources reports

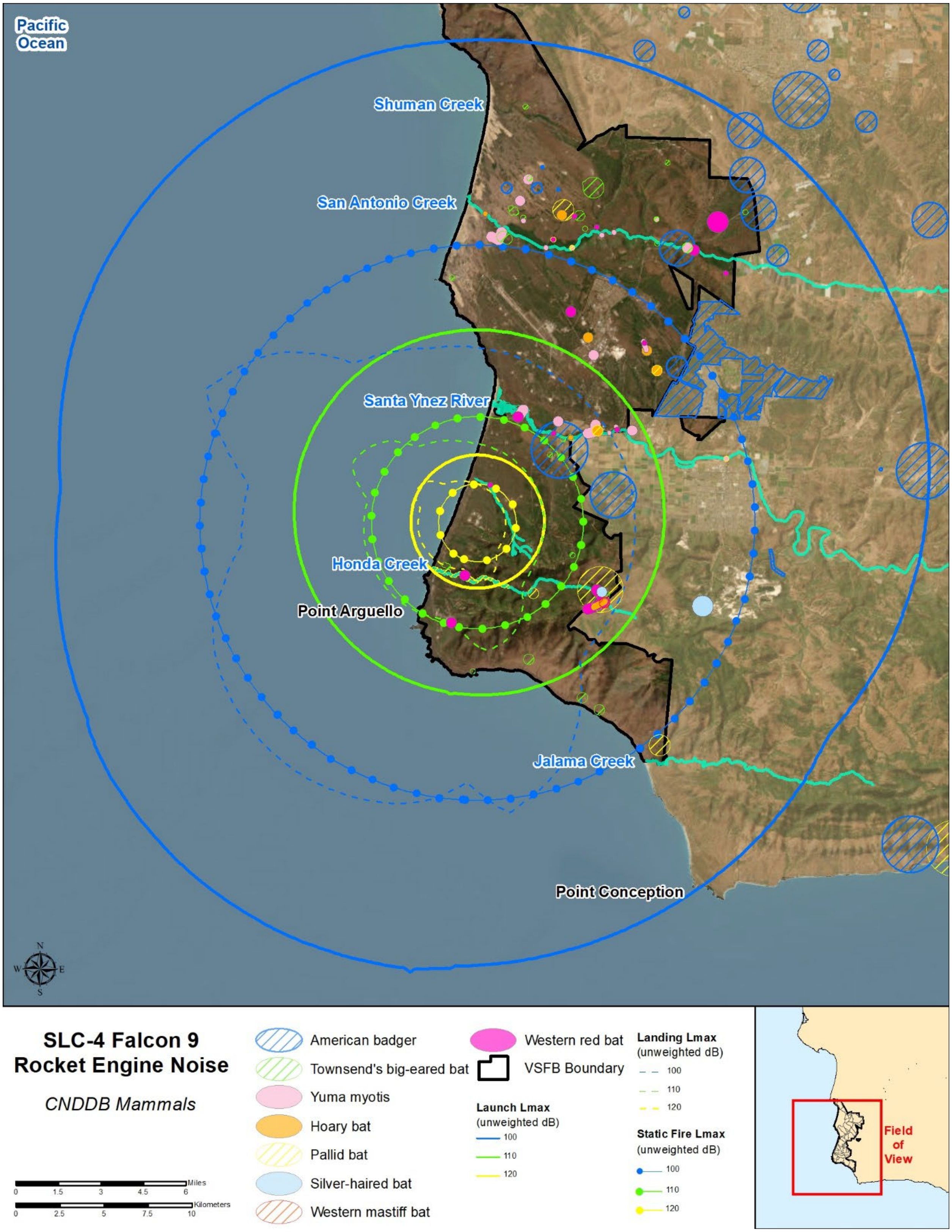

Figure B.0-1. Special status mammal CNDDB localities and Falcon 9 SLC-4 static fire, launch, and landing rocket engine noise model results.

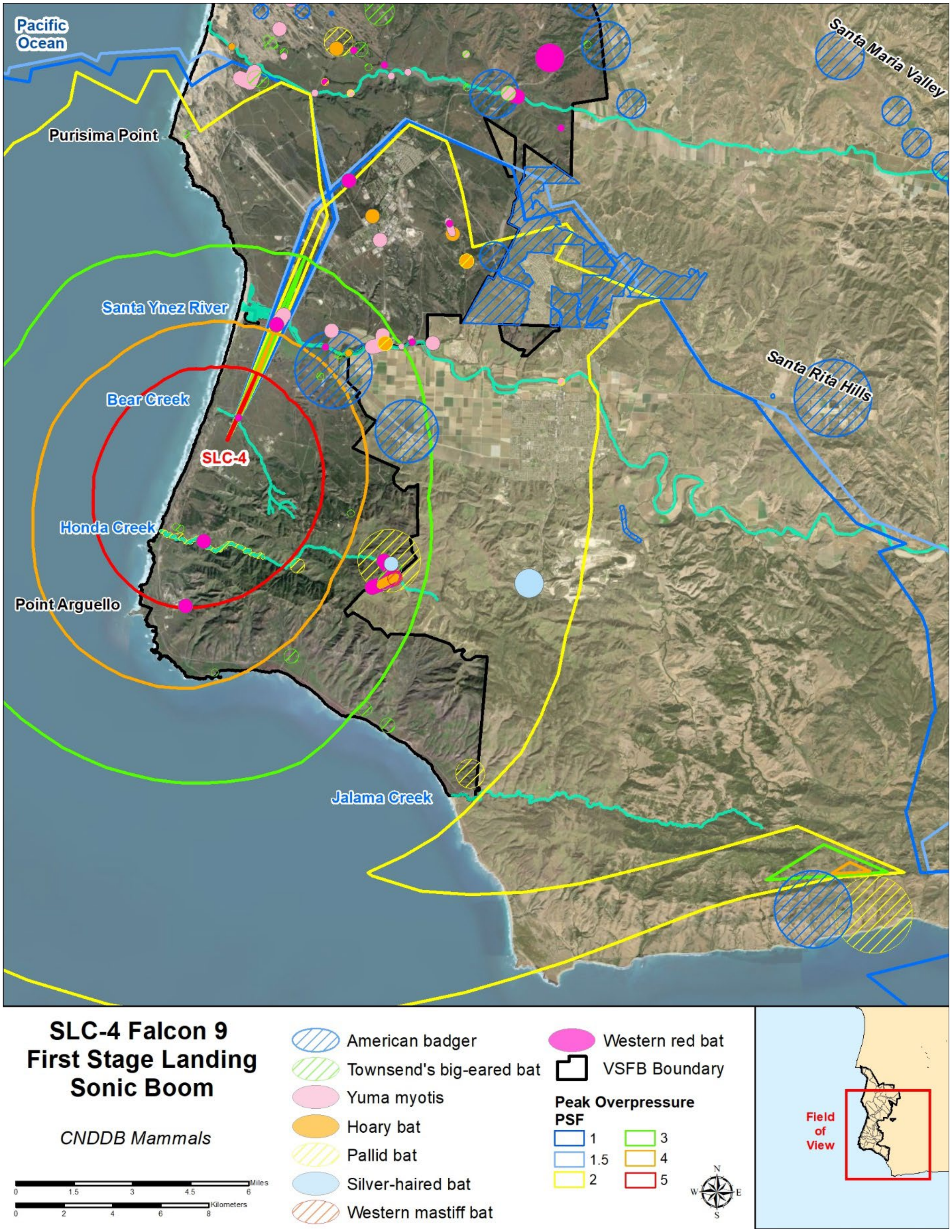

Figure B.0-2. Special status mammal CNDDB localities and example SLC-4 landing sonic boom contours.

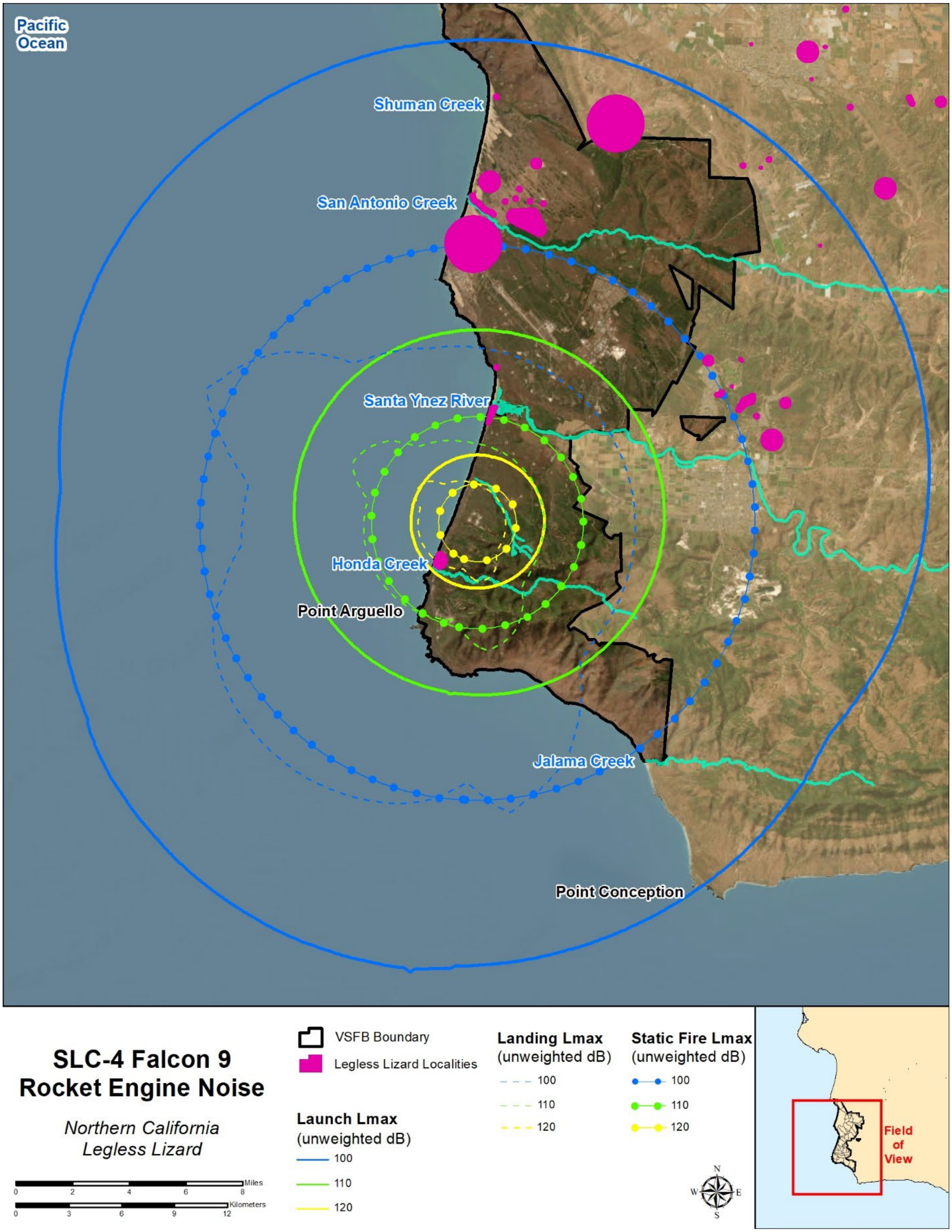

Figure B.0-3. Northern legless lizard localities and Falcon 9 SLC-4 static fire, launch, and landing rocket engine noise model results.

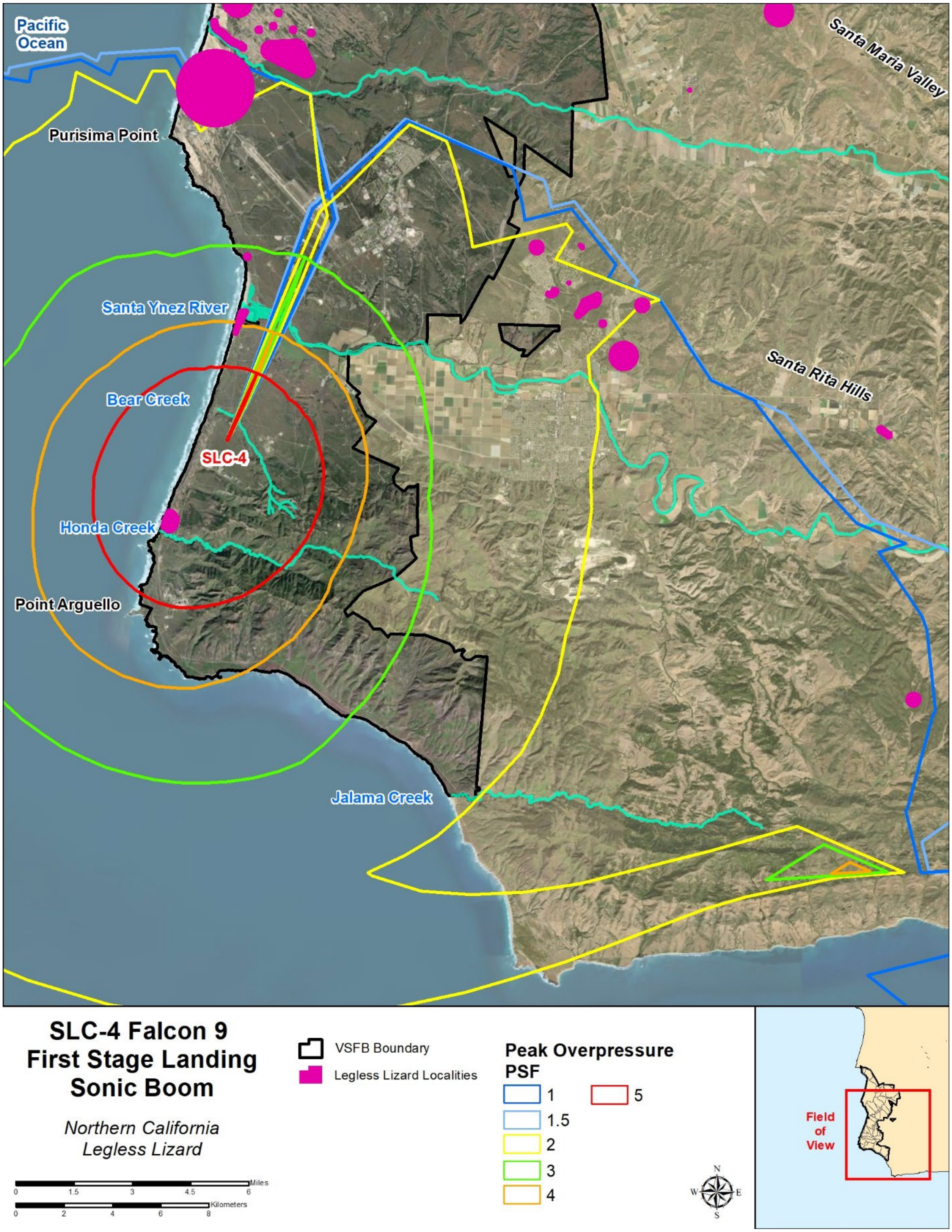

Figure B.0-4. Northern legless localities and example SLC-4 landing sonic boom contours.

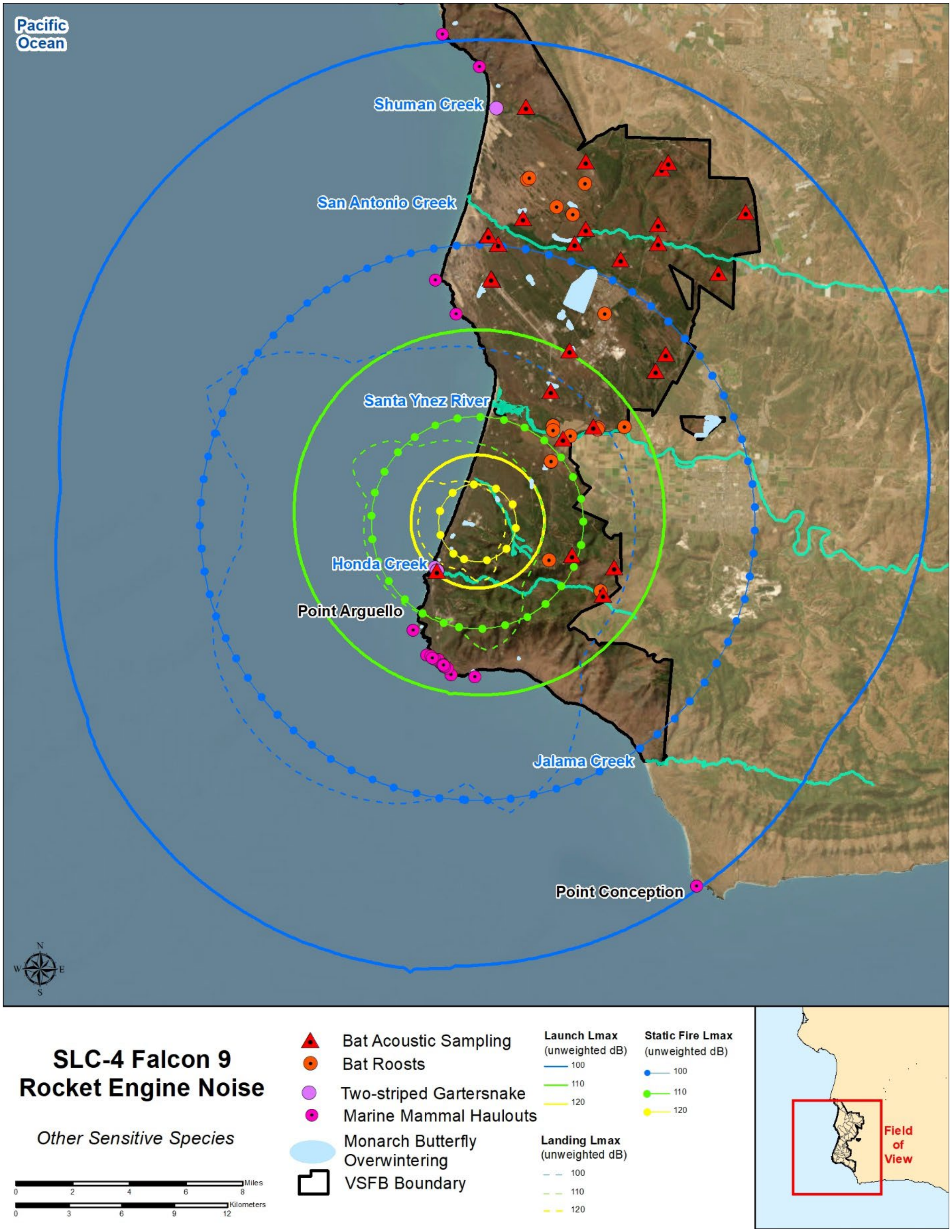

Figure B.0-5. Other sensitive species and Falcon 9 SLC-4 static fire, launch, and landing rocket engine noise model results.

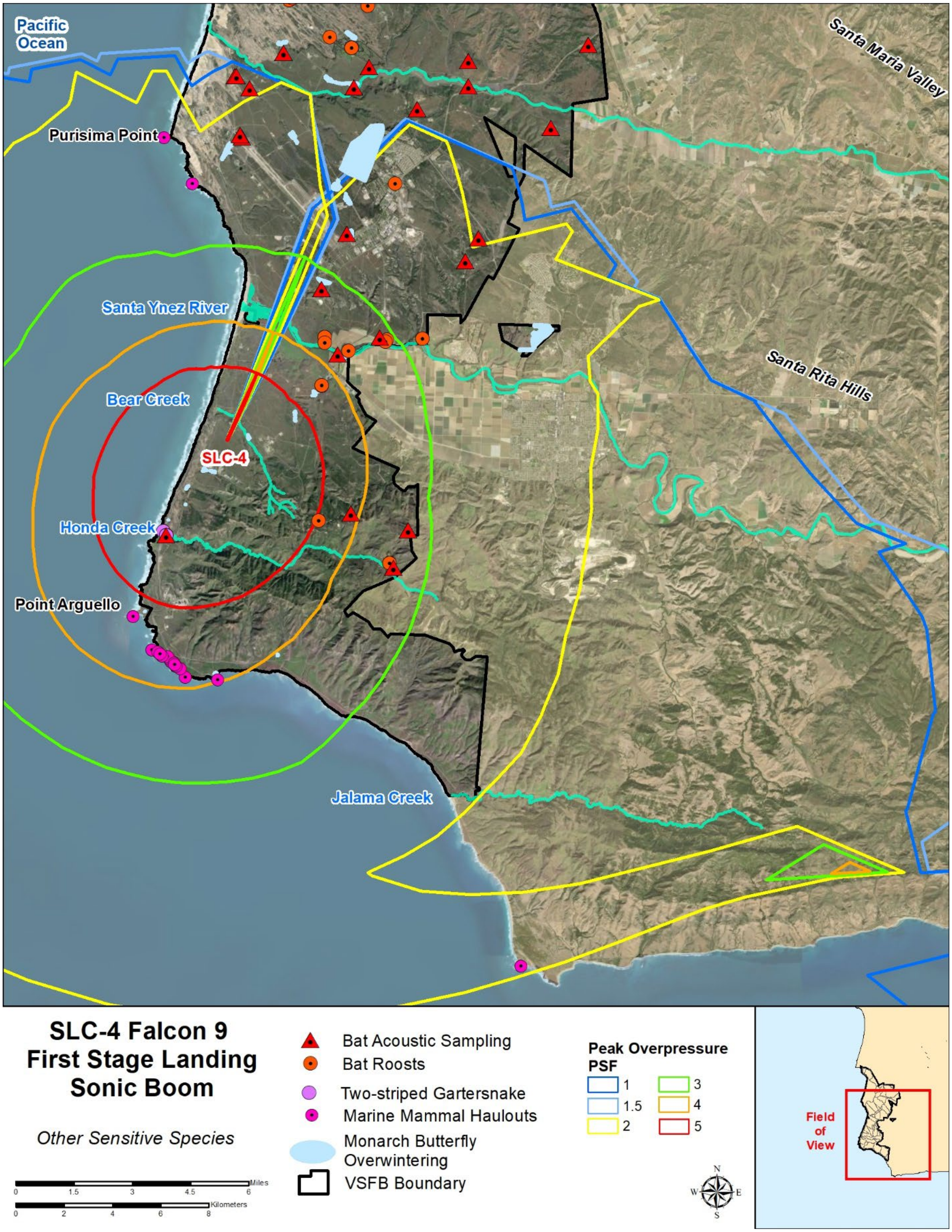

Figure B.0-6. Other sensitive species and example SLC-4 landing sonic boom contours.

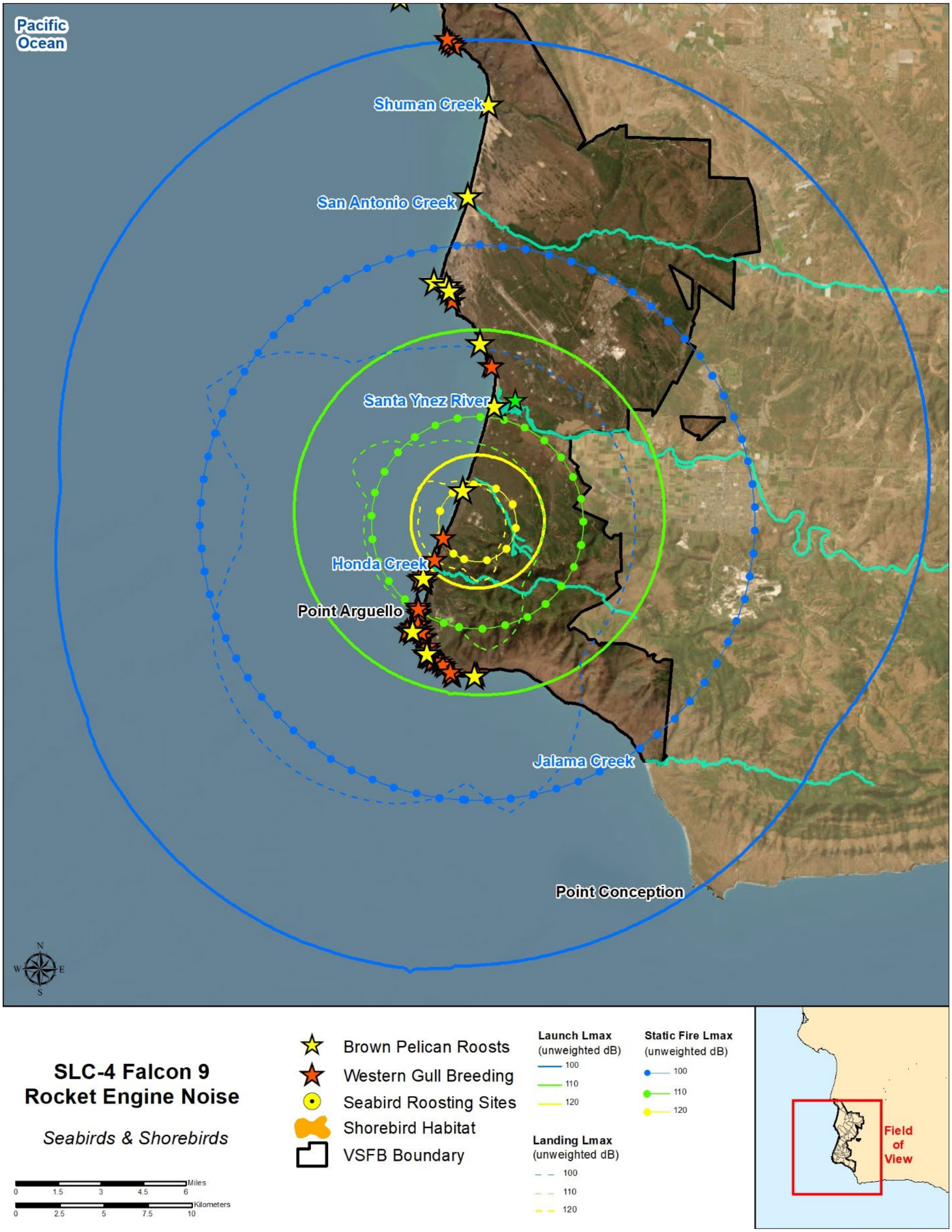

Figure B.0-7. Seabirds, shorebirds, and Falcon 9 SLC-4 static fire, launch, and landing rocket engine noise model results.

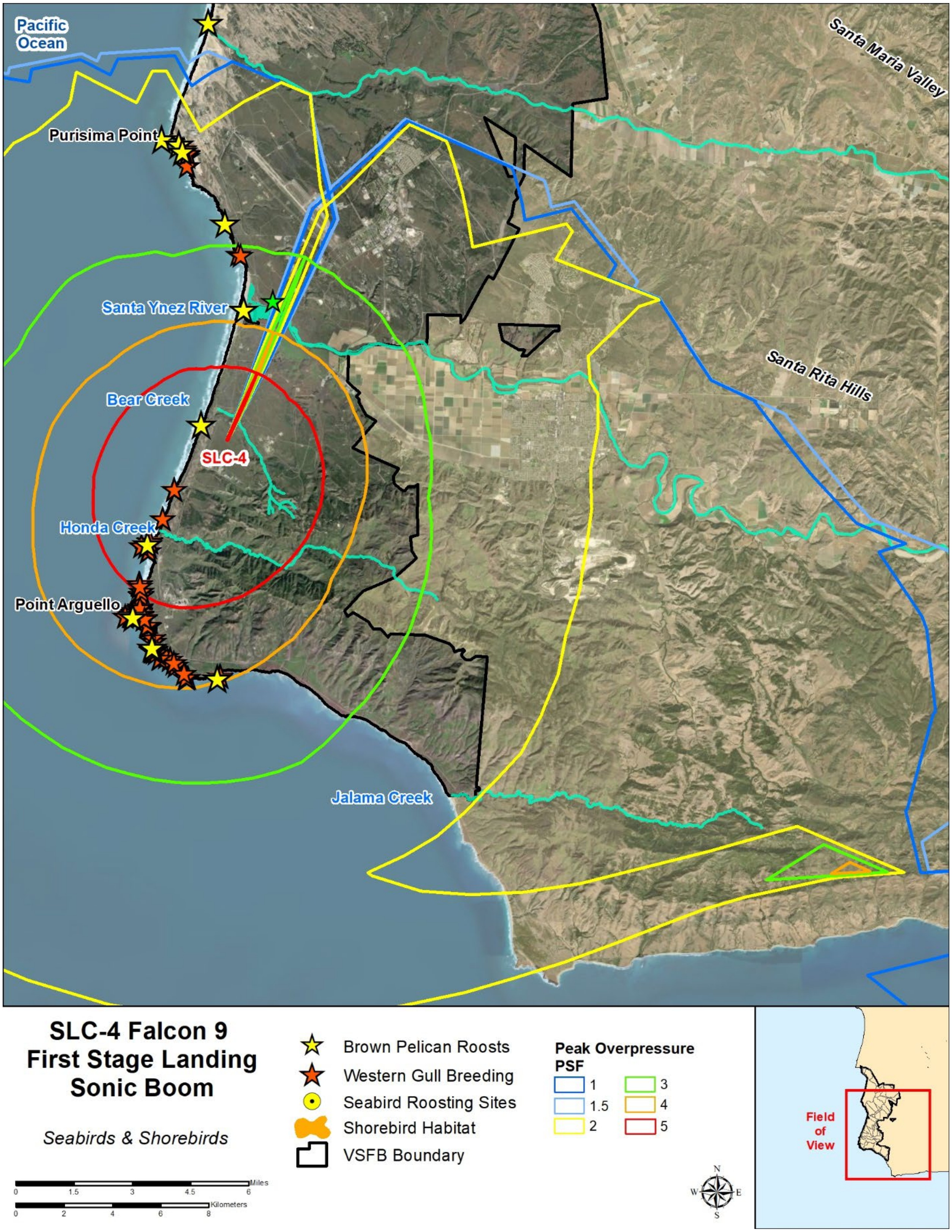

Figure B.0-8. Seabirds, shorebirds, and example SLC-4 landing sonic boom contours.

APPENDIX C – SBC EVACUATION EMAIL NOTIFICATIONS

From:	Santa Barbara County Parks Reservations
To:	Santa Barbara County Parks Reservations
Subject:	IMPORTANT INFORMATION REGARDING YOUR JALAMA BEACH RESERVATION (November 16)

Dear Valued Jalama Beach County Park Visitor,

Vandenberg Space Force Base and SpaceX has scheduled a launch for Thursday, November 16, 2023. The launch window is from 11:38 pm to 3:30 am the early morning of the 17th.

At this time **Jalama Beach is <u>not</u> subject to an evacuation** order due to the estimated number of overnight visitors being below the population threshold set by Space Force Launch Control, Safety Office, and the Federal Aviation Administration (FAA). **However, as the launch date/time approaches, if the estimated population threshold is exceeded, there will be a need to evacuate the campground from 3-hrs prior am/pm on November 16th until an all-clear status is issued by Space Force**.

While we **do not** anticipate the need to evacuate the campground at this time, please note the following:

- If an evacuation order is issued you will be notified in a subsequent email and all campers will be evacuated to the end of Jalama Road on to Highway 1. If you will be in mid-stay, you do not have to break down your campsite, and large camping gear may be left behind; however, we do recommend you take your valuables with you.
- While the campground is not currently subject to evacuation, if you do stay overnight in the park, please be advised while highly unlikely, there is a small risk of launch vehicle failure which could cause debris to fall on the campground.
- If you would like to move your check-in date or shorten your stay, depending on availability, please submit a reservation change form by visiting www.sbparks.org/support or contact our Call Center at (805) 568-2460. All changes will be made at no additional charge, and any shortened stays will be partially refunded.
- You may move your stay the evening of the launch to Cachuma Lake Recreation Area, depending on availability, which is approximately 50 miles from Jalama Beach. Please submit a reservation change form by visiting www.sbparks.org/support or contact our Call Center at (805) 568-2460 for availability at Cachuma Lake.
- If you would like to completely cancel the reservation, please submit a reservation change form by visiting www.sbparks.org/support or contact our Call Center (805) 568-2460. You must contact the Call Center by web form or phone to receive a full refund for your cancellation. Remember to disclose the “Jalama Safety Relocation” as the reason for your cancellation. Alternatively, please be advised that cancellations and refund requests initiated through the website will only include the site fee.

Please note that there is always a possibility that the launch may be cancelled or postponed to a later time. Backup dates are November 17th, 18th, and 19th.

We sincerely apologize for any inconvenience this may have caused, and hope this notification will help you make any necessary adjustments to your plans. Please let us know if you have any questions or concerns regarding this launch, and thank you for camping at Jalama Beach Park.

APPENDIX D – NMFS LETTER OF AUTHORIZATION

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
1315 East-West Highway
Silver Spring, Maryland 20910

DEPARTMENT OF COMMERCE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

NATIONAL MARINE FISHERIES SERVICE

Letter of Authorization

The U.S. Space Force (USSF), is hereby authorized to take marine mammals incidental to those activities at Vandenberg Space Force Base (VSFB), California, in accordance with 50 CFR 217, Subpart G--Taking Marine Mammals Incidental to U.S. Space Force Launches and Operations at Vandenberg Space Force Base (VSFB), California subject to the provisions of the Marine Mammal Protection Act (16 U.S.C. 1361 *et seq.*; MMPA) and the following conditions:

1. This Letter of Authorization (LOA) is valid April 10, 2024, through April 9, 2029.

2. This Authorization is valid only for the unintentional taking of the species and stocks of marine mammals identified in Condition 4 incidental to rocket and missile launches and supporting operations originating at VSFB.

3. This Authorization is valid only if USSF or any person(s) operating under its authority implements the mitigation, monitoring, and reporting required pursuant to 50 CFR §§ 217.64 and 217.65 and implements the Terms and Conditions of this Authorization.

4. <u>General Conditions</u>

   (a) A copy of this LOA must be in the possession of USSF, its designees, and personnel operating under the authority of this LOA.

   (b) The incidental take of marine mammals under the activities identified in Condition 2 and 50 CFR § 217.60 of the regulations, by Level B harassment only, is limited to the species and stocks and number of takes shown in Table 1.

Species	**Stock**	**Annual Take by Level B harassment**	**5-Year Total Take by Level B harassment**
Harbor seal	California	11,135	38,591
California sea lion	United States	84,870	281,021
Northern elephant seal	California Breeding	9,438	29,590
Steller sea lion	Eastern	550	1,900
Northern fur seal	California	5,909	18,383
Guadalupe fur seal	Mexico	23	71

(c) The taking by injury (Level A harassment), serious injury, or death of any of the species listed in condition 3(b) of the Authorization or any taking of any other species of marine mammal is prohibited and may result in the modification, suspension, or revocation of this LOA.

5. Mitigation

USSF, and any persons operating under its authority, must implement the following mitigation measures when conducting the activities identified in Condition 2 of this Authorization.

(a) USSF must provide pupping information to launch proponents at the earliest possible stage in the launch planning process and direct launch proponents to, if practicable, avoid scheduling launches during pupping seasons on VSFB from 1 March to 30 April and on the Northern Channel Islands from 1 June- 31 July. If practicable, rocket launches predicted to produce a sonic boom on the Northern Channel Islands >3 pounds per square foot (psf) from 1 June – 31 July will be scheduled to coincide with tides in excess of +1.0 ft (0.3 m), with an objective to do so at least 50 percent of the time.

(b) For manned flight operations, aircraft must use approved routes for testing and evaluation. Manned aircraft must also remain outside of a 1,000-ft (305 m) buffer around pinniped rookeries and haul-out sites (except in emergencies such as law enforcement response or Search and Rescue operations, and with a reduced, 500-ft (152 m) buffer at Small Haul-out 1).

(c) UAS classes 0-2 must maintain a minimum altitude of 300 ft (91 m) over all known marine mammal haulouts when marine mammals are present, except at take-off and landing. Class 3 must maintain a minimum altitude of 500 ft (152 m), except at take-off and landing. UAS classes 4 and 5 only operate from the VSFB airfield and must maintain a minimum altitude of 1,000 ft (305 m) over marine mammal haulouts except at take-off and landing. USSF must not fly class 4 or 5 UAS below 1,000 ft (305 m) over haulouts.

6. Monitoring

USSF is required to conduct marine mammal and acoustic monitoring as described below:

(a) Monitoring at VSFB and NCI must be conducted by at least one NMFS-approved Protected Species Observer (PSO) trained in marine mammal science. PSOs must have demonstrated proficiency in the identification of all age and sex classes of all marine mammal species that occur at VSFB and on NCI. They must be knowledgeable of approved count methodology and have experience in observing pinniped behavior, especially that due to human disturbances.

(b) In the event that the PSO requirements described in paragraph (a) of this section cannot be met (*e.g.*, access is prohibited due to safety concerns), daylight or nighttime video monitoring must be used in lieu of PSO monitoring. In certain circumstances where the daylight or nighttime video monitoring is also not possible (*e.g.*, USSF is unable to access a monitoring site due to road conditions or human safety concerns), USSF must notify NMFS.

(c) At VSFB, USSF must conduct marine mammal monitoring and take acoustic measurements for all new rockets, for rockets (existing and new) launched from new facilities, and for larger or louder rockets (including those with new launch proponents) than those that have been previously launched from VSFB during their first three launches and for the first three launches from any new facilities during March through July.

i. For launches that occur during the harbor seal pupping season (March 1 through June 30) or when higher numbers of California sea lions are present (June 1 through July 31), monitoring must be conducted. At least one NMFS-approved PSO trained in marine mammal science must conduct the monitoring.

ii. When launch monitoring is required, monitoring must begin at least 72 hours prior to the launch and continue through at least 48 hours after the launch. Monitoring must include multiple surveys each day, with a minimum of four surveys per day.

iii. For launches within the harbor seal pupping season, USSF must conduct a follow-up survey of pups.

iv. For launches that occur during daylight, USSF must make time-lapse video recordings to capture the reactions of pinnipeds to each launch. For launches that occur at night, USSF must employ night video monitoring, when feasible.

v. When possible, PSOs must record: species, number, general behavior, presence and number of pups, age class, gender, and reaction to launch noise, or to natural or other human-caused disturbances. PSOs must also record environmental conditions, including visibility, air temperature, clouds, wind speed and direction, tides, and swell height and direction.

(d) USSF must conduct sonic boom modeling prior to the first three small or medium rocket launches from new launch proponents or at new launch facilities, and all heavy or super-heavy rocket launches.

(e) USSF must conduct marine mammal monitoring and take acoustic measurements at the NCI if the sonic boom model indicates that pressures from a boom will reach or exceed 7 psf from 1 January through 28 February, 5 psf from 1 March through 31

July, or 7 psf from 1 August through 30 September. No monitoring is required on NCI from 1 October through 31 December.

i. The monitoring site must be selected based upon the model results, prioritizing a significant haulout site on one of the islands where the maximum sound pressures are expected to occur.

ii. USSF must estimate the number of animals on the monitored beach and record their reactions to the launch noise and conduct more focused monitoring on a smaller subset or focal group.

iii. Monitoring must commence at least 72 hours prior to the launch, during the launch and at least 48 hours after the launch, unless no sonic boom is detected by the monitors and/or by the acoustic recording equipment, at which time monitoring may be stopped.

iv. For launches that occur in darkness, USSF must use night vision equipment.

v. Monitoring for each launch must include multiple surveys each day that record, when possible: species, number, general behavior, presence of pups, age class, gender, and reaction to sonic booms or natural or human-caused disturbances.

vi. USSF must collect photo and/or video recordings for daylight launches when feasible, and if the launch occurs in darkness night vision equipment will be used.

vii. USSF must record environmental conditions, including visibility, air temperature, clouds, wind speed and direction, tides, and swell height and direction.

(f) USSF must continue to test equipment and emerging technologies, including but not limited to night vision cameras, newer models of remote video cameras and other means of remote monitoring at both VSFB and on the NCI.

(g) USSF must evaluate UAS based or space-based technologies that become available for suitability, practicability, and for any advantage that remote sensing may provide to existing monitoring approaches.

(h) USSF must monitor marine mammals during the first three launches of the missiles for the new Ground Based Strategic Defense program during the months of March through July across the 5-year duration of this LOA.

i. When launch monitoring is required, monitoring must include multiple surveys each day, with a minimum of four surveys per day.

ii. When possible, PSOs must record: species, number, general behavior, presence and number of pups, age class, gender, and reaction to launch noise, or to natural or other human-caused disturbances. PSOs must also record environmental conditions, including visibility, air temperature, clouds, wind speed and direction, tides, and swell height and direction.

(i) USSF must conduct semi-monthly surveys (two surveys per month) to monitor the abundance, distribution, and status of pinnipeds at VSFB. Whenever possible, these surveys will be timed to coincide with the lowest afternoon tides of each month when the greatest numbers of animals are usually hauled out. If a VSFB or area closure precludes monitoring on a given day, USSF must monitor on the next best day.

i. PSOs must gather the following data at each site: species, number, general behavior, presence and number of pups, age class, gender, and any reactions to natural or human-caused disturbances. PSOs must also record environmental conditions, including visibility, air temperature, clouds, wind speed and direction, tides, and swell height and direction.

7. <u>Reporting</u>

(a) USSF must submit an annual report each year to NMFS Office of Protected Resources and West Coast Region on March 1st of each year that describes all activities and monitoring for the specified activities during that year. This includes launch monitoring information in Condition 7(a)(i) through (iii) for each launch where monitoring is required or conducted. The annual reports must also include a summary of the documented numbers of instances of harassment incidental to the specified activities, including non-launch activities (*e.g.*, takes incidental to aircraft or helicopter operations observed during the semi-monthly surveys). Annual reports must also include the results of the semi-monthly sentinel marine mammal monitoring described in Condition 6(i), results of tests of equipment and emerging technologies described in condition 6(f), and results of evaluation of UAS based or space-based technologies described in condition 6(g).

i. Launch information, including:

1) Date(s) and time(s) of the launch (and sonic boom, if applicable);

2) Number(s), type(s), and location(s) of rockets or missiles launched;

ii. Monitoring program design; and

iii. Results of the launch-specific monitoring program, including:

1) Date(s) and location(s) of marine mammal monitoring;

2) Number of animals observed, by species, on the haulout prior to commencement of the launch or recovery;

3) General behavior and, if possible, age (including presence and number of pups) and sex class of pinnipeds hauled out prior to the launch or recovery;

4) Number of animals, by species, age, and sex class that responded at a level indicative of harassment. Harassment is characterized by:

A. Movements in response to the source of disturbance, ranging from short withdrawals at least twice the animal's body length to longer retreats over the beach, or if already moving a change of direction of greater than 90 degrees; or

B. All retreats (flushes) to the water.

5) Number of animals, by species, age, and sex class that entered the water, the length of time the animal(s) remained off the haulout, and any behavioral responses by pinnipeds that were likely in response to the specified activities, including in response to launch noise or a sonic boom;

6) Environmental conditions including visibility, air temperature, clouds, wind speed and direction, tides, and swell height and direction; and

7) Results of acoustic monitoring, including the following:

A. Recorded sound levels associated with the launch (in SEL, SPL_{peak}, and SPL_{rms});

B. Recorded sound levels associated with the sonic boom (if applicable), in psf; and

C. The estimated distance of the recorder to the launch site and the distance of the closest animals to the launch site.

iv. Results of the semi-monthly sentinel marine mammal monitoring described in Condition 6(i), including:

1) Number of animals observed, by species;

2) General behavior and, if possible, age (including presence and number of pups) and sex class of pinnipeds hauled out;

3) Any reactions to natural or human-caused disturbances;

4) Environmental conditions including visibility, air temperature, clouds, wind speed and direction, tides, and swell height and direction.

(b) USSF must submit a final, comprehensive 5-year report to NMFS Office of Protected Resources within 90 days of the expiration of this LOA. This report must:

i. Summarize the activities undertaken and the results reported in all annual reports;

ii. Assess the impacts at each of the major rookeries; and

iii. Assess the cumulative impacts on pinnipeds and other marine mammals from the activities specified in Condition 2.

(c) If the activity identified in Condition 2 likely resulted in the take of marine mammals not identified in Condition 4(b), then the USSF must notify the NMFS Office of Protected Resources and the NMFS West Coast Region stranding coordinator within 24 hours of the discovery of the take.

(d) In the event that personnel involved in the activities discover an injured or dead marine mammal, USSF must report the incident to the Office of Protected Resources (OPR), NMFS (PR.ITP.MonitoringReports@noaa.gov and itp.davis@noaa.gov) and to the West Coast regional stranding network (866-767-6114) as soon as feasible.

The report must include the following information:

i. Time, date, and location (latitude/longitude) of the first discovery (and updated location information if known and applicable);

ii. Species identification (if known) or description of the animal(s) involved;

iii. Condition of the animal(s) (including carcass condition if the animal is dead);

iv. Observed behaviors of the animal(s), if alive;

v. If available, photographs or video footage of the animal(s); and

vi. General circumstances under which the animal was discovered.

(e) If real-time monitoring during a launch shows that the activity identified in Condition 2 is reasonably likely to have resulted in the mortality or injury of any marine mammal, USSF must notify NMFS within 24 hours (or next business day). NMFS and USSF must then jointly review the launch procedure and the mitigation requirements and make appropriate changes through the adaptive management process, as necessary and before any subsequent launches of rockets and missiles with similar or greater sound fields and/or sonic boom pressure levels.

8. This Authorization may be modified, suspended or withdrawn if USSF fails to abide by the conditions prescribed herein or if the authorized taking is having more than a negligible impact on the species or stock of affected marine mammals.

9. Renewals and Modifications of Letter of Authorization

   (a) A LOA issued under 50 CFR §§ 216.106 and § 217.66 for the activity identified in Condition 2 of this Authorization and 50 CFR § 217.60(a) and (b) shall be modified upon request by USSF, provided that:

      i. The specified activity and mitigation, monitoring, and reporting measures, as well as the anticipated impacts, are the same as those described and analyzed for this subpart (excluding changes made pursuant to the adaptive management provision in paragraph (c) of this section); and

      ii. NMFS determines that the mitigation, monitoring, and reporting measures required by the previous LOA under these regulations were implemented.

   (b) For LOA modification or renewal requests by the applicant that include changes to the activity or the mitigation, monitoring, or reporting measures (excluding changes made pursuant to the adaptive management provision in paragraph (c) of this section) that do not change the findings made for the regulations or that result in no more than a minor change in the total estimated number of takes (or distribution by species or stock or years), NMFS may publish a notice of proposed changes to the LOA in the *Federal Register*, including the associated analysis of the change, and solicit public comment before issuing the LOA.

   (c) An LOA issued under 50 CFR §§ 216.106 and 217.66 for the activity identified in Condition 2 of this Authorization and 50 CFR § 217.60(a) and (b) may be modified by NMFS under the following circumstances:

      i. After consulting with the USSF regarding the practicability of the modifications, NMFS, through adaptive management, may modify (including adding or removing measures) the existing mitigation, monitoring, or reporting measures if doing so creates a reasonable likelihood of more effectively accomplishing the goals of the mitigation and monitoring.

      ii. Possible sources of data that could contribute to the decision to modify the mitigation, monitoring, or reporting measures in an LOA include:

         1) Results from the USSF's monitoring from the previous year(s);

2) Results from other marine mammal and/or sound research or studies; or

3) Any information that reveals marine mammals may have been taken in a manner, extent or number not authorized by these regulations or a subsequent LOA.

iii. If, through adaptive management, the modifications to the mitigation, monitoring, or reporting measures are more than minor, NMFS will publish a notice of the proposed changes to the LOA in the *Federal Register* and solicit public comment.

(d) If NMFS determines that an emergency exists that poses a significant risk to the well-being of the species or stocks of marine mammals specified in the regulations and this Authorization, an LOA may be modified without prior notice or opportunity for public comment. Notice would be published in the *Federal Register* within 30 days of the action.

MARZIN.CATHERINE.GAELLE.1365836082 Digitally signed by MARZIN.CATHERINE.GAELLE.1365836082 Date: 2024.04.09 11:41:00 -04'00'

For Kimberly Damon-Randall, Director
Office of Protected Resources

CALIFORNIA COASTAL COMMISSION
ENERGY, OCEAN RESOURCES AND FEDERAL CONSISTENCY
455 MARKET STREET, SUITE 300
SAN FRANCISCO, CA 94105-2421
VOICE (415) 904-5200
FAX (415) 904-5400

August 14, 2024

Beatrice L. Kephart
Chief, Installation Management Flight
Department of the Air Force
ATTN: Tiffany Whitsitt-Odell
1028 Iceland Avenue
Vandenberg SFB, CA 93437-6010
Via e-mail to: beatrice.kephart@spaceforce.mil

Re: Consistency Determination CD-0003-24 (Increase in Space Exploration Technologies Corporation's Falcon 9 launch and landing activities at VSFB to 36 and 12 per year, respectively, as well as the addition of offshore barge landing locations in the Pacific Ocean)

Dear Chief Kephart,

On August 8, 2024, the California Coastal Commission conditionally concurred with the above-referenced consistency determination submitted by the Department of the Air Force, for an increase in Space Exploration Technologies Corporation's (SpaceX) Falcon 9 launch and landing activities at Vandenberg Space Force Base to 36 and 12 per year, respectively, as well as the addition of offshore barge landing locations in the Pacific Ocean. The Commission found the proposed activities to be consistent with the California Coastal Management Program, provided that the Department of the Air Force agrees that the project will be modified in accordance with the following conditions.

Conditions:

1. **On-Base Enhanced Biological Monitoring Program.** Within 30 days of the Commission's consideration of Consistency Determination No. CD-0003-24, the Department of the Air Force (DAF) shall prepare and provide for the Executive Director's review and comment an enhanced biological monitoring program for Vandenberg Space Force Base (VSFB) focused on evaluating the biological effects of engine noise and sonic booms from launches and boost-back landings. DAF shall consider comments provided by the Executive Director and address them through modifications to the enhanced biological monitoring program and/or written responses as to why such modifications are infeasible. The enhanced biological monitoring program shall be implemented and include descriptions of how the following will be accomplished:

    a. **Monitoring.** In addition to the monitoring required (1) by the United States Fish and Wildlife Service (USFWS) in their March 21, 2023, Biological Opinion (2023 USFWS BO), including for western snowy plover, California least tern, California red-legged frog, and southern sea otter, and (2) by the National Marine Fisheries Services (NMFS) in their Letter of Authorization

(LOA) dated April 9, 2024 (2024 NMFS LOA), for marine mammals, DAF shall implement the following supplemental monitoring activities and measures to maintain and improve ongoing monitoring:

i. Continue the on-base marine mammal (by daylight or nighttime video recording or by at least one NMFS-approved Protected Species Observer trained in marine mammal science) and acoustic monitoring as required by the previous NMFS LOA (dated April 10, 2019), including:
   (1) Pinniped activity at VAFB shall be monitored in the vicinity of the haulout nearest the launch and landing complex, or, in the absence of pinnipeds at that location, at another nearby haulout, for at least 72 hours prior to any planned launch, and continued for a period of time not less than 48 hours subsequent to the launch and/or landings for (a) any launches of space launch vehicles or landings of the Falcon 9 First Stage occurring from January 1 through July 31, and (b) any landings of the Falcon 9 First Stage occurring from August 1 through December 31 that are predicted to result in a sonic boom of 1.0 pounds per square foot (psf) or above at VAFB;
   (2) For any launches or Falcon 9 First Stage landings occurring from January 1 through July 31, follow-up surveys must be conducted within two weeks of the launch.

ii. Monitoring of the on-base pallid bat and western red bat populations in a manner sufficient to assess potential changes in habitat use patterns and population levels;

iii. Monitoring of the on-base monarch butterfly populations in a manner sufficient to assess potential changes in habitat use patterns and population levels;

iv. Identification of data and appropriate ongoing monitoring of off-base reference site populations of western snowy plover, California least tern, and California red-legged frog that can be used as a basis of comparison for on-base monitoring results. If no such data and appropriate ongoing monitoring can be identified, it shall be established; and

v. Identification of data and appropriate ongoing monitoring of off-base reference site populations of marine mammals that can be used as a basis of comparison for on-base monitoring results. If no such data and appropriate ongoing monitoring can be identified, it shall be established; and

vi. Equipment redundancy and data-handling improvements to help ensure further loss of monitoring data is avoided.

b. **Analysis of Monitoring Data.** DAF shall conduct analysis of the USFWS- and NMFS-required monitoring data and the supplemental monitoring data described above on an annual basis, in preparation of the annual reports described below, that shall include multivariate statistical analyses of the changes in population trends using: (a) relevant historical population data; (b) frequency of launches and on-base boost-back landings over different time scales; (c) seasonality of launches and sensitive times of year for respective species; (d) geospatial variability; (e) off-base reference site data; (f) climatic and oceanographic patterns (e.g. El Niño, Pacific Decadal Oscillation, storms, ocean temperature); (g) acoustic monitoring data; (h) and patterns of other variables including (as relevant to the respective species), but not limited to, pupping rates, breeding rates, beach width, behavior during launches, and forage base or food web trends. Relevant population trends to analyze include, but are not limited to, population sizes and locations, and for western snowy plovers and least terns, rates of breeding success (including number of hatched chicks and fledglings), nest/colony abandonment, injury, or mortality to eggs or chicks. Analysis of potential impacts from individual launches shall also include use of the results of the landscape-level camera monitoring for western snowy plover and California least tern required by the 2023 USFWS BO.

c. **Reporting.** No later than July 1 of each year, DAF shall send an annual report to the Executive Director for the enhanced biological monitoring program. The annual report shall include the monitoring data and results collected over the previous year as well as any initial conclusions, including those from the analyses detailed above in part b of this condition, regarding potential effects to any monitored species as a result of space launch and landing activity at Vandenberg Space Force Base. If significant disruption or degradation of habitat values are identified from these conclusions in terms of either (i) a statistically significant change, or (ii) a change greater than the baseline annual variation over the course of two consecutive years, in monitored indicators of species population or reproductive success, and cannot confidently be attributed to other natural- or human-caused catastrophic factors not related to the launch and landing activities, DAF shall prepare and provide for the Commission’s federal consistency review a proposal for avoidance, minimization and mitigation measures to address the impacts.

   The annual report submittal shall also include the following:

   i. Annual reports prepared for the 2023 USFWS BO on western snowy plover, California least tern, California red-legged frog, and southern sea otter (including any individual reports for those species referenced in the annual reports);
   ii. The results of marine mammal monitoring carried out consistent with the 2024 NMFS LOA and consistent with part a(i) of this condition;
   iii. The annual “Monitoring and Management of the Endangered California Least Tern and the Threatened Western Snowy Plover at Vandenberg Space Force Base” reports;
   iv. The results of on-base monarch butterfly monitoring;
   v. The results of pallid bat and western red bat monitoring; and
   vi. Modeled sonic boom conditions for each launch based on trajectory and atmospheric conditions.

Every three years, the third annual report shall include a summary of the previous three years of monitoring results as well as conclusions regarding potential effects to the monitored species as a result of space launch and landing activity at Vandenberg Space Force Base. Within 60 days of providing this three-year report of monitoring results to the Executive Director, DAF shall convene a meeting of relevant staff from the Commission, USFWS and NMFS to present and discuss the monitoring results and conclusions.

2. **Off-Base Sonic Boom Minimization Measures.** Within 30 days of the Commission's consideration of Consistency Determination No. CD-0003-24, the Department of the Air Force (DAF) shall submit, for Executive Director review and comment, a Sonic Boom Minimization Plan for limiting the spatial extent and severity (in terms of overpressure levels) of sonic booms caused by launches. This plan shall include measures for evaluating modeling for specific atmospheric conditions to anticipate sonic boom effects on the Northern Channel Islands and off-base areas of the mainland coast of Santa Barbara, Ventura, and Los Angeles Counties, and measures for making decisions on launch time and trajectory based on an analysis to minimize the spatial extent and severity of sonic booms experienced in those off-base areas. DAF shall consider comments provided by the Executive Director and address them through modifications to the Sonic Boom Minimization Plan and/or written responses as to why such modifications are infeasible. DAF shall implement the Sonic Boom Minimization Plan.

3. **Off-Base Acoustic and Biological Monitoring.** If implementation of the Sonic Boom Minimization Plan would not result in avoidance of sonic boom effects on the Northern Channel Islands and off-base areas of the coastal zone in mainland Santa Barbara, Ventura, and Los Angeles Counties, the Department of the Air Force (DAF) shall prepare and provide for Executive Director review and comment, an Acoustic and Biological Monitoring Program for affected coastal areas outside of Vandenberg Space Force Base that shall include: (a) monitoring that quantifies species response to sonic booms, including in areas of special biological significance, such as marine mammal haulout sites, and in Environmentally Sensitive Habitat Areas (ESHA), including dune ESHA and significant bird breeding, nesting, foraging, or roosting sites, which could be affected by sonic booms; and (b) acoustic monitoring at those sites during launches to measure received sonic boom overpressure levels. DAF shall consider comments provided by the Executive Director and address them through modifications to the Acoustic and Biological Monitoring Program and/or written responses as to why such modifications are infeasible. DAF shall implement the Acoustic and Biological Monitoring Program.

4. **Lighting Management Plan.** A Lighting Management Plan is being completed and will be submitted to the USFWS as a requirement of the BO. DAF will provide the Commission with a copy of the approved management plan DAF will consider comments provided by the Executive Director on the Lighting Management Plan and address them, when practicable in coordination with the USFWS. Once the BO is issued, DAF will implement the Lighting Management Plan.

5. **Coastal Access and Recreation Enhancement.** Within 30 days of the Commission's consideration of Consistency Determination No. CD-0003-24, DAF will provide, for Executive Director review and comments, an update on the Coastal Access and Recreation Enhancement efforts it is pursuing. The update will include (1) specific details and schedules for implementation of the commitments DAF has made for the evacuation shuttle, satellite internet and Highway 1 digital signage projects for Jalama Beach County Park and the Lompoc Unified School District third grade beach field trip program; (2) details of measures that SpaceX and DAF will take to ensure that the proposed launch activities will not exceed DAF's commitment to cause more than 12 annual closures of Jalama Beach; and (3) a minimum notice period, coordinated with the Santa Barbara County Parks and Recreation Department, for any planned evacuations for Jalama Beach. DAF will consider comments provided by the Executive Director in response to the update and strive to address them when possible.

6. **Marine Debris.** DAF will ensure that annual payments by the Space Exploration Corporation (SpaceX) are made at a rate of $20 (adjusted annually for inflation) for each pound of unrecoverable marine debris generated as a result of space launch and landing activities, including the release of weather balloons in advance of launch and/or landing activities occurring in State waters. These marine debris offset payments will be provided to the U.C. Davis Lost Fishing Gear Recovery Project (U.C Davis Program) and DAF and the Executive Director will collaborate to identify a public or non-profit organization focused on removal of hazardous waste from the marine environment or battery/electronic waste recycling and reduction efforts that can also receive funding. Once that organization is identified, future marine debris offset payments will be divided equally between it and the U.C. Davis Program. In addition, DAF will, within 30 days of the Commission's consideration of Consistency Determination No. CD-0003-24, provide an update to the Executive Director describing its recent efforts to evaluate and implement measures to reduce the amount of marine debris released as part of launch activities (and described in the CD and the 2023 EA/FONSI for 36 launches), such as by minimizing the number of weather balloons released per launch, exploring alternatives to the released weather balloons, and modifying the radiosondes. If technological and/or operational advancements in the future allow for further reductions of the use of weather balloons or marine debris associated with launches, DAF will consider further marine debris reduction efforts. DAF will also provide an annual report to the Executive Director by January 1st of each year that includes the amounts and types of marine debris released as part of each SpaceX launch and provides details about the amounts of plastics and other materials within the released debris.

7. **Commercial and Recreational Fishing Coordination Plan.** Within 30 days of the Commission's consideration of Consistency Determination No. CD-0003-24, DAF will submit a Commercial and Recreational Fishing Coordination Plan to the Executive Director for review and comments. The Plan will include the development and implementation of a communication protocol, including regular dialogue, developed in coordination with the commercial and recreational fishing industry most~~ly~~ likely to be affected by launch and landing activities at Vandenberg Space Force Base as well as an email to local fishermen's associations that include the date and time of the surveillance area, and the vessel hazard area that is also

available in the Notice to Mariners, and for how long these will be in effect. DAF shall consider comments provided by the Executive Director and strive to address them, when possible.

The basis for the conditions under the enforceable policies of the California Coastal Management Program is provided in the attached adopted findings (the staff recommendation mailed for the August 8, 2024, Commission meeting with modifications and additions as detailed in the staff report addenda dated August 6 and 7, 2024). As reflected in the adopted findings and letter received from DAF on August 6, 2024, it is the Commission's understanding that the subject consistency determination was modified to include implementation of the protective measures described in conditions four through seven described above. These conditions were included by the Commission in its conditional concurrence simply to memorialize DAF's commitment. The Commission determined that, only as conditioned, could the project be found consistent to the maximum extent practicable with the enforceable policies of the California Coastal Management Program. The Commission notes that as provided in 15 CFR § 930.4(b), should DAF not agree with the Commission's conditions of concurrence, then all parties shall treat this conditional concurrence as an objection. If DAF were to decide to proceed with the project in such a situation, we would expect it to be carried out as described in its consistency determination, including as revised in DAF's letter of August 6, 2024.

If you have questions, please feel free to contact Walt Deppe at Walt.Deppe@coastal.ca.gov.

Sincerely,

Cassidy Teufel
Director
Energy, Ocean Resources, Federal Consistency, and Technical Services

Cc:

Darryl York, Department of the Air Force, U.S. Space Force (darryl.york@spaceforce.mil)

Tiffany Whitsitt-Odell, Department of the Air Force, U.S. Space Force (tiffany.whitsitt-odell@spaceforce.mil)

APPENDIX E
Air Quality

South Coast
Air Quality Management District
21865 Copley Drive, Diamond Bar, CA 91765-4178
South Coast AQMD (909) 396-2000 • www.aqmd.gov

September 26, 2024

Colonel Mark A. Shoemaker, USSF
Commander
Space Launch Delta 30
747 Nebraska Ave, Ste A302
Vandenberg SFB, CA 93437-6261

RE: General Conformity Determination for the increased SpaceX launch operations at Vandenberg Space Force Base during 2025–2030

To. Mr. Shoemaker,

This letter is in response to your letter dated September 24, 2024 requesting South Coast Air Quality Management District (South Coast AQMD) to accommodate the anticipated emissions within the South Coast Air Basin (Basin) from the SpaceX increased launch operations at Vandenberg Space Force Base (VSFB) in the Air Quality Management Plan (AQMP)/State Implementation Plan (SIP) emissions budget for general conformity purposes.

The general conformity determination process is intended to demonstrate that a proposed Federal action will not: (1) cause or contribute to new violations of a national ambient air quality standard (NAAQS); (2) interfere with provisions in the applicable SIP for maintenance of any NAAQS; (3) increase the frequency or severity of existing violations of any standard; or (4) delay the timely attainment of any standard. As such, for general conformity determination, the proposed federal action needs to conform to the latest approved SIP/AQMP.

The Basin is designated as an extreme non-attainment area for ozone, serious non-attainment area for PM2.5 and maintenance area for Carbon Monoxide. To accommodate projects subject to general conformity requirements and to streamline the review process, general conformity budgets for NOx and VOC emissions were established in an AQMP. The 2016 AQMP[1], which is the latest SIP approved by U.S. EPA, established set aside accounts to accommodate emissions subject to general conformity requirements. The set-aside accounts include 2 tons per day (tpd) or 730 tons per year (tpy) of NOx and 0.5 tpd or 182.5 tpy of VOC each year starting in 2017 through 2030, and 0.5 tpd (182.5 tpy) of NOx and 0.2 tpd (73 tpy) of VOC in 2031. Emissions from this set-aside account are granted on a first-come-first-serve basis, and as of September 2024, a limited amount of NOx and VOC emissions remain available. It's important to note that the

[1] https://www.aqmd.gov/home/air-quality/air-quality-management-plans/final-2016-aqmp

general conformity set-aside accounts are subject to change in future AQMPs. The 2022 AQMP[2], for instance, introduces control measure EGM-02, which seeks to eliminate the general conformity set-aside account after 2031. Instead, EGM-02 proposes to require that new federal project emissions be accommodated with appropriate mitigation or offset of the increased emissions. The 2022 AQMP was submitted to U.S. EPA via California Air Resource Board (CARB) in February 2023 and is currently under review.

The proposed U.S. Space Force (USSF) project (Proposed Action) involves increasing the annual SpaceX Falcon launch cadence at VSFB through launches at Space Launch Complex (SLC)-4. The project proposes to transport first stages from the Port of Long Beach to the VSFB Harbor via a "roll-on-roll-off" barge. A support tug would be launched from the Port of Long Beach or Port Hueneme and travel up the coast to assist the barge and primary tug in maneuvering into and out of the VSFB Harbor. The Proposed Action would include up to 50 events per year utilizing roll-on-roll-off operations.

South Coast AQMD staff has reviewed the emissions anticipated from the Proposed Action based on the information provided in your letter. We have determined that the NOx emissions exceeding the de minimis thresholds can be accommodated within the general conformity budgets established in the 2016 AQMP. Table 1 below shows the emissions from operation activities during 2025 to 2030 that are accommodated within the SIP set-aside budget established in the 2016 AQMP.

Table 1. The Proposed Action Emissions Accommodated in 2016 AQMP General Conformity Budgets (tons per year)*

Pollutants	Emission Phase	2025	2026	2027	2028	2029	2030
NOx	Operation	31.26	31.26	31.26	31.26	31.26	31.26

*USSF commits to track actual emission of the Proposed Action within the Basin annually and return the surplus credits, if any, to South Coast AQMD general conformity budget

The emissions submitted by USSF in their request were conservatively estimated to align with those in the Draft Environmental Assessment,[3] and represent the maximum potential emissions that could result from the Proposed Action. To ensure that the actual project emissions are accounted for in the South Coast AQMD's set-aside account accurately, USSF will prepare an annual report to track project activities within the Basin, quantify the associated emissions, and

[2] https://www.aqmd.gov/home/air-quality/air-quality-management-plans/air-quality-mgt-plan

[3] Available at https://www.vandenberg.spaceforce.mil/About-Us/Environmental/EAS/

submit to the South Coast AQMD by March 30 each year. If the actual emissions from the Proposed Action are lower than the emissions identified in this letter, any surplus credits will be returned to the South Coast AQMD annually, as specified in Attachment 2 of the USSF's request letter.

Emissions from the Federal agency's future SpaceX launch activities within the Basin, scheduled for 2031 to 2055, are not included in this determination. A separate General Conformity Determination process will be required, which will be developed in collaboration with the South Coast AQMD at a future date.

In summary, based on our evaluation, the proposed USSF project to be conducted in 2025 through 2030 will conform to the latest EPA approved AQMP as the project's emissions are accommodated within the AQMP's emissions budgets, and the proposed project is not expected to result in any new or additional violations of the NAAQS or impede the projected attainment of the NAAQS in the years 2025 through 2030.

If you have any questions, please contact me at (909) 396-3244 or imacmillan@aqmd.gov or Dr. Sang-Mi Lee, Rules and Planning Manager at (909)-396-3169 or slee@aqmd.gov.

Sincerely,

Ian V. MacMillan

Ian MacMillan
Assistant Deputy Executive Officer
Planning, Rule Development & Implementation
South Coast Air Quality Management District

Attachments:

1. Letter from U.S. Space Force dated September 24, 2024
2. Appendix A of Air Quality and Greenhouse Gas Emissions Technical Report: Falcon Program Expansion at Vandenberg Space Force Base, California. September 2024.
   Available at: https://www.vandenberg.spaceforce.mil/About-Us/Environmental/EAS/

eCC: Tom Kelly, US EPA Region IX
Barbara Baird, South Coast AQMD
Kathryn Roberts, South Coast AQMD
Sarah Rees, South Coast AQMD
Sang-Mi Lee, South Coast AQMD
Barbara Radlein, South Coast AQMD

Marc Carreras Sospedra, South Coast AQMD
Rui Zhang, South Coast AQMD

DEPARTMENT OF THE AIR FORCE
UNITED STATES SPACE FORCE
SPACE LAUNCH DELTA 30

September 24, 2024

Colonel Mark A. Shoemaker, USSF
Commander
Space Launch Delta 30
747 Nebraska Ave, Ste A302
Vandenberg SFB CA 93437-6261

Dr. Sarah Rees, Deputy Executive Officer
South Coast Air Quality Management District
Planning, Rule Development and Area Source Division
21865 Copley Drive
Diamond Bar CA 91765

Dear Dr. Rees

The general conformity findings outlined in this letter have been prepared by Dudek on behalf of Space Launch Delta 30 (SLD 30) to summarize the anticipated direct and indirect criteria pollutant emissions for the proposed Falcon Program Expansion Project (Proposed Action).

The Proposed Action is to increase the annual Falcon launch cadence at Vandenberg Space Force Base (VSFB) through launches at Space Launch Complex (SLC)-4. While most of the operations occur on VSFB, there are marine vessel operations that occur within the South Coast Air Basin (SCAB). The Proposed Action proposes to transport first stages from the Port of Long Beach to the VSFB Harbor via a "roll-on-roll-off" barge. The first stage would be pulled by a Tier 3 (or higher) tug from the Port of Long Beach into the VSFB Harbor. A support tug would be launched from the Port of Long Beach or Port Hueneme and travel up the coast to assist the barge and primary tug in maneuvering into and out of the VSFB Harbor. The Proposed Action would include up to 50 events per year utilizing roll-on-roll-off operations.

The Proposed Action is subject to the National Environmental Policy Act (NEPA) and requires a General Conformity Determination under the U.S. Clean Air Act. SLD 30 is currently preparing an Environmental Assessment for this Project. Annual net emissions anticipated to occur in the SCAB related to the Proposed Action were calculated and are presented in Tables 1 and 2 in Attachment 1. As shown in those tables, emissions of nitrogen oxides (NOx) within the SCAB are projected to be 31.26 tons per year, which exceeds the general conformity de minimis level of 10 tons per year, during years 2025 through 2030. NOx is a precursor pollutant to ozone, a pollutant for which the SCAB is designated as an "extreme" nonattainment area for multiple ozone national ambient air quality standards. All other air emissions are projected to be below de minimis levels for all years in which emissions were inventoried. There would be no construction emissions within the SCAB.

Attachment 1 also provides the anticipated average daily NOx emissions associated with the Proposed Action. While emissions were conservatively assumed to be constant through the operation of the proposed project's lifetime, it is reasonable to assume that emissions would go down over time due to increases in efficiency and marine vessel upgrades. Furthermore, the anticipated emissions from the Proposed Action, which align with those in the Draft Environmental Assessment, represent the maximum potential emissions that could result from the Proposed Action. To ensure that the South Coast Air Quality Management District (SCAQMD) emission budget accurately reflects the actual project emissions, SLD 30 will prepare an annual report to track project activities within the SCAB, quantify the associated emissions, and submit to the SCAQMD by March 30 each year. If the actual emissions from the Proposed Action are lower than the projected, any surplus credits will be returned to the SCAQMD annually. A detailed calculation methodology for the annual reporting is included in Attachment 2. SLD 30's Draft Environmental Assessment, Request for General Conformity Determination, and associated attachments are available online at: https://www.vandenberg.spaceforce.mil/About-Us/Environmental/EAS/.

We respectfully request that the SCAQMD affirm that these emissions levels can be accommodated within the general conformity budget established in the Final 2016 Air Quality Management Plan (Appendix VI-D). We understand that this SIP set aside budget is reserved to handle General Conformity projects that exceed de minimis levels.

If you have any questions or would like to discuss the undertaking in more detail, please contact Ms. Bea Kephart, (805) 605-7924, beatrice.kephart@spaceforce.mil.

Sincerely

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MARK A. SHOEMAKER, Colonel, USSF
Commander

2 Attachments:
1: Project Emissions
2: Annual Reporting Methodology

Attachment 1: Project Emissions

Table 1. Annual Project Operational Emissions – Proposed Action SCAQMD

Emission Source	VOC	NO_x	CO	SO_x	PM_{10}	$PM_{2.5}$
	Tons Per Year					
Solvent Use	0.00	0.00	0.00	0.00	0.00	0.00
Emergency Generators	0.00	0.00	0.00	0.00	0.00	0.00
Worker Vehicles	0.00	0.00	0.00	0.00	0.00	0.00
Fleet Vehicle Use	0.00	0.00	0.00	0.00	0.00	0.00
Vendor-Contractor Vehicles	0.00	0.00	0.00	0.00	0.00	0.00
Off-Road Equipment	0.00	0.00	0.00	0.00	0.00	0.00
RP-1, RSV Loading, and Payload Fueling	0.00	0.00	0.00	0.00	0.00	0.00
Roll-On-Roll-Off	2.54	31.62	46.38	0.57	0.71	0.71
Launch	0.00	0.00	0.00	0.00	0.00	0.00
Payload Fairing Recovery	0.14	0.67	0.28	0.11	0.05	0.05
Landings	0.00	1.07	0.00	0.00	0.00	0.00
Total	**2.68**	**33.36**	**46.66**	**0.68**	**0.76**	**0.76**
Baseline	**0.34**	**2.10**	**1.35**	**0.05**	**0.07**	**0.07**
Delta (Proposed Action – Baseline)	**2.34**	**31.26**	**45.31**	**0.63**	**0.69**	**0.69**
General Conformity De Minimis Thresholds	*10*	*10*	*100*	-	*100*	*70*
Threshold Exceeded?	**No**	**Yes**	**No**	**No**	**No**	**No**

Notes: VOC = volatile organic compound; NO_x = oxides of nitrogen; CO = carbon monoxide; SO_x = sulfur oxides; PM_{10} = coarse particulate matter; $PM_{2.5}$ = fine particulate matter; <0.01 = reported value less than 0.01.
See Appendix A for complete results.
Totals may not sum due to rounding.

Table 2. Daily Project Operational Emissions – Proposed Action SCAQMD

Emission Source	VOC	NO_x	CO	SO_x	PM_{10}	$PM_{2.5}$
	Tons Per Day					
Solvent Use	0.00	0.00	0.00	0.00	0.00	0.00
Emergency Generators	0.00	0.00	0.00	0.00	0.00	0.00
Worker Vehicles	0.00	0.00	0.00	0.00	0.00	0.00
Fleet Vehicle Use	0.00	0.00	0.00	0.00	0.00	0.00
Vendor-Contractor Vehicles	0.00	0.00	0.00	0.00	0.00	0.00
Off-Road Equipment	0.00	0.00	0.00	0.00	0.00	0.00
RP-1, RSV Loading, and Payload Fueling	0.00	0.00	0.00	0.00	0.00	0.00
Roll-On-Roll-Off	0.01	0.09	0.13	0.002	0.002	0.002
Launch	0.00	0.00	0.00	0.00	0.00	0.00
Payload Fairing Recovery	0.0004	0.002	0.001	0.0003	0.0001	0.0001
Landings	0.0000	0.003	0.0000	0.0000	0.0000	0.0000
Total	**0.01**	**0.09**	**0.13**	**0.002**	**0.002**	**0.002**
Baseline	**0.001**	**0.01**	**0.004**	**0.0001**	**0.0002**	**0.0002**
Delta (Proposed Action – Baseline)	**0.01**	**0.09**	**0.12**	**0.002**	**0.002**	**0.002**

Notes: VOC = volatile organic compound; NO_x = oxides of nitrogen; CO = carbon monoxide; SO_x = sulfur oxides; PM_{10} = coarse particulate matter; $PM_{2.5}$ = fine particulate matter; <0.01 = reported value less than 0.01.
See Appendix A for complete results.
Totals may not sum due to rounding.

Attachment 2: Annual Reporting Methodology

By March 30 of each year, SLD 30 will submit an annual report summarizing actual emissions occurred from the Proposed Action in the jurisdiction of the SCAQMD from the previous calendar year.

Onboard GPS data from the marine vessels will be used to ensure that emissions within the SCAQMD jurisdiction are accurately captured and reported. The emissions from the marine vessels will be calculated based on annual fuel consumption and engine run hours using the following equations:

Equation 1: Load Factor

$$LF = \frac{G\ x\ HHV}{Engines\ x\ HP\ x\ Hrs\ x\ BSFC}$$

Where:
LF = load factor
G = total gallons for the year of R99
HHV = higher heating value (137,000 btu/gallon for R99)
Engines = number of engines
HP = engine rating brake horsepower of the engine
Hrs = total engine hours for the year
BSFC = brake specific fuel consumption (7,420 btu/bhp-hr)

Equation 2: Emissions

$$Em = \frac{EF\ x\ kW\ x\ LF\ x\ Hrs\ x\ Engines}{453.6\ x\ 2{,}000}$$

Where:
Em = Annual emissions (tons per year)
EF = pollutant specific emission factor (g/kW-hr)
kW = kilowatt rating of engine
LF = load factor of engine (from equation 1)
Hrs = total engine hours for the year
Engines = number of engines
453.6 = conversion factor (453.6 g = pound)
2,000 = conversion factor (2,000 pounds = ton)

Due to the lack of available jurisdiction specific records for the offroad equipment and the fact that offroad equipment comprise a small portion of the overall proposed emissions, SLD-30 will track the actual operating days for offroad equipment. This can be done based on detailed marine vessel trip information. The hours per day will be assumed to be the same as within the 2024 EA[1]. The emissions will be calculated using equation 3 below.

[1] Available at: https://www.vandenberg.spaceforce.mil/About-Us/Environmental/EAS/

Equation 3: Offroad Equipment Emissions

$$Em = \frac{EF\ x\ HP\ x\ LF\ x\ Hrs\ x\ Days}{453.6\ x\ 2{,}000}$$

Where:
EM = annual emissions (tons per year)
EF = pollutant specific emission factor (g/hp-hr)
HP = horsepower of engine
LF = load factor (from 2024 EIS)
Hrs = hours per day (from 2024 EIS)
Days = days per year
453.6 = conversion factor (453.6 g = pound)
2,000 = conversion factor (2,000 pounds = ton)

Air Quality and Greenhouse Gas Emissions Technical Report

Falcon Program Expansion Alternative 1 at Vandenberg Space Force Base, California

OCTOBER 2024

Prepared for:

SPACE LAUNCH DELTA 30, INSTALLATION MANAGEMENT FLIGHT ENVIRONMENTAL ASSETS
1028 Iceland Avenue, Building 11146
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Prepared by:

DUDEK
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Contact: Adam Poll

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Table of Contents

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TABLES

APPENDIX

Acronyms and Abbreviations

Acronym/Abbreviation	Definition
CAA	Clean Air Act
CO	carbon monoxide
EPA	U.S. Environmental Protection Agency
HAP	hazardous air pollutant
NAAQS	National Ambient Air Quality Standards
NO_2	nitrogen dioxide
NO_x	oxides of nitrogen
O_3	ozone
PM_{10}	particulate matter with an aerodynamic diameter less than or equal to 10 microns
$PM_{2.5}$	particulate matter with an aerodynamic diameter less than or equal to 2.5 microns
Alternative 1	Falcon Program Expansion at Vandenberg Space Force Base
SO_2	sulfur dioxide
SO_x	sulfur oxides
VOC	volatile organic compound

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Executive Summary

The purpose of this technical report is to assess the potential air quality emissions impacts associated with implementation of the Falcon Program Expansion Alternative 1 (Alternative 1) and alternatives at Vandenberg Space Force Base (VSFB), California.

Project and Approach Overview

Alternative 1 is to increase the annual Falcon launch cadence at VSFB through launches at Space Launch Complex (SLC)-4 to support future commercial and U.S. government launch service needs.

The project site is in Santa Barbara County, California but has components occurring within Ventura and Los Angeles Counties. The California Air Resources Board is responsible for maintaining air quality standards in California. The local air districts implement adopted air quality standards and regulations.

Operational criteria air pollutant emissions were estimated using the Air Conformity Applicability Model (ACAM), spreadsheet models, and the California Emissions Estimator Model (CalEEMod). Alternative 1 does not contain a construction component.

Air Quality

Criteria air pollutants are defined as pollutants for which the federal and state governments have established ambient air quality standards, or criteria, for outdoor concentrations to protect public health. Criteria air pollutants include ozone (O_3), nitrogen dioxide (NO_2), carbon monoxide (CO), sulfur dioxide (SO_2), particulate matter with an aerodynamic diameter less than or equal to 10 microns (PM_{10}), particulate matter with an aerodynamic diameter less than or equal to 2.5 microns ($PM_{2.5}$), and lead. Pollutants that were evaluated were reactive organic gases, oxides of nitrogen (NO_x), CO, sulfur oxides (SO_x), PM_{10}, and $PM_{2.5}$. Reactive organic gases and NO_x are important because they are precursors to O_3.

Insignificance Criteria

For air quality impact assessments, significance is defined by the degree to which the effects of Alternative 1 potentially could affect public health or safety. The U.S. Air Force (USAF) conducts National Environmental Policy Act (NEPA) and General Conformity Rule air quality impact assessments in tandem within the Environmental Impact Analysis Process (EIAP) (HQ AFCEC/CZTQ 2023a).

The USAF insignificance thresholds are EPA-established annual emission rates that, if exceeded, would trigger a regulatory requirement. Insignificance indicators are EPA-established rate thresholds that are partially applied or applied out of context to their intended use; however, can provide a direct gauge of potential impact. Although indicators do not trigger a regulatory requirement, they do provide an indication or a warning that the action is potentially approaching a threshold which would trigger a significant regulatory requirement.

The air quality impact evaluation for this action requires two separate analyses: the Clean Air Act (CAA) General Conformity Analysis and an analysis under NEPA. Impacts of air pollutants emitted by activities in the Pacific Ocean, bays, and inland locations in State waters (i.e., up to 3 nm from the coast) are assessed under the General

Conformity Rule. Impacts of air pollutants emitted by activities in the Pacific Ocean, bays, and inland locations in U.S. territorial seas (i.e., up to 12 nm from the coast) are assessed under NEPA. Each coastal state may claim the territorial sea that extends seaward up to 12 nm from its shores and exercise sovereignty over its territorial sea, the air space above it, and the seabed and subsoil beneath it (National Oceanic and Atmospheric Administration [NOAA] 2017). The state jurisdictions may extend the full distance of territorial seas or may retain historical limits.

The project's operational emissions are below the DAF insignificance thresholds within the SBCAPCD and VCAPCD jurisdictions. Operational emissions exceed the DAF insignificance threshold for NOx in the SCAQMD jurisdiction; however, Alternative 1's operational emissions are within the SCAQMD set-aside emission budget approved in the 2016 AQMP. As such, the SCAQMD has granted the use of the NOx set aside account for Alternative 1 to conform to the latest EPA approved AQMP as the emissions from the project are accommodated within the AQMP's emissions budgets, and the proposed project is not expected to result in any new or additional violations of the NAAQS or impede the projected attainment of the NAAQS.

Greenhouse Gas Emissions

Alternative 1 would generate greenhouse gas (GHG) emissions during operation. During operation, GHGs would be generated from launch and landings, boost-back, fairing recovery, roll-on-roll-off, personnel, energy use, solid waste generation, and water and wastewater.

The social cost of GHG (SC-GHG) is an economic concept used to quantify the monetary value of the long-term societal damages caused by the emission of GHGs into the atmosphere. This metric seeks to capture the various adverse impacts associated with GHG emissions, such as climate change, health problems, ecosystem damage, and economic losses. By assigning a dollar value to these damages, the SC-GHG provides a tool for policymakers, businesses, and governments to assess the true costs of emitting CO_2, CH_4, N_2O, and other GHGs. Under a 5% discount rate, Alternative 1 would have a SC-GHGs of over $1.9 million, under a 3% discount rate over $6.3 million, and at a 2.5% discount rate over $9.2 million.

Alternative 1 would not have an adverse effect on water, ecosystem and ecosystem services, the coast, indigenous peoples, energy, food, or human health. In terms of climate change impacts on Alternative 1, it may adapt to changing conditions of water supplies; keep employees safe by following all California Occupational Safety and Health Administration regulations; and prepare for major storm and flooding events and adjust operations accordingly.

1 Introduction

1.1 Report Purpose and Scope

The purpose of this technical report is to assess the potential air emissions associated with implementation of the Falcon Program Expansion (Alternative 1) and alternatives at Vandenberg Space Force Base (VSFB), California. This assessment uses the thresholds based on the Department of the Air Force (DAF) insignificance thresholds and indicators to determine if the project would result in an adverse effect.

This introductory section provides a description of the project and the project location. Chapter 2, Air Quality, describes the air quality–related environmental setting, regulatory setting, existing air quality conditions, and threshold and analysis methodology, and presents an air quality impact analysis. Chapter 3, Greenhouse Gases, describes the greenhouse gas (GHG)–related environmental setting, regulatory setting, existing conditions, and threshold and analysis methodology, and presents a GHG impact analysis. Chapter 4, References Cited, provides a list of the references used in this report.

1.2 Regional and Local Setting

Alternative 1 would be located at Space Launch Complex (SLC)-4 on VSFB. VSFB occupies 99,604 acres of central Santa Barbara County, California, and is approximately halfway between San Diego and San Francisco. VSFB occurs in a transitional ecological region that includes the northern and southern distributional limits for many plant and animal species. The Santa Ynez River and State Highway 246 divide VSFB into two distinct parts: North Base and South Base. SLC-4 is located on South Base. SLC-4E is the existing Falcon 9 program launch facility.

1.3 Project Description

Alternative 1 is to increase the annual Falcon launch cadence at VSFB through launches at SLC-4 to support future commercial and U.S. government launch service needs. A description of Alternative 1 is in the following sections.

1.3.1 Launch Vehicle

SpaceX would launch Falcon 9 from SLC-4. Falcon 9 is approximately 229 feet tall and produces approximately 1.7 million pounds of thrust at liftoff. A discussion of Falcon 9 can be found in the 2016 EA and associated supplemental environmental documents.

1.3.2 Launch

SpaceX would conduct launch operations in the same way as described in the 2023 SEA and previous environmental documents (Department of Air Force 2023). One to 3 days before each launch, an engine static fire test, which lasts a few seconds, may be performed. The need to conduct a static fire test depends on the mission, but there would be no more than 30 static fire events per year. Launch operations would occur day or night, at any time during the year. Following each launch, SpaceX would perform a boost-back and landing of the first stage, either downrange on a droneship or at landing zones at VSFB. Mission objectives may occasionally require expending the first stage booster in the Pacific Ocean, as the 2023 SEA described. If intentionally expending the first stage, it would break up upon atmospheric re-entry and there would be no residual propellant or explosion upon impact with the Pacific Ocean. The first stage remnants would sink to the bottom of the ocean.

SpaceX, the USSF, the FAA, and the USCG implement numerous protocols and procedures to assess, avoid, mitigate, and minimize potential risks to public safety and the environment during space launch, which are discussed throughout this EA. The Falcon 9 launch vehicle is proven as one of the most reliable space launch vehicles ever developed, with over a 99% launch success rate since June 2010. While unlikely, there is an extremely low risk of a launch failure. This represents an off-nominal, very low probability, and worst-case scenario, and is not assessed in detail for these reasons. SpaceX implements an Operations Safety Plan at SLC-4, and in the event of a launch failure, SpaceX would activate an Emergency Action Plan. Accordingly, the potential impacts on the environment resulting from a launch failure are not expected to be significant.

Alternative 1 does not include altering the dimensions (shape and altitude) of the airspace or shipping lanes. USCG District Eleven was granted specific regulatory authority to restrict vessel movement, implement safety and warning zones, and provide early warning advisement, but all responsibility to limit risk to navigation safety is solely on the acting space party. USCG District Eleven will advise SpaceX and SLD 30 when the risk exceeds acceptable levels and the primary applicant will be responsible for minimizing the risk with alternate strategies before formal publications. Federal government agencies, including the USCG, are responsible for ensuring maritime safety as required applicable statutes and regulations, such as the PWSA, 33 C.F.R. § 1 (*General Provisions*), 14 C.F.R. § 450 (*Launch and Reentry License Requirements*), and 40 C.F.R. § 229.3 (*Transportation and Disposal of Vessels*). To comply with the necessary notification requirements, SLD 30 would notify USCG of any upcoming launch operations to ensure safe launches over the high seas and navigable waters of the U.S., consistent with current procedures. The USCG would be responsible for issuing NOTMARs that provide hazard area locations before each mission event with ocean impacts. A NOTMAR provides notice of temporary changes in conditions or hazards in navigable waterways with maritime traffic to assist in mitigating risks for dangers associated with waterway users. This tool provides an established and reliable line of communication with the maritime public. The NOTMAR would include the operations dates and times and coordinates of the hazardous operation area.

All launch and reentry operations would comply with the necessary notification requirements, including issuing NOTAMs, as defined in agreements required for an FAA issued launch license. Advance notice via Notice to Air Missions (NOTAMs) and identifying Aircraft Hazard Areas assist general aviation pilots to schedule around any temporary disruption of flight activities in the area of operation. A NOTAM provides notice of unanticipated or temporary changes to components of, or hazards in, the National Airspace System (FAA Order JO 7930.2S, Notices to Air Missions). The FAA issues a NOTAM at least 72 hours before a launch or reentry activity in the airspace to notify pilots and other interested parties of temporary conditions. Launches and reentries would be infrequent and of short duration, and SpaceX regularly provides FAA with updates and schedule changes to their notional three-month launch schedule to minimize interruption to air traffic. FAA's licensing requirements, the process for closures of the National Air Space System, and VSFB's Range Safety actions during launch operations are the 2023 SEA.

1.3.3 Launch Frequency

SpaceX's proposes to increase its launch cadence at VSFB from 36 to 50 launches per year. SpaceX has continued to improve its turn-around time between launches which has provided more opportunity for launches at SLC-4.

1.3.4 Boost-back and Landing

SpaceX would land first stage boosters at VSFB or downrange on a droneship as described in the 2023 SEA. Launches from SLC-4 and those landing downrange on a droneship would occur as described in the 2023 SEA. SpaceX would land up to 12 boosters at SLC-4.

Fairing recovery and jettisoning of the Merlin Vacuum Engine skirt ring would occur as described in the 2023 SEA. The droneship would then transport the booster to the Port of Long Beach as described in the 2023 SEA.

1.3.5 Payloads

Payloads and their associated materials/fuels/volumes are mission dependent, but would be similar to current commercial and government payloads as described 2011 *Environmental Assessment for Launch of NASA Routine Payloads* (NASA 2011). As discussed in the 2023 SEA, Falcon launches from SLC-4 would have similar payloads.

1.3.6 Personnel and Ground Operations

Operations would be similar to those described in the 2023 SEA at SLC-4. To support a cadence increase, SpaceX anticipates adding up to 400 additional personnel to VSFB operations. The existing SpaceX facilities are adequate to support the staff increase. Ground transportation support during launch campaigns would continue to be minimal. SpaceX would continue to utilize up to four specialized trucks per launch to transport boosters between existing SpaceX facilities, including facilities in Hawthorne, California, Building 398, and the hangar at SLC-4 on VSFB. The first stage, second stage, interstage, and payload are each transported by 18-wheel trucks. Fuel and helium are also delivered by 18-wheel trucks on a weekly basis. Personal vehicles would be used by employees to commute locally on and off site. Payload integration and pre-launch protocols associated with Alternative 1 would remain unchanged. However, these operations would increase in frequency to support 50 launches per year.

1.3.7 Utilities

SpaceX would utilize approximately 70,000 gallons of water per launch at SLC-4, as described in the 2023 SEA. Landing operations at SLC-4 would continue to utilize approximately 40,000 gallons per landing.

1.3.8 Vehicle Refurbishment

SpaceX would continue to process vehicles at existing SpaceX facilities, including Building 398 and the SLC-4 hangar for launch operations. Operations include refurbishing the recovered first stage and fairing for reuse in future missions. With launches of up to 50 Falcon 9 from SLC-4, up to 50 boosters and 50 fairings would be refurbished each year. Solvents such as isopropyl alcohol, isopar, and Simple Green would be used during these operations, as well for launch pad operations, facility maintenance, and system flushing.

1.3.9 Booster Roll-On-Roll-Off

SpaceX proposes to transport first stages and fairings from the Port of Long Beach to the VSFB Harbor via a “roll-on-roll-off” (RORO) barge. The first stage would be transferred from the droneship to SpaceX’s Self-

Propelled Modular Transport (SPMT) that is positioned on a small, low draft barge. The first stage would be pulled by a tug using a Tier 3 (or higher) engine from the Port of Long Beach into the VSFB Harbor. The first stage would then be driven off the barge by the SPMT and travel from VSFB Harbor to the hangar at SLC-4E, where it would be unloaded. A support tug would be launched from the Port of Hueneme and travel up the coast to assist the barge and primary tug in maneuvering into and out of the VSFB Harbor, the exact arrival time would depend on tide. On day two, the support tug would hotel (also known as berthing while producing in-port emissions while moored) at VSFB harbor for 24 hours. On day three, SpaceX would perform the RORO operation, requiring approximately 15 hours for the primary tug to execute the operation. The support tug would assist the operation, then hotel at the VSFB harbor for the remainder of the time. On day four, the support tug would remain hoteling at VSFB harbor for 24 hours. On day five, the support tug would travel back to the Port of Hueneme, with the exact departure time dependent on tide. Alternative 1 would include up to 50 events per year utilizing roll-on-roll-off operations.

1.3.10 No Action Alternative

Under the No Action Alternative, SpaceX would not increase the annual cadence for Falcon operations from VSFB. SpaceX's ability to fully meet the National Space Transportation Policy goals of providing low-cost reliable access to and from space would be negatively affected, as would the more short-term need to meet the increase in current and future manifest demands. Therefore, the No Action Alternative does not meet the Purpose and Need.

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2 Air Quality

2.1 Environmental Setting

The project site takes place within Santa Barbara County, Ventura County, and Los Angeles County, California.

2.1.1 Meteorological and Topographical Conditions

The primary factors that determine air quality are the locations of air pollutant sources and the amounts of pollutants emitted. Meteorological and topographical conditions, however, also are important. Factors such as wind speed and direction, air temperature gradients and sunlight, and precipitation and humidity interact with physical landscape features to determine the movement and dispersal of criteria air pollutants.

VSFB occupies 99,604 acres of central Santa Barbara County, California, and is approximately halfway between San Diego and San Francisco. VSFB is located within the South-Central Coastal Air Basin (SCCAB), which includes San Luis Obispo, Santa Barbara, and Ventura counties. The Santa Barbara County Air Pollution Control District (SBCAPCD) has jurisdiction over Santa Barbara County and the Ventura County Air Pollution Control District (VCAPCD) has jurisdiction over Ventura County. Alternative 1 would also take place within Los Angeles County for fairing recovery and ocean landings. Los Angeles County is located within the South Coast Air Basin (SCAB) and the South Coast Air Quality Management District (SCAQMD). As such, additional discussion is provided for that region.

Climate

Air quality in the SCCAB is influenced by its meteorological conditions. The Mediterranean climate is characterized by warm summers and mild winters with relatively dry weather. The annual precipitation is on average 17.7 inches per year and the average maximum temperature is 70.8ºF and the average minimum temperature is 50.2 ºF (WRCC 2016).

The climate of the SCCAB is strongly influenced by its proximity to the Pacific Ocean and the location of the high-pressure cell in the northeastern Pacific. With a Mediterranean-type climate, the project area is characterized by warm, dry summers and cool winters with occasional rainy periods. Cool, humid marine air causes frequent fog and low clouds along the coast, generally during the night and morning hours in the late spring and early summer months. The project area is subject to a diurnal cycle in which daily onshore winds from the west and northwest are replaced by mild offshore breezes flowing from warm inland valleys during night and early morning hours. This alternating cycle can create a situation where suspended pollutants are swept offshore at night, and then carried back onshore the following day. Dispersion of pollutants is further degraded when the wind velocity for both day and nighttime breezes is low. The region is also subject to seasonal “Santa Ana” winds. These are typically hot, dry northerly winds that blow offshore at 15 to 20 mph, but can reach speeds in excess of 60 mph.

Two types of temperature inversions (warmer air on top of cooler air) are created in the area: subsidence and radiational. The subsidence inversion is a regional effect created by the Pacific high in which air is heated as it is compressed when it flows from the high-pressure area to the low-pressure areas inland. This type of inversion generally forms at about 1,000 to 2,000 feet and can occur throughout the year, but it is most evident during the summer months. Radiational, or surface, inversions are formed by the more rapid cooling of air near the ground during the night, especially during winter. This type of inversion is typically lower (0 to 500 feet at VSFB, for example) and is generally accompanied by stable air. Both types of inversions limit the dispersal of air pollutants within the regional airshed, with the more stable the air (low wind speeds, uniform temperatures), the lower the amount of pollutant dispersion.

South Coast Air Basin

The metropolitan portions of the County are within the South Coast Air Basin (SCAB). The SCAB is a 6,745-square-mile area bounded by the Pacific Ocean to the west and the San Gabriel, San Bernardino, and San Jacinto Mountains to the north and east. Projects located within the SCAB are subject to the rules and regulations imposed by the SCAQMD, as well as the California Ambient Air Quality Standards (CAAQS) adopted by CARB and National Ambient Air Quality Standards (NAAQS) adopted by the EPA, as detailed below in Section 2.2, Regulatory Setting.

Climate and Topography

The SCAB's air pollution problems are a consequence of the combination of emissions from the nation's second-largest urban area, meteorological conditions that hinder dispersion of those emissions, and mountainous terrain surrounding the SCAB that traps pollutants as they are pushed inland with the sea breeze (SCAQMD 2017). Meteorological and topographical factors that affect air quality in the SCAB are described below.[1]

Climate

The SCAB is characterized as having a Mediterranean climate (typified as semiarid with mild winters, warm summers, and moderate rainfall). The general region lies in the semi-permanent high-pressure zone of the eastern Pacific; as a result, the climate is mild and tempered by cool sea breezes. The usually mild climatological pattern is interrupted infrequently by periods of extremely hot weather, winter storms, or Santa Ana winds.

Moderate temperatures, comfortable humidity, and limited precipitation characterize the climate in the SCAB. The average annual temperature varies little throughout the SCAB, averaging 75°F. However, with a less-pronounced oceanic influence, the eastern inland portions of the SCAB show greater variability in annual minimum and maximum temperatures. All portions of the SCAB have recorded temperatures over 100°F in recent years. Although the SCAB has a semiarid climate, the air near the surface is moist because of the presence of a shallow marine layer. Except for infrequent periods when dry air is brought into the SCAB by offshore winds, the ocean effect is dominant. Periods with heavy fog are frequent, and low stratus clouds, occasionally referred to as "high fog," are a characteristic climate feature. Annual average relative humidity is 70% at the coast and 57% in the eastern part of the SCAB (SCAQMD 1993). Precipitation in the SCAB is typically 9 to 14 inches annually and is rarely in the form of snow or hail because of typically warm weather. However, annual precipitation averages about 18.19 inches at the Project site, falling mostly from October through May (WRCC 2016).[2] Most of the rainfall in Southern California occurs between late fall and early spring, with most rain typically occurring in the months of January and February. Overall, Los Angeles's climate is characterized by relatively low rainfall, with warm summers and mild winters. Average temperatures range from a high of 92.2°F in July to a low of 40.0°F in December (WRCC 2016).

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1 The discussion of meteorological and topographical conditions of the SCAB is based on information provided in the Final 2016 Air Quality Management Plan (SCAQMD 2017).

2 Local climate data for the County is based on the most-representative station measured by the Western Regional Climate Center, which is the Newhall climatological station.

Sunlight

The presence and intensity of sunlight are necessary prerequisites for the formation of photochemical smog. Under the influence of the ultraviolet radiation of sunlight, certain primary pollutants (mainly reactive hydrocarbons and oxides of nitrogen [NO_x][3]) react to form secondary pollutants (primarily oxidants). Since this process is time dependent, secondary pollutants can be formed many miles downwind of the emission sources. Southern California also has abundant sunshine, which drives the photochemical reactions that form pollutants such as ozone (O_3) and a substantial portion of fine particulate matter ($PM_{2.5}$ or particulate matter 2.5 microns or less in diameter). In the SCAB, high concentrations of O_3 are normally recorded during the late spring, summer, and early autumn months, when more intense sunlight drives enhanced photochemical reactions. Because of the prevailing daytime winds and time-delayed nature of photochemical smog, oxidant concentrations are highest in the inland areas of Southern California.

Temperature Inversions

Under ideal meteorological conditions and irrespective of topography, pollutants emitted into the air mix and disperse into the upper atmosphere. However, the Southern California region frequently experiences temperature inversions in which pollutants are trapped and accumulate close to the ground. The inversion, a layer of warm, dry air overlaying cool, moist marine air, is a normal condition in coastal Southern California. The cool, damp, and hazy sea air capped by coastal clouds is heavier than the warm, clear air, which acts as a lid through which the cooler marine layer cannot rise. The height of the inversion is important in determining pollutant concentration. When the inversion is approximately 2,500 feet above mean sea level, the sea breezes carry the pollutants inland to escape over the mountain slopes or through the passes. At a height of 1,200 feet above mean sea level, the terrain prevents the pollutants from entering the upper atmosphere, resulting in the pollutants settling in the foothill communities. Below 1,200 feet above mean sea level, the inversion puts a tight lid on pollutants, concentrating them in a shallow layer over the entire coastal basin. Usually, inversions are lower before sunrise than during the daylight hours.

Mixing heights for inversions are lower in the summer and inversions are more persistent, being partly responsible for the high levels of O_3 observed during summer months in the SCAB. Smog in Southern California is generally the result of these temperature inversions combining with coastal day winds and local mountains to contain the pollutants for long periods, allowing them to form secondary pollutants by reacting in the presence of sunlight. The SCAB has a limited ability to disperse these pollutants due to typically low wind speeds and the surrounding mountain ranges.

As with other regions within the SCAB, the County is susceptible to air inversions, which trap a layer of stagnant air near the ground where pollutants are further concentrated. These inversions produce haziness, which is caused by moisture, suspended dust, and a variety of chemical aerosols emitted by trucks, automobiles, furnaces, and other sources. Elevated concentrations of coarse particulate matter (PM_{10}; particulate matter 10 microns or less in diameter) and $PM_{2.5}$ can occur in the SCAB throughout the year, but they occur most frequently in fall and winter. Although there are some changes in emissions by day of the week and by season, the observed variations in pollutant concentrations are primarily the result of seasonal differences in weather conditions.

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3 NO_x is a general term pertaining to compounds of nitric oxide, nitrogen dioxide, and other oxides of nitrogen.

Pollutants and Effects

Criteria Air Pollutants

Criteria air pollutants are defined as pollutants for which the federal and state governments have established ambient air quality standards, or criteria, for outdoor concentrations to protect public health. The national and California standards have been set, with an adequate margin of safety, at levels above which concentrations could be harmful to human health and welfare. These standards are designed to protect the most sensitive persons from illness or discomfort. Pollutants of concern include O_3, nitrogen dioxide (NO_2), carbon monoxide (CO), sulfur dioxide, PM_{10}, $PM_{2.5}$, and lead. In California, sulfates, vinyl chloride, hydrogen sulfide, and visibility-reducing particles are also regulated as criteria air pollutants. These pollutants, as well as TACs, are discussed in the following paragraphs.[4]

Ozone (O_3). O_3 is a strong-smelling, pale blue, reactive, toxic chemical gas consisting of three oxygen atoms. It is a secondary pollutant formed in the atmosphere by a photochemical process involving the sun's energy and O_3 precursors. These precursors are mainly NO_x and volatile organic compounds (VOCs). The maximum effects of precursor emissions on O_3 concentrations usually occur several hours after they are emitted and many miles from the source. Meteorology and terrain play major roles in O_3 formation, and ideal conditions occur during summer and early autumn on days with low wind speeds or stagnant air, warm temperatures, and cloudless skies. O_3 exists in the upper atmosphere O_3 layer (stratospheric O_3) and at the Earth's surface in the troposphere (ground-level O_3).[5] The O_3 that EPA and CARB regulate as a criteria air pollutant is produced close to the ground level, where people live, exercise, and breathe. Ground-level O_3 is a harmful air pollutant that causes numerous adverse health effects, described below, and is thus considered "bad" O_3. Stratospheric, or "good," O_3 occurs naturally in the upper atmosphere, where it reduces the amount of ultraviolet light (i.e., solar radiation) entering the Earth's atmosphere. Without the protection of the beneficial stratospheric O_3 layer, plant and animal life would be seriously harmed.

O_3 in the troposphere (near the surface) causes numerous adverse health effects; short-term exposures (lasting for a few hours) to O_3 at levels typically observed in Southern California can result in breathing pattern changes, reduction of breathing capacity, increased susceptibility to infections, inflammation of the lung tissue, and some immunological changes (EPA 2013).

Inhalation of O_3 causes inflammation and irritation of the tissues lining human airways, causing and worsening a variety of symptoms. Exposure to O_3 can reduce the volume of air that the lungs breathe in, thereby causing shortness of breath. O_3 in sufficient doses increases the permeability of lung cells, rendering them more susceptible to toxins and microorganisms. The occurrence and severity of health effects from O_3 exposure vary widely among individuals, even when the dose and the duration of exposure are the same. Research shows adults and children who spend more time outdoors participating in vigorous physical activities are at greater risk from the harmful health effects of O_3 exposure. While there are relatively few studies on the effects of O_3 on children, the available studies show that children are no more or less likely to suffer harmful effects than adults. However, there are a number of reasons why children may be more susceptible to O_3 and other pollutants. Children and teens spend nearly twice as much time outdoors and engaged in vigorous activities as adults. Children breathe more rapidly than adults and inhale more pollution per pound of their body weight than adults. Also, children are less likely than adults to notice their own symptoms and avoid harmful exposures. Further research may be able to better distinguish between health effects in

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4 The descriptions of the criteria air pollutants and associated health effects are based on EPA's "Criteria Air Pollutants" (EPA 2018a), as well as CARB's "Glossary" (CARB 2019a) and "Fact Sheet: Air Pollution Sources, Effects and Control" (CARB 2009).

5 The troposphere is the layer of the Earth's atmosphere nearest to the surface of the Earth. The troposphere extends outward about 5 miles at the poles and about 10 miles at the equator.

children and adults. Children, adolescents, and adults who exercise or work outdoors, where O_3 concentrations are the highest, are at the greatest risk of harm from this pollutant (CARB 2019b).

Volatile Organic Compounds. Hydrocarbons are organic gases that are formed from hydrogen and carbon and sometimes other elements. Hydrocarbons that contribute to formation of O_3 are referred to and regulated as VOCs (also referred to as reactive organic gases). Combustion engine exhaust, oil refineries, and fossil-fueled power plants are the sources of hydrocarbons. Other sources of anthropogenic and bio-pedogenic hydrocarbons include evaporation from petroleum fuels, solvents, dry cleaning solutions, and paint.

The primary health effects of VOCs result from the formation of O_3 and its related health effects. High levels of VOCs in the atmosphere can interfere with oxygen intake by reducing the amount of available oxygen through displacement. Carcinogenic forms of hydrocarbons, such as benzene, are considered TACs. There are no separate ambient air quality standards for VOCs as a group.

Nitrogen Dioxide (NO_2). NO_2 is a brownish, highly reactive gas that is present in all urban atmospheres. The major mechanism for the formation of NO_2 in the atmosphere is the oxidation of the primary air pollutant nitric oxide, which is a colorless, odorless gas. NO_x plays a major role, together with VOCs, in the atmospheric reactions that produce O_3. NO_x is formed from fuel combustion under high temperature or pressure. In addition, NO_x is an important precursor to acid rain and may affect both terrestrial and aquatic ecosystems. The two major emissions sources are transportation and stationary fuel combustion sources such as electric utility and industrial boilers.

A large body of health science literature indicates that exposure to NO_2 can induce adverse health effects. The strongest health evidence, and the health basis for the ambient air quality standards for NO_2, results from controlled human exposure studies that show that NO_2 exposure can intensify responses to allergens in allergic asthmatics. In addition, a number of epidemiological studies have demonstrated associations between NO_2 exposure and premature death, cardiopulmonary effects, decreased lung function growth in children, respiratory symptoms, emergency room visits for asthma, and intensified allergic responses. Infants and children are particularly at risk because they have disproportionately higher exposure to NO_2 than adults due to their greater breathing rate for their body weight and their typically greater outdoor exposure duration. Several studies have shown that long-term NO_2 exposure during childhood, the period of rapid lung growth, can lead to smaller lungs at maturity in children with higher levels of exposure compared to children with lower exposure levels. In addition, children with asthma have a greater degree of airway responsiveness compared with adult asthmatics. In adults, the greatest risk is to people who have chronic respiratory diseases, such as asthma and chronic obstructive pulmonary disease (CARB 2019c).

Carbon Monoxide (CO). CO is a colorless, odorless gas formed by the incomplete combustion of hydrocarbon, or fossil fuels. CO is emitted almost exclusively from motor vehicles, power plants, refineries, industrial boilers, ships, aircraft, and trains. In urban areas, such as the Project location, automobile exhaust accounts for the majority of CO emissions. CO is a nonreactive air pollutant that dissipates relatively quickly; therefore, ambient CO concentrations generally follow the spatial and temporal distributions of vehicular traffic. CO concentrations are influenced by local meteorological conditions—primarily wind speed, topography, and atmospheric stability. CO from motor vehicle exhaust can become locally concentrated when surface-based temperature inversions are combined with calm atmospheric conditions, which is a typical situation at dusk in urban areas from November to February. The highest levels of CO typically occur during the colder months of the year, when inversion conditions are more frequent.

CO is harmful because it binds to hemoglobin in the blood, reducing the ability of blood to carry oxygen. This interferes with oxygen delivery to the body's organs. The most common effects of CO exposure are fatigue, headaches, confusion and reduced mental alertness, light-headedness, and dizziness due to inadequate oxygen delivery to the brain. For people with cardiovascular disease, short-term CO exposure can further reduce their body's already compromised ability to respond to the increased oxygen demands of exercise, exertion, or stress. Inadequate oxygen delivery to the heart muscle leads to chest pain and decreased exercise tolerance. Unborn babies whose mothers experience high levels of CO exposure during pregnancy are at risk of adverse developmental effects. Unborn babies, infants, elderly people, and people with anemia or with a history of heart or respiratory disease are most likely to experience health effects with exposure to elevated levels of CO (CARB 2019d).

Sulfur Dioxide (SO_2). SO_2 is a colorless, pungent gas formed primarily from incomplete combustion of sulfur-containing fossil fuels. The main sources of SO_2 are coal and oil used in power plants and industries; as such, the highest levels of SO_2 are generally found near large industrial complexes. In recent years, SO_2 concentrations have been reduced by the increasingly stringent controls placed on stationary source emissions of SO_2 and limits on the sulfur content of fuels.

Controlled human exposure and epidemiological studies show that children and adults with asthma are more likely to experience adverse responses with SO_2 exposure, compared with the non-asthmatic population. Effects at levels near the 1-hour standard are those of asthma exacerbation, including bronchoconstriction accompanied by symptoms of respiratory irritation such as wheezing, shortness of breath, and chest tightness, especially during exercise or physical activity. Also, exposure at elevated levels of SO_2 (above 1 part per million [ppm]) results in increased incidence of pulmonary symptoms and disease, decreased pulmonary function, and increased risk of mortality. Older people and people with cardiovascular disease or chronic lung disease (such as bronchitis or emphysema) are most likely to experience these adverse effects (CARB 2019e).

SO_2 is of concern both because it is a direct respiratory irritant and because it contributes to the formation of sulfate and sulfuric acid in particulate matter (NRC 2005). People with asthma are of particular concern, both because they have increased baseline airflow resistance and because their SO_2-induced increase in airflow resistance is greater than in healthy people, and it increases with the severity of their asthma (NRC 2005). SO_2 is thought to induce airway constriction via neural reflexes involving irritant receptors in the airways (NRC 2005).

Particulate Matter. Particulate matter pollution consists of very small liquid and solid particles floating in the air, which can include smoke, soot, dust, salts, acids, and metals. Particulate matter can form when gases emitted from industries and motor vehicles undergo chemical reactions in the atmosphere. $PM_{2.5}$ and PM_{10} represent fractions of particulate matter. Coarse particulate matter (PM_{10}) consists of particulate matter that is 10 microns or less in diameter, which is about 1/7 the thickness of a human hair. Major sources of PM_{10} include crushing or grinding operations; dust stirred up by vehicles traveling on roads; wood-burning stoves and fireplaces; dust from construction, landfills, and agriculture; wildfires and brush/waste burning; industrial sources; windblown dust from open lands; and atmospheric chemical and photochemical reactions. Fine particulate matter ($PM_{2.5}$) consists of particulate matter that is 2.5 microns or less in diameter, which is roughly 1/28 the diameter of a human hair. $PM_{2.5}$ results from fuel combustion (e.g., from motor vehicles and power generation and industrial facilities), residential fireplaces, and woodstoves. In addition, $PM_{2.5}$ can be formed in the atmosphere from gases such as sulfur oxides (SO_x), NO_x, and VOCs.

$PM_{2.5}$ and PM_{10} pose a greater health risk than larger-size particles. When inhaled, these tiny particles can penetrate the human respiratory system's natural defenses and damage the respiratory tract. $PM_{2.5}$ and PM_{10} can increase the number and severity of asthma attacks, cause or aggravate bronchitis and other lung diseases, and reduce the body's ability to fight infections. Very small particles of substances such as lead, sulfates, and nitrates can cause lung damage directly or be absorbed into the bloodstream, causing damage elsewhere in the body. Additionally, these substances can transport adsorbed gases such as chlorides or ammonium into the lungs, also causing injury. Whereas PM_{10} tends to collect in the upper portion of the respiratory system, $PM_{2.5}$ is so tiny that it can penetrate deeper into the lungs and damage lung tissue. Suspended particulates also damage and discolor surfaces on which they settle and produce haze and reduce regional visibility.

A number of adverse health effects have been associated with exposure to both $PM_{2.5}$ and PM_{10}. For $PM_{2.5}$, short-term exposures (up to 24-hour duration) have been associated with premature mortality, increased hospital admissions for heart or lung causes, acute and chronic bronchitis, asthma attacks, emergency room visits, respiratory symptoms, and restricted activity days. These adverse health effects have been reported primarily in infants, children, and older adults with preexisting heart or lung diseases. In addition, of all of the common air pollutants, $PM_{2.5}$ is associated with the greatest proportion of adverse health effects related to air pollution, both in the United States and worldwide based on the World Health Organization's Global Burden of Disease Project. Short-term exposures to PM_{10} have been associated primarily with worsening of respiratory diseases, including asthma and chronic obstructive pulmonary disease, leading to hospitalization and emergency department visits (CARB 2017a).

Long-term exposure (months to years) to $PM_{2.5}$ has been linked to premature death, particularly in people who have chronic heart or lung diseases, and reduced lung function growth in children. The effects of long-term exposure to PM_{10} are less clear, although several studies suggest a link between long-term PM_{10} exposure and respiratory mortality. The International Agency for Research on Cancer published a review in 2015 that concluded that particulate matter in outdoor air pollution causes lung cancer (CARB 2017a).

Lead. Lead in the atmosphere occurs as particulate matter. Sources of lead include leaded gasoline; the manufacturing of batteries, paints, ink, ceramics, and ammunition; and secondary lead smelters. Prior to 1978, mobile emissions were the primary source of atmospheric lead. Between 1978 and 1987, the phaseout of leaded gasoline reduced the overall inventory of airborne lead by nearly 95%. With the phaseout of leaded gasoline, secondary lead smelters, battery recycling, and manufacturing facilities are becoming lead-emissions sources of greater concern.

Prolonged exposure to atmospheric lead poses a serious threat to human health. Health effects associated with exposure to lead include gastrointestinal disturbances, anemia, kidney disease, and in severe cases, neuromuscular and neurological dysfunction. Of particular concern are low-level lead exposures during infancy and childhood. Such exposures are associated with decrements in neurobehavioral performance, including intelligence quotient (IQ) performance, psychomotor performance, reaction time, and growth. Children are highly susceptible to the effects of lead.

Sulfates. Sulfates are the fully oxidized form of sulfur, which typically occur in combination with metals or hydrogen ions. Sulfates are produced from reactions of SO_2 in the atmosphere and can result in respiratory impairment, as well as reduced visibility.

Vinyl Chloride. Vinyl chloride is a colorless gas with a mild, sweet odor, which has been detected near landfills, sewage plants, and hazardous waste sites, due to the microbial breakdown of chlorinated solvents. Short-term exposure to high levels of vinyl chloride in air can cause nervous system effects, such as dizziness, drowsiness, and headaches. Long-term exposure through inhalation can cause liver damage, including liver cancer (CARB 2021a).

Hydrogen Sulfide. Hydrogen sulfide is a colorless and flammable gas that has a characteristic odor of rotten eggs. Sources of hydrogen sulfide include geothermal power plants, petroleum refineries, sewers, sewage treatment plants, and stagnant runoff from clogged water basins. Exposure to hydrogen sulfide can result in nuisance odors, as well as headaches and breathing difficulties at higher concentrations.

Visibility-Reducing Particles. Visibility-reducing particles are any particles in the air that obstruct the range of visibility. Effects of reduced visibility can include obscuring the viewshed of natural scenery, reducing airport safety, and discouraging tourism. Sources of visibility-reducing particles are the same as for $PM_{2.5}$.

Non-Criteria Air Pollutants

Toxic Air Contaminants (TACs). A substance is considered toxic if it has the potential to cause adverse health effects in humans, including increasing the risk of cancer upon exposure, or acute and/or chronic non-cancer health effects. A toxic substance released into the air is considered a TAC. TACs are identified by federal and state agencies based on a review of available scientific evidence. In the state of California, TACs are identified through a two-step process that was established in 1983 under the Toxic Air Contaminant Identification and Control Act. This two-step process of risk identification and risk management and reduction was designed to protect residents from the health effects of toxic substances in the air. In addition, the California Air Toxics "Hot Spots" Information and Assessment Act, AB 2588, was enacted by the legislature in 1987 to address public concern over the release of TACs into the atmosphere. The law requires facilities emitting toxic substances to provide local air pollution control districts with information that will allow an assessment of the air toxics problem, identification of air toxics emissions sources, location of resulting hotspots, notification of the public exposed to significant risk, and development of effective strategies to reduce potential risks to the public over 5 years.

Examples include diesel particulate matter, certain aromatic and chlorinated hydrocarbons, certain metals, and asbestos. TACs are generated by a number of sources, including stationary sources, such as dry cleaners, gas stations, combustion sources, and laboratories; mobile sources, such as automobiles; and area sources, such as landfills and oil and gas facilities. Adverse health effects associated with exposure to TACs may include carcinogenic (i.e., cancer-causing) and non-carcinogenic effects. Non-carcinogenic effects typically affect one or more target organ systems and may be experienced on either short-term (acute) or long-term (chronic) exposure to a given TAC.

Diesel Particulate Matter (DPM). DPM is part of a complex mixture that makes up diesel exhaust. Diesel exhaust is composed of two phases, gas and particle, both of which contribute to health risks. More than 90% of DPM is less than 1 micrometer in diameter (about 1/70 the diameter of a human hair), and thus is a subset of $PM_{2.5}$ (CARB 2019f). DPM is typically composed of carbon particles ("soot," also called black carbon) and numerous organic compounds, including over 40 known cancer-causing organic substances. Examples of these chemicals include polycyclic aromatic hydrocarbons, benzene, formaldehyde, acetaldehyde, acrolein, and 1,3-butadiene (CARB 2019f). The CARB classified "particulate emissions from diesel-fueled engines" (i.e., DPM) (17 CCR 93000) as a TAC in August 1998. DPM is emitted from a broad range of diesel engines: on-road diesel engines, including trucks, buses, and cars, and off-road diesel engines, including locomotives, marine vessels, and heavy-duty construction equipment, among others. Approximately 70% of all airborne cancer risk in California is associated with DPM (Propper et al. 2015). To reduce the cancer risk associated with DPM, CARB adopted a diesel risk reduction plan in 2000 (CARB 2000). Because it is part of $PM_{2.5}$, DPM also contributes to the same non-cancer health effects as

$PM_{2.5}$ exposure. These effects include premature death; hospitalizations and emergency department visits for exacerbated chronic heart and lung disease, including asthma; increased respiratory symptoms; and decreased lung function in children. Several studies suggest that exposure to DPM may also facilitate development of new allergies (CARB 2019f). Those most vulnerable to non-cancer health effects are children, whose lungs are still developing, and older people, who often have chronic health problems.

Odorous Compounds. Odors are generally regarded as an annoyance or a quality of life impact, rather than a health hazard. Manifestations of a person's reaction to odors can range from psychological (e.g., irritation, anger, or anxiety) to physiological (e.g., circulatory and respiratory effects, nausea, vomiting, and headache). The ability to detect odors varies considerably among the population and overall is quite subjective. People may have different reactions to the same odor. An odor that is offensive to one person may be perfectly acceptable to another (e.g., coffee roaster). An unfamiliar odor is more easily detected and is more likely to cause complaints than a familiar one. In a phenomenon known as odor fatigue, a person can become desensitized to almost any odor, and recognition may only occur with an alteration in the intensity. The occurrence and severity of odor impacts depend on the nature, frequency, and intensity of the source; wind speed and direction; microclimate; relative humidity; temperature; topography; and the sensitivity of receptors.

Ambient Air Quality

CARB, air districts, and other agencies monitor ambient air quality at approximately 250 air quality monitoring stations across the state. The SBCAPCD monitors local ambient air quality within the County. Air quality monitoring stations usually measure pollutant concentrations 10 feet above ground level; therefore, air quality is often referred to in terms of ground-level concentrations. The most recent background ambient air quality data from 2020 to 2022 are presented in Table 1, Local Ambient Air Quality Data.

The ambient data presented in Table 1 reflect the highest concentrations reported at the monitoring station located at 128 South H Street, Lompoc. Of the available monitoring stations within the SCCAB, the Lompoc station is considered representative of the air quality experienced in Alternative 1's vicinity. The ambient concentrations and number of days exceeding the ambient air quality standards is also shown in Table 1.

Table 1. Local Ambient Air Quality Data

Averaging Time	Unit	Agency/ Method	Ambient Air Quality Standard	Measured Concentration by Year			Exceedances by Year		
				2020	2021	2022	2020	2021	2022
Ozone (O_3)									
Maximum 1-hour concentration	ppm	California	0.12	0.038	0.040	0.067	0	0	0
Maximum 8-hour concentration	ppm	California	0.070	0.034	0.035	0.055	0	0	0
		National	0.070	0.030	0.035	0.055	0	0	0
Nitrogen Dioxide (NO_2)									
	ppm	California	0.18	0.028	0.027	0.024	0	0	0

Table 1. Local Ambient Air Quality Data

Averaging Time	Unit	Agency/ Method	Ambient Air Quality Standard	Measured Concentration by Year			Exceedances by Year		
				2020	2021	2022	2020	2021	2022
Maximum 1-hour concentration		National	0.100	0.028	0.027	0.024	0	0	0
Annual concentration	ppm	California	0.030	0.003	0.003	0.003	0	0	0
		National	0.053	0.003	0.003	0.003	0	0	0
Carbon Monoxide (CO)									
Maximum 1-hour concentration	ppm	California	20	2.5	1.9	0.9	0	0	0
		National	35	2.5	1.9	0.9	0	0	0
Maximum 8-hour concentration	ppm	California	9.0	0.7	0.8	0.7	0	0	0
		National	9	0.7	0.8	0.7	0	0	0
Sulfur Dioxide (SO_2)									
Maximum 1-hour concentration	ppm	National	0.075	0.026	0.002	0.002	0	0	0
Maximum 24-hour concentration	ppm	National	0.14	0.003	0.001	0.001	0	0	0
Annual concentration	ppm	National	0.030	0.0003	0.0002	0.0003	0	0	0
Coarse Particulate Matter (PM_{10})[a]									
Maximum 24-hour concentration	μg/m³	California	50	110.8	76.0	53.6	(17) 17.1	(1) ND	(1) 1.0
		National	150	106.7	73.1	50.9	(0) 0.0	(0) 0.0	(0) 0.0
Annual concentration	μg/m³	California	20	21.7	ND	17.1	0	0	0
Fine Particulate Matter ($PM_{2.5}$)[a]									
Maximum 24-hour concentration	μg/m³	National	35	85.6	18.4	20.7	(8) 8.5	(0) 0.0	(0) 0.0
Annual concentration	μg/m³	California	12	6.5	5.8	5.6	0	0	0
		National	12.0	6.5	5.7	5.6	0	0	0

Sources: CARB 2022a; EPA 2022.

Notes: ppm = parts per million by volume; — = not available; μg/m³ = micrograms per cubic meter; ND = insufficient data available to determine the value.

Data taken from CARB iADAM (http://www.arb.ca.gov/adam) and EPA AirData (http://www.epa.gov/airdata/) represent the highest concentrations experienced over a given year.

Exceedances of national and California standards are only shown for O_3 and particulate matter. Daily exceedances for particulate matter are estimated days because PM_{10} and $PM_{2.5}$ are not monitored daily. All other criteria pollutants did not exceed national or

California standards during the years shown. There is no national standard for 1-hour O_3, annual PM_{10}, or 24-hour SO_2, nor is there a California 24-hour standard for $PM_{2.5}$.

[a] Measurements of PM_{10} and $PM_{2.5}$ are usually collected every 6 days and every 1 to 3 days, respectively. Number of days exceeding the standards is a mathematical estimate of the number of days concentrations would have been greater than the level of the standard had each day been monitored. The numbers in parentheses are the measured number of samples that exceeded the standard.

2.2 Regulatory Setting

2.2.1 Federal Regulations

2.2.1.1 Criteria Air Pollutants

The federal Clean Air Act (CAA), passed in 1970 and last amended in 1990, forms the basis for the national air pollution control effort. The U.S. Environmental Protection Agency (EPA) is responsible for implementing most aspects of the CAA, including setting National Ambient Air Quality Standards (NAAQS) for major air pollutants; setting hazardous air pollutant (HAP) standards; approving state attainment plans; setting motor vehicle emission standards; issuing stationary source emission standards and permits; and establishing acid rain control measures, stratospheric ozone (O_3) protection measures, and enforcement provisions. Under the CAA, NAAQS are established for the following criteria pollutants: O_3, carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), particulate matter 10 microns in size or smaller (PM_{10}), and particulate matter 2.5 microns in size or smaller ($PM_{2.5}$), and lead.

The NAAQS describe acceptable air quality conditions designed to protect the health and welfare of the citizens of the United States. The NAAQS (other than for O_3, NO_2, SO_2, PM_{10}, $PM_{2.5}$, and those based on annual averages or arithmetic mean) are not to be exceeded more than once per year. NAAQS for O_3, NO_2, SO_2, PM_{10}, and $PM_{2.5}$ are based on statistical calculations over 1- to 3-year periods, depending on the pollutant. The CAA requires the EPA to reassess the NAAQS at least every 5 years to determine whether adopted standards are adequate to protect public health based on current scientific evidence. States with areas that exceed the NAAQS must prepare a state implementation plan that demonstrates how those areas will attain the NAAQS within mandated time frames. The NAAQS are presented in Table 2.

The CAA contains milestones for states to develop air pollution control plans. Areas within states that do not meet the NAAQS, usually identified at the county level, are designated as nonattainment areas. For areas designated as nonattainment areas, the state must develop a plan to implement pollution control strategies to attain the NAAQS. Once attainment is achieved, a state must develop a plan to maintain air quality.

Ozone is not emitted directly to the atmosphere by industrial or combustion processes. Rather, O_3 is formed through the reaction between volatile organic compounds (VOCs) and oxides of nitrogen (NO_x). VOCs and NO_x are known as O_3 precursors, and these precursor emissions are regulated by the EPA to achieve O_3 reductions.

Table 2. Ambient Air Quality Standards

Pollutant	Averaging Time	California Standards[a]	National Standards[b]	
		Concentration[c]	Primary[c,d]	Secondary[c,e]
O_3	1 hour	0.09 ppm (180 μg/m³)	—	Same as Primary Standard[f]
	8 hours	0.070 ppm (137 μg/m³)	0.070 ppm (137 μg/m³)[f]	
NO_2[g]	1 hour	0.18 ppm (339 μg/m³)	0.100 ppm (188 μg/m³)	Same as Primary Standard
	Annual Arithmetic Mean	0.030 ppm (57 μg/m³)	0.053 ppm (100 μg/m³)	
CO	1 hour	20 ppm (23 mg/m³)	35 ppm (40 mg/m³)	None
	8 hours	9 ppm (10 mg/m³)	9 ppm (10 mg/m³)	
SO_2[h]	1 hour	0.25 ppm (655 μg/m³)	0.075 ppm (196 μg/m³)	—
	3 hours	—	—	0.5 ppm (1,300 μg/m³)
	24 hours	0.04 ppm (105 μg/m³)	0.14 ppm (for certain areas)[g]	—
	Annual	—	0.030 ppm (for certain areas)[g]	—
PM_{10}[i]	24 hours	50 μg/m³	150 μg/m³	Same as Primary Standard
	Annual Arithmetic Mean	20 μg/m³	—	
$PM_{2.5}$[i]	24 hours	—	35 μg/m³	Same as Primary Standard
	Annual Arithmetic Mean	12 μg/m³	9.0 μg/m³	15.0 μg/m³
Lead[j,k]	30-day Average	1.5 μg/m³	—	—
	Calendar Quarter	—	1.5 μg/m³ (for certain areas)[k]	Same as Primary Standard
	Rolling 3-Month Average	—	0.15 μg/m³	
Hydrogen sulfide	1 hour	0.03 ppm (42 μg/m³)	—	—
Vinyl chloride[j]	24 hours	0.01 ppm (26 μg/m³)	—	—
Sulfates	24 hours	25 μg/m³	—	—

Table 2. Ambient Air Quality Standards

Pollutant	Averaging Time	California Standards[a]	National Standards[b]	
		Concentration[c]	Primary[c,d]	Secondary[c,e]
Visibility reducing particles	8 hour (10:00 a.m. to 6:00 p.m. PST)	Insufficient amount to produce an extinction coefficient of 0.23 per kilometer due to the number of particles when the relative humidity is less than 70%	—	—

Source: CARB 2023; EPA 2023.

Notes: O_3 = ozone; ppm = parts per million by volume; μg/m³ = micrograms per cubic meter; NO_2 = nitrogen dioxide; CO = carbon monoxide; mg/m³= milligrams per cubic meter; SO_2 = sulfur dioxide; PM_{10} = particulate matter with an aerodynamic diameter less than or equal to 10 microns; $PM_{2.5}$ = particulate matter with an aerodynamic diameter less than or equal to 2.5 microns.

a California standards for O_3, CO, SO_2 (1-hour and 24-hour), NO_2, suspended particulate matter (PM_{10}, $PM_{2.5}$), and visibility-reducing particles are values that are not to be exceeded. All others are not to be equaled or exceeded. California Ambient Air Quality Standards are listed in the Table of Standards in Section 70200 of Title 17 of the California Code of Regulations.

b National standards (other than O_3, NO_2, SO_2, particulate matter, and those based on annual averages or annual arithmetic mean) are not to be exceeded more than once per year. The O_3 standard is attained when the fourth highest 8-hour concentration measured at each site in a year, averaged over three years, is equal to or less than the standard. For PM_{10}, the 24-hour standard is attained when the expected number of days per calendar year with a 24-hour average concentration above 150 μg/m³ is equal to or less than one. For $PM_{2.5}$, the 24-hour standard is attained when 98% of the daily concentrations, averaged over 3 years, are equal to or less than the standard.

c Concentration expressed first in units in which it was promulgated. Equivalent units given in parentheses are based on a reference temperature of 25°C and a reference pressure of 760 torr. Most measurements of air quality are to be corrected to a reference temperature of 25°C and a reference pressure of 760 torr; ppm in this table refers to ppm by volume, or micromoles of pollutant per mole of gas.

d National Primary Standards: The levels of air quality necessary, with an adequate margin of safety, to protect the public health.

e National Secondary Standards: The levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant.

f On October 1, 2015, the national 8-hour O_3 primary and secondary standards were lowered from 0.075 to 0.070 ppm.

g To attain the national 1-hour standard, the three-year average of the annual 98th percentile of the one-hour daily maximum concentrations at each site must not exceed 100 parts per billion (ppb). Note that the national 1-hour standard is in units of ppb. California standards are in units of ppm. To directly compare the national 1-hour standard to the California standards, the units can be converted from ppb to ppm. In this case, the national standard of 100 ppb is identical to 0.100 ppm.

h On June 2, 2010, a new 1-hour SO_2 standard was established, and the existing 24-hour and annual primary standards were revoked. To attain the national 1-hour standard, the three-year average of the annual 99th percentile of the one-hour daily maximum concentrations at each site must not exceed 75 ppb. The 1971 SO_2 national standards (24-hour and annual) remain in effect until one year after an area is designated for the 2010 standard, except that in areas designated nonattainment of the 1971 standards, the 1971 standards remain in effect until implementation plans to attain or maintain the 2010 standards are approved.

i On December 14, 2012, the national annual $PM_{2.5}$ primary standard was lowered from 15 μg/m³ to 12 μg/m³. The existing national 24-hour $PM_{2.5}$ standards (primary and secondary) were retained at 35 μg/m³, as was the annual secondary standard of 15 μg/m³. The existing 24-hour PM_{10} standards (primary and secondary) of 150 μg/m³ were also retained. The form of the annual primary and secondary standards is the annual mean averaged over three years.

j California Air Resources Board has identified lead and vinyl chloride as toxic air contaminants with no threshold level of exposure for adverse health effects determined. These actions allow for the implementation of control measures at levels below the ambient concentrations specified for these pollutants.

k The national standard for lead was revised on October 15, 2008, to a rolling three-month average. The 1978 lead standard (1.5 μg/m³ as a quarterly average) remains in effect until one year after an area is designated for the 2008 standard, except that in areas designated nonattainment for the 1978 standard, the 1978 standard remains in effect until implementation plans to attain or maintain the 2008 standard are approved.

Airborne particulate matter is not a single pollutant, but rather a mixture of many chemical species. PM_{10}, and $PM_{2.5}$ are derived from different emission sources, and also have different chemical compositions. Emissions from the combustion of gasoline, oil, diesel fuel, and wood produce much of the $PM_{2.5}$ pollution found in outdoor air, as well as a significant portion of PM_{10}. PM_{10} also includes dust from construction sites, landfills, and agriculture; wildfires and brush/waste burning; industrial sources; wind-blown dust from open lands; pollen; and fragments of bacteria. Particulate matter may be either directly emitted from sources (primary particles) or formed in the atmosphere through chemical reactions of gases (secondary particles) such as SO_2, NOx, VOCs, and ammonia. These organic compounds can be emitted by both natural sources, such as trees and vegetation, and anthropogenic sources, such as industrial processes and motor vehicle exhaust. Particulate matter emissions are regulated to achieve ambient $PM_{2.5}$ reductions.

2.2.1.2 Hazardous Air Pollutants

The 1977 federal CAA amendments required the EPA to identify national emission standards for HAPs to protect public health and welfare. HAPs include certain volatile organic chemicals, pesticides, herbicides, and radionuclides that present a tangible hazard based on scientific studies of exposure to humans and other mammals. Under the 1990 federal CAA Amendments, which expanded the control program for HAPs, 187 substances and chemical families were identified as HAPs.

2.2.1.3 General Conformity Determination

The General Conformity Rule applies to all federal actions for projects except highway and transit programs. Title I, Section 176(c)(1) of the CAA defines conformity as the upholding of “an implementation plan’s purpose of eliminating or reducing the severity and number of violations of the NAAQS and achieving expeditious attainment of such standards.” According to 40 CFR 93.152, “Federal action means any activity engaged in by a department, agency, or instrumentality of the Federal government, or any activity that a department, agency or instrumentality of the Federal government supports in any way, provides financial assistance for, licenses, permits, or approves, other than activities related to transportation plans, programs, and projects developed, funded, or approved under title 23 U.S.C. or the Federal Transit Act (49 U.S.C. 1601 et seq.).” Alternative 1 has activities within NAAQS nonattainment areas and entails support from the U.S. Space Force and permitting from the FAA; consequently, the action is a federal action and general conformity applies. Therefore, whether a General Conformity determination would apply for portions of the action within nonattainment/maintenance areas must be ascertained through a General Conformity applicability analysis. Finally, according to 40 CFR 93(e), “if an action would result in emissions originating in more than one nonattainment or maintenance area, the conformity must be evaluated for each area separately.” As Alternative 1 occurs within more than one nonattainment or maintenance area, the conformity must be evaluated within each area.

2.2.2 State Regulations

California Clean Air Act of 1988

The California Clean Air Act requires air quality management districts to adopt and enforce regulations to achieve and maintain air quality that is within state air quality standards. The act also requires preparation of a Clean Air Plan (CAP).

Toxic Air Contaminants

A TAC is defined by California law as an air pollutant that may cause or contribute to an increase in mortality or an increase in serious illness, or which may pose a present or potential hazard to human health. Federal laws use the hazardous air pollutants to refer to the same types of compounds that are referred to as TACs under state law. California regulates TACs primarily through the Tanner Air Toxics Act (Assembly Bill [AB] 1807) and the Air Toxics Hot Spots Information and Assessment Act of 1987 (AB 2588).

AB 1807 sets forth a formal procedure for CARB to designate substances as TACs. This includes research, public participation, and scientific peer review before CARB can designate a substance as a TAC. Pursuant to AB 2588, existing facilities that emit air pollutants above specified levels were required to (1) prepare a TAC emission inventory plan and report; (2) prepare a risk assessment if TAC emissions were significant; (3) notify the public of significant risk levels; and (4) if health impacts were above specified levels, prepare and implement risk reduction measures.

The following regulatory measures pertain to the reduction of DPM and criteria pollutant emissions from off-road equipment and diesel-fueled vehicles.

Idling of Commercial Heavy Duty Trucks (13 CCR 2485)

In July 2004, CARB adopted an Airborne Toxic Control Measure (ATCM) to control emissions from idling trucks. The ATCM prohibits idling for more than 5 minutes for all commercial trucks with a gross vehicle weight rating over 10,000 pounds. The ATCM contains an exception that allows trucks to idle while queuing or involved in operational activities.

In-Use Off-Road Diesel-Fueled Fleets (13 CCR 2449 et seq.)

In July 2007, CARB adopted an ATCM for in-use off-road diesel vehicles. This regulation requires that specific fleet average requirements be met for NO_x emissions and for particulate matter emissions. Where average requirements cannot be met, best available control technology requirements apply. The regulation also includes several recordkeeping and reporting requirements.

In response to AB 8 2X, the regulations were revised in July 2009 (effective December 3, 2009) to allow a partial postponement of the compliance schedule in 2011 and 2012 for existing fleets. On December 17, 2010, CARB adopted additional revisions to further delay the deadlines reflecting reductions in diesel emissions due to the poor economy and overestimates of diesel emissions in California. The revisions delayed the first compliance date until no earlier than January 1, 2014, for large fleets, with final compliance by January 1, 2023. The compliance dates for medium fleets were delayed until an initial date of January 1, 2017, and final compliance date of January 1, 2023. The compliance dates for small fleets were delayed until an initial date of January 1, 2019, and final compliance date of January 1, 2028. Correspondingly, the fleet average targets were made more stringent in future compliance years. The revisions also accelerated the phaseout of older equipment with newer equipment added to existing large and medium fleets over time, requiring the addition of Tier 2 or higher engines starting on March 1, 2011, with some exceptions; Tier 2 or higher engines on January 1, 2013, without exception; and Tier 3 or higher engines on January 1, 2018 (January 1, 2023, for small fleets). SpaceX shall adhere to the CARB In-Use Off-Road Diesel-Fueled Fleets Regulation (CARB 2024) for fleet management and fuel selection.

On October 28, 2011 (effective December 14, 2011), the executive officer approved amendments to the regulation. The amendments included revisions to the applicability section and additions and revisions to the definition. The initial date for requiring the addition of Tier 2 or higher engines for large and medium fleets, with some exceptions, was revised to January 1, 2012. New provisions also allow for the removal of emission control devices for safety or visibility purposes. The regulation also was amended to combine the particulate matter and NO_x fleet average targets under one, instead of two, sections. The amended fleet average targets are based on the fleet's NO_x fleet average, and the previous section regarding particulate matter performance requirements was deleted completely. The best available control technology requirements, if a fleet cannot comply with the fleet average requirements, were restructured and clarified. Other amendments to the regulations included minor administrative changes to the regulatory text.

In-Use On-Road Diesel-Fueled Vehicles (13 CCR 2025)

On December 12, 2008, CARB adopted an ATCM to reduce NO_x and particulate matter emissions from most in-use on-road diesel trucks and buses with a gross vehicle weight rating greater than 14,000 pounds. The original ATCM regulation required fleets of on-road trucks to limit their NO_x and particulate matter emissions through a combination of exhaust retrofit equipment and new vehicles. The regulation limited particulate matter emissions for most fleets by 2011, and limited NO_x emissions for most fleets by 2013. The regulation did not require any vehicle to be replaced before 2012 and never required all vehicles in a fleet be replaced.

In December 2009, the CARB Governing Board directed staff to evaluate amendments that would provide additional flexibility for fleets adversely affected by the struggling California economy. On December 17, 2010, CARB revised this ATCM to delay its implementation along with limited relaxation of its requirements. Starting on January 1, 2015, lighter trucks with a gross vehicle weight rating of 14,001 to 26,000 pounds with 20-year-old or older engines need to be replaced with newer trucks (2010 model year emissions equivalent as defined in the regulation). Trucks with a gross vehicle weight rating greater than 26,000 pounds with 1995 model year or older engines needed to be replaced as of January 1, 2015. Trucks with 1996 to 2006 model year engines must install a Level 3 (85% control) diesel particulate filter starting on January 1, 2012, to January 1, 2014, depending on the model year, and then must be replaced after 8 years. Trucks with 2007 to 2009 model year engines have no requirements until 2023, at which time they must be replaced with 2010 model year emissions-equivalent engines, as defined in the regulation. Trucks with 2010 model year engines would meet the final compliance requirements. The ATCM provides a phase-in optio2n under which a fleet operator would equip a percentage of trucks in the fleet with diesel particulate filters, starting at 30% as of January 1, 2012, with 100% by January 1, 2016. Under each option, delayed compliance is granted to fleet operators who have or will comply with requirements before the required deadlines.

On September 19, 2011 (effective December 14, 2011), the Executive Officer approved amendments to the regulations, including revisions to the compliance schedule for vehicles with a gross vehicle weight rating of 26,000 pounds or less to clarify that all vehicles must be equipped with 2010 model year emissions equivalent engines by 2023. The amendments included revised and additional credits for fleets that have downsized; implemented early particulate matter retrofits; incorporated hybrid vehicles, alternative-fueled vehicles, and vehicles with heavy-duty pilot ignition engines; and implemented early addition of newer vehicles. The amendments included provisions for additional flexibility, such as for low-usage construction trucks, and revisions to previous exemptions, delays, and extensions. Other amendments to the regulations included minor administrative changes to the regulatory text, such as recordkeeping and reporting requirements related to other revisions.

California Health and Safety Code Section 41700

Section 41700 of the California Health and Safety Code states that a person shall not discharge from any source whatsoever quantities of air contaminants or other material that cause injury, detriment, nuisance, or annoyance to any considerable number of persons or to the public, or that endanger the comfort, repose, health, or safety of any of those persons or the public, or that cause, or have a natural tendency to cause, injury or damage to business or property. This section also applies to sources of objectionable odors.

2.3 Regional and Local Air Quality Conditions

2.3.1 Attainment Designation

Pursuant to the 1990 federal CAA Amendments, the EPA classifies air basins (or portions thereof) as "attainment" or "nonattainment" for each criteria air pollutant based on whether the NAAQS have been achieved. Generally, if the recorded concentrations of a pollutant are lower than the standard, the area is classified as "attainment" for that pollutant. If an area exceeds the standard, the area is classified as "nonattainment" for that pollutant. If there is not enough data available to determine whether the standard is exceeded in an area, the area is designated as "unclassified" or "unclassifiable." The designation of "unclassifiable/attainment" means that the area meets the standard or is expected to meet the standard despite a lack of monitoring data. Areas that achieve the standards after a nonattainment designation are re-designated as maintenance areas and must have approved Maintenance Plans to ensure continued attainment of the standards.

Santa Barbara County (where the action will occur) is within the Santa Barbara County Air Pollution Control District (SBCAPCD) and is in attainment for all NAAQSs; however, the county is nonattainment for the state 8-hour O_3 and 24-hour and annual PM_{10} standards.

Ventura County (where the action will occur) is within the Ventura County Air Pollution Control District (VCAPCD) and is in serious nonattainment for the 2008 and 2015 8-hour O_3 NAAQS. Additionally, the county is nonattainment for O_3 and the 24-hour and annual state PM_{10} standard and attainment for all other state and federal standards.

Los Angeles County (where the action will occur) is within the South Coast Air Quality Management District (SCAQMD) is extreme nonattainment for the 2008 and 2015 8-hour O_3 NAAQSs; maintenance for the 1971 CO NAAQS; nonattainment for the 2008 Pb NAAQS; maintenance for the 1987 PM_{10} NAAQS with a classification of serious; and nonattainment for the 1997, 2006, and 2012 $PM_{2.5}$ NAAQSs with a classification of serious. Additionally, the SCAQMD is nonattainment for the 1-hour O_3, 8-hour O_3, 24-hour and annual PM_{10}, and annual $PM_{2.5}$ state standards.

2.4 Insignificance Criteria and Methodology

2.4.1 Insignificance Thresholds and Indicators

For air quality impact assessments, significance is defined by the degree to which the effects of Alternative 1 potentially could affect public health or safety. The U.S. Air Force (USAF) conducts National Environmental Policy Act (NEPA) and General Conformity Rule air quality impact assessments in tandem within the Environmental Impact Analysis Process (EIAP) (HQ AFCEC/CZTQ 2023a). The air quality EIAP process is broken into three progressive levels of assessment: Level I, Exempt Action Screening (determine if a formal Air Quality Assessment is required);

Level II, Quantitative Air Quality Assessment (a formal emissions quantifying assessment to eliminate insignificant air impacts from further assessment); and Level III, Advanced Air Quality Assessment (part science and part art, both quantitative and qualitative assessments of air impact). These levels are designed to ensure completion of an air quality assessment at the lowest level possible; with each level of assessment having a specific significance threshold or indicator that, if not exceeded, allows exiting the assessment.

If an action is not exempt for Air Quality EIAP, it must proceed to a Level II, Quantitative Assessment. A Level II assessment is a quantification of annual net change in emissions that are compared against levels of annual emissions (i.e., thresholds or indicator) that are known to have de minimis (insignificant) effects on public health or safety. De minimis values were established in the General Conformity Rule (40 CFR 93 Subpart B) as definitive insignificance thresholds for actions occurring within areas designated as nonattainment or maintenance for one or more National Ambient Air Quality Standard (NAAQS). However, for Level II NEPA air impact assessments, the USAF had to establish legally defensible insignificance values (indicators) for actions occurring within attainment areas. Insignificance thresholds are EPA-established annual emission rates that, if exceeded, would trigger a regulatory requirement. Insignificance indicators are EPA-established rate thresholds that are partially applied or applied out of context to their intended use; however, can provide a direct gauge of potential impact. Although indicators do not trigger a regulatory requirement, they do provide an indication or a warning that the action is potentially approaching a threshold which would trigger a significant regulatory requirement.

The air quality impact evaluation for this action requires two separate analyses: the Clean Air Act (CAA) General Conformity Analysis and an analysis under NEPA. Impacts of air pollutants emitted by activities in the Pacific Ocean, bays, and inland locations in State waters (i.e., up to 3 nm from the coast) are assessed under the General Conformity Rule. Impacts of air pollutants emitted by activities in the Pacific Ocean, bays, and inland locations in U.S. territorial seas (i.e., up to 12 nm from the coast) are assessed under NEPA. Each coastal state may claim the territorial sea that extends seaward up to 12 nm from its shores and exercise sovereignty over its territorial sea, the air space above it, and the seabed and subsoil beneath it (National Oceanic and Atmospheric Administration [NOAA] 2017). The state jurisdictions may extend the full distance of territorial seas or may retain historical limits.

Table 3 presents the air quality DAF insignificance thresholds and indicators that would be applied to Alternative 1's emissions.

Table 3. DAF Insignificance Thresholds/Indicators

Pollutant	Santa Barbara County (SBCAPCD)	Ventura County (VCAPCD)	Los Angeles County (SCAQMD)
	Tons Per Year		
Ozone (NO_x or VOC)	250	50*	10*
Carbon Monoxide (CO)	250	250	100*
SO_2 or NOx	250	250	250
PM_{10}	250	250	100*
$PM_{2.5}$ (NOx, VOC, SOx, or NH_3)	250	250	70*
Lead (Pb)	25	25	25*

Source: HQ AFCEC/CZTQ 2023a.
Notes: * Indicates a General Conformity Threshold.

NOx = oxides of nitrogen; SO_2 = sulfur dioxide; NO_2 = nitrogen dioxide; VOC = volatile organic compound; CO = carbon monoxide; PM_{10} = particulate matter with an aerodynamic diameter less than or equal to 10 microns; $PM_{2.5}$ = particulate matter with an aerodynamic diameter less than or equal to 2.5 microns; NH_3 = ammonia; Pb = lead; SBCAPCD = Santa Barbara County Air Pollution Control District; VCAPCD = Ventura County Air Pollution Control District; SCAQMD = South Coast Air Quality Management District.

2.4.2 Approach and Methodology

An air quality impact assessment is accomplished with a net-change inventory analyses for each nonattainment/maintenance area the action will occur within. In accordance with DAF guidance, NEPA (40 CFR 1508), and the General Conformity Rule (40 CFR 93 Subpart B), a net-change inventory analyses is an evaluation of the total action-related annual increased emissions (direct and indirect emissions) of the criteria pollutant (or their precursors) combined with the total action-related annual decreased emissions results in an overall annual net change in emissions for the entire action. Alternative 1's worst-year (highest emission year) annual net change in emissions for each pollutant (or precursors) are screened against the applicable insignificance indicators or thresholds (de minimis values). If the results of net-change inventory analyses indicate all criteria pollutant (or precursors) are below the insignificance indicators or thresholds, the action is considered to have an insignificant impact on air quality for both NEPA and General Conformity. If the results of net-change inventory analyses indicate one or more criteria pollutant (or precursors) are equal to or above the insignificance indicators or thresholds, the action is considered to have a potentially significant impact on air quality and further assessment is required and a General Conformity determination is required if a threshold is exceeded.

2.4.2.1 Operational Activities

Baseline

Baseline operational activity emissions from SLC-4 were taken from the 2023 EA. These include emissions from launches and landings, payload fairing recovery, booster roll-on roll-off, and operation of SLC-4.

Alternative 1

Alternative 1 would generate criteria air pollutant emissions during operation from launches and landings, payload fairing recovery, booster roll-on roll-off, and operation of SLC-4. The following section discusses the emission calculation methodology for each activity.

Falcon 9 Launch

SpaceX would launch Falcon 9 up to 50 times per year from VSFB in the same manner as described in the 2020 EA (EA for SpaceX Falcon Launches at Kennedy Space Center and Cape Canaveral Air Force Station). It is estimated that it takes a Falcon 9 up to 23 seconds to reach 3,000 feet elevation after a launch. Static fire tests last a duration of 7 seconds. The emission factors for estimating emissions from Falcon 9 launches were taken from the *Exhaust Plume Calculations for SpaceX Merlin5 Booster Engine* by Sierra Engineering & Software, Inc. (included as Appendix B). The analysis was done using a single engine firing into a stable environment within 516 feet of the engine exhaust. This assumes the gas generator exhaust is efficiently entrained into the rocket exhaust. The analysis from the single engine was then extrapolated to estimate the emissions for all 9 engines for the Falcon 9. The Performance Correlation Program (PERCORP) is a model that uses known engine performance to estimate mixing and vaporization efficiencies in liquid rocket engines and provide a simple method of predicting nozzle exit-plane flow constituents and properties. The PERCORP analysis model was used to estimate the oxidizer/fuel mixture ratio variations that exist within the M1D thrust chamber. The fuel-rich combustion model in PERCORP was also used to estimate the gas generator exhaust constituents. PERCORP was run iteratively with VIPER (version 4.5 Beta Apr-2018) until the VIPER output ISP matched the target value. The VIPER output includes details of the pressure, temperature, velocity and species concentration across the nozzle exit plane. The SPF III code (Version 4.2.3a Patch 2) was used to predict the flow structure of the free exhaust plume and the entrainment of ambient air. The M8 chemical system was augmented with CH_4, C_2H_2 and C_2H_4. However, there were several species in the PERCORP-generated GG exhaust ($C_{12}H_{23}$, C_7H_{14}, C_3H_6, C_2H_6) that were not included in the SPF DATABANK. Rather than trying to add the species, Sierra's kerosene cracking reactions, plus some judicious chemistry analogs, were used to convert these species into simpler constituents the code can handle. The subsequent TDK simulation of the plume chemistry requires an approximate fit of the air entrainment rate. The SPF air entrainment profile was fit to an "availability profile" for the TDK simulations, allowing ambient air to be "mixed" into the plume flow. Achieving a good fit of the entrainment with the simple availability model within TDK requires running the 1-D analysis in 3-pieces, restarting the simulation with temperature and species information from the previous analysis and updating the air availability rate parameters. The one-dimensional kinetic model (ODK) in the TDK code was used to model chemical reactions within the evolving plume flow field. The pollutant flow rates were calculated in terms of lb_m generated per second of steady engine operation.

Although the exhaust is fuel-rich and contains high concentrations of CO, subsequent entrainment of ambient air results in complete conversion of the CO into CO_2 and oxidation of the soot from the gas generator exhaust. A small amount of thermal NOx is formed as NO. Each takeoff may be preceded by a static fire test of the engines, which lasts a few seconds. The need to conduct a static fire test is mission dependent, but there would be no more than 30 static fire events per year. Emissions were estimated using a spreadsheet model.

Payload Fairing Recovery

After each launch, the fairing is recovered from the Pacific Ocean via a support marine vessel. The fairing and parafoil would be recovered by a salvage ship stationed in the Proposed Landing Area near the anticipated splashdown site, but no closer than 12 nm offshore. Emissions from the support vessel were calculated using a spreadsheet model and emission factors based on the engine tier and the activity data for the recovery.

Landings

Similar to launch operations, there are emissions of NOx during the landing of the Falcon first stage. Landings occur both on land and on water in the Pacific Ocean. For water landings, the first stage and barge are towed using a marine vessel back to the Port of Long Beach. Emissions were estimated using a spreadsheet model with emission factors based on the engine tier and activity data. During landing, only 3 of the 9 engines are used in a Falcon 9 booster. The engines burn 18 seconds during a landing below 3,000 feet.

Booster Roll-On-Roll-Off

SpaceX proposes to transport first stages and fairings from the Port of Long Beach to the VSFB Harbor via a "roll-on-roll-off" (RORO) barge. The first stage would be transferred from the droneship to SpaceX's Self-Propelled Modular Transport (SPMT) that is positioned on a small, low draft barge. The first stage would be pulled by a tug using a Tier 3 (or better) engine from the Port of Long Beach into the VSFB Harbor. The first stage would then be driven off the barge by the SPMT and travel from VSFB Harbor to the hangar at SLC-4E, where it would be unloaded. A support tug would be launched from the Port of Hueneme or Port of Long Beach and travel up the coast to assist the barge and primary tug in maneuvering into and out of the VSFB Harbor, the exact arrival time would depend on tide. The SPMT would then be loaded back on to the barge and travel back to the Port of Long Beach. The support tug would then return to the Port of Hueneme or Port of Long Beach. Alternative 1 would include up to 50 events per year utilizing the RORO barge and tugs. Emissions were estimated using a spreadsheet model with emission factors based on the engine tier and activity data.

Payload Processing, Refurbishment, and Operations

Payloads and their associated materials/fuels/volumes are mission dependent but would be similar to current commercial and government payloads. In November 2011, NASA, with the USAF as a cooperating agency, prepared an EA for Launch of NASA Routine Payloads on Expendable Launch Vehicles (NASA 2011). SpaceX would continue to process payloads at existing SpaceX facilities, including Building 398, and the SLC-4 hangar. Operations include refurbishing the recovered first stage and fairing for reuse in future missions. Up to four boosters and six fairings may be refurbished concurrently. With 50 Falcon 9 launches from SLC-4, up to 50 boosters and 50 fairings would be refurbished each year. Solvents such as isopropyl alcohol, isopar, and Simple Green would be used during these operations, as well for launch pad operations, facility maintenance, and system flushing. SpaceX recovers solvents in accordance with a solvent recovery plan and thus not all solvents used are emitted. Emissions were estimated using permitted emission factors from SLC-4 as well as anticipated activity data from the increase in operations at SLC-4. Emissions were estimated using a spreadsheet model and ACAM.

2.4.3 Air Quality Impact Assessment

Operational emissions were estimated for the project and are discussed separately below. Alternative 1 will occur within three counties: Santa Barbara, Ventura, and Los Angeles. Santa Barbara County falls within the SBCAPCD's jurisdiction and has no nonattainment/maintenance areas. Ventura County falls within the VCAPCD's jurisdiction and has only one nonattainment area. Los Angeles County falls within the SCAQMD's jurisdiction; however, Los Angeles County has multiple nonattainment and maintenance areas for the same criteria pollutant with differing severity classifications and boundaries. It was determined that the portion of Los Angeles County where the action will occur encompasses five nonattainment areas and two maintenance areas. Therefore, the air quality impact assessment is divided into three independent assessments to ensure that each nonattainment or maintenance area is evaluated separately as required under 40 CFR 93(e).

2.4.3.1 Santa Barbara County

Operation of Alternative 1 would generate criteria pollutant and HAP emissions from mobile sources, including vehicle trips from passenger vehicles and heavy-duty trucks, marine vessels, booster launches and landings, launch vehicle processing, and off-road equipment used for maintenance. Table 4 presents the annual operational emissions associated with Alternative 1 (year 2025) as estimated as described in Section 2.4.2.1 within Santa Barbara County. The baseline emissions from the 2023 EA are included to show the net emissions for Alternative 1. Details of the emission calculations are provided in Appendix A.

Table 4. Annual Project Operational Emissions, Santa Barbara County – Alternative 1

Emission Source	VOC	NO_x	CO	SO_x	PM_{10}	$PM_{2.5}$	Pb	NH_3
	Tons Per Year							
Solvent Use	5.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Emergency Generators	1.08	6.03	3.32	0.87	0.99	0.99	0.00	0.00
Worker Vehicles	1.13	0.55	6.93	0.01	0.07	0.03	0.00	0.14
Fleet Vehicle Use	0.08	0.04	0.50	0.00	0.01	0.00	0.00	0.01
Vendor-Contractor Vehicles	0.11	0.05	0.66	0.00	0.01	0.00	0.00	0.01
Off-Road Equipment	1.49	13.33	17.98	0.04	0.41	0.38	0.00	0.00
RP-1, RSV Loading, and Payload Fueling	0.06	0.11	0.00	0.00	0.00	0.00	0.00	0.00
Roll-On-Roll-Off	2.38	28.72	42.56	0.56	0.60	0.60	0.01	0.00
Launch	0.00	7.07	0.00	0.00	0.00	0.00	0.00	0.00
Booster and Payload Fairing Recovery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Landings and Static Fire	0.00	1.19	0.00	0.00	0.00	0.00	0.00	0.00
Total	**12.26**	**57.09**	**71.95**	**1.48**	**2.09**	**2.00**	**0.01**	**0.16**
Baseline	**8.02**	**8.01**	**2.89**	**0.05**	**0.10**	**0.10**	**0.00**	**0.04**
Net (Alternative 1 – Baseline)	**4.24**	**49.08**	**69.06**	**1.43**	**1.99**	**1.90**	**0.01**	**0.12**
DAF Insignificance Thresholds	*250*	*250*	*250*	*250*	*250*	*250*	*25*	*250*
Threshold Exceeded?	**No**	**No**	**No**	**No**	**No**	**No**	**No**	**No**

Notes: VOC = volatile organic compound; NO_x = oxides of nitrogen; CO = carbon monoxide; SO_x = sulfur oxides; PM_{10} = coarse particulate matter; $PM_{2.5}$ = fine particulate matter; <0.01 = reported value less than 0.01; Pb = lead; NH_3 = ammonia; DAF = Department of the Air Force.
See Appendix A for complete results.
Totals may not sum due to rounding.

As shown in Table 4, net annual emissions of Alternative 1 within Santa Barbara County would not exceed the DAF insignificance thresholds. As such, the project would not have an adverse effect on air quality within Santa Barbara County.

2.4.3.2 Ventura County

Operation of Alternative 1 would generate criteria pollutant and HAP emissions from marine vessels. Table 5 presents the annual operational emissions associated with Alternative 1 (year 2025) as estimated as described in Section 2.4.2.1 within Ventura County.

Table 5. Annual Project Operational Emissions – Alternative 1 Ventura County

Emission Source	VOC	NO_x	CO	SO_x	PM_{10}	$PM_{2.5}$	Pb	NH_3
	Tons Per Year							
Solvent Use	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Emergency Generators	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Worker Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fleet Vehicle Use	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vendor-Contractor Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Off-Road Equipment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RP-1, RSV Loading, and Payload Fueling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Roll-On-Roll-Off	2.11	25.18	37.40	0.50	0.54	0.54	0.00	0.00
Launch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Booster and Payload Fairing Recovery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Landings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**2.11**	**25.18**	**37.40**	**0.50**	**0.54**	**0.54**	**0.00**	**0.00**
Baseline	**0.19**	**0.88**	**0.85**	**0.00**	**0.03**	**0.03**	**0.00**	**0.00**
Net (Alternative 1 – Baseline)	**1.92**	**24.30**	**36.55**	**0.50**	**0.51**	**0.51**	**0.00**	**0.00**
DAF Insignificance Thresholds	*50**	*50**	*250*	*250*	*250*	*250*	*25*	*250*
Threshold Exceeded?	**No**	**No**	**No**	**No**	**No**	**No**	**No**	**No**

Notes: * Indicates a General Conformity Threshold.
VOC = volatile organic compound; NO_x = oxides of nitrogen; CO = carbon monoxide; SO_x = sulfur oxides; PM_{10} = coarse particulate matter; $PM_{2.5}$ = fine particulate matter; <0.01 = reported value less than 0.01; Pb = lead; NH_3 = ammonia; DAF = Department of the Air Force.
See Appendix A for complete results.
Totals may not sum due to rounding.

As shown in Table 5, annual emissions of Alternative 1 would not exceed the DAF insignificance thresholds. As such, Alternative 1 would not have an adverse effect on air quality in Ventura County.

2.4.3.3 Los Angeles County

Operation of Alternative 1 would generate VOCs, NO_x, CO, SO_x, PM_{10}, and $PM_{2.5}$ emissions from marine vessels, booster landing, and recovery operations within Los Angeles County. Table 6 presents the annual operational emissions associated with Alternative 1 (year 2025) as estimated as described in Section 2.4.2.1 within Los Angeles County.

Table 6. Annual Project Operational Emissions – Alternative 1 Los Angeles County

Emission Source	VOC	NO_x	CO	SO_x	PM_{10}	$PM_{2.5}$	Pb	NH_3
	Tons Per Year							
Solvent Use	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Emergency Generators	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Worker Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fleet Vehicle Use	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vendor-Contractor Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Off-Road Equipment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RP-1, RSV Loading, and Payload Fueling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Roll-On-Roll-Off	2.54	31.62	46.38	0.57	0.71	0.71	0.01	0.00
Launch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Booster and Payload Fairing Recovery	0.14	0.67	0.28	0.11	0.05	0.05	0.00	0.00
Landings	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.00
Total	**2.68**	**33.36**	**46.66**	**0.68**	**0.76**	**0.76**	**0.01**	**0.00**
Baseline	**0.34**	**2.10**	**1.35**	**0.05**	**0.07**	**0.07**	**0.00**	**0.00**
Net (Alternative 1 – Baseline)	**2.34**	**31.26**	**45.31**	**0.63**	**0.69**	**0.69**	**0.01**	**0.00**
DAF Insignificance Thresholds	*10**	*10**	*100**	*250*	*100**	*70**	*25**	*70**
Threshold Exceeded?	**No**	**Yes**	**No**	**No**	**No**	**No**	**No**	**No**

Notes: * Indicates a General Conformity Threshold.
VOC = volatile organic compound; NO_x = oxides of nitrogen; CO = carbon monoxide; SO_x = sulfur oxides; PM_{10} = coarse particulate matter; $PM_{2.5}$ = fine particulate matter; <0.01 = reported value less than 0.01; Pb = lead; NH_3 = ammonia; DAF = Department of the Air Force.
See Appendix A for complete results.
Totals may not sum due to rounding.

As shown in Table 6, annual emissions of Alternative 1 would not exceed the DAF insignificance thresholds for VOC, CO, SO_x, PM_{10}, $PM_{2.5}$, Pb, or NH_3. However, emissions of NOx would exceed the insignificance threshold. As such, a general conformity determination is necessary to determine if Alternative 1 would have an adverse effect on air quality within Los Angeles County. This is discussed in more detail in Section 2.4.3.4.

2.4.3.4 General Conformity Analysis

The general conformity determination process is intended to demonstrate that a proposed Federal action will not: (1) cause or contribute to new violations of a national ambient air quality standard (NAAQS); (2) interfere with provisions in the applicable SIP for maintenance of any NAAQS; (3) increase the frequency or severity of existing violations of any standard; or (4) delay the timely attainment of any standard. As such, for general conformity determination, the proposed federal action needs to conform to the latest approved SIP/AQMP. As discussed in Section 2.3.1, Santa Barbara County is in attainment for all NAAQS; therefore, general conformity does not apply. Ventura County is in serious nonattainment for the 2008 and 2015 8-hour O_3 NAAQS. As shown in Table 5, the net emissions from Alternative 1 would not exceed the General Conformity de minimis thresholds for VOC or NOx. Therefore, Alternative 1 would have an insignificant impact on air quality within Ventura County.

Los Angeles County is designated as an extreme non-attainment area for ozone, serious non-attainment for $PM_{2.5}$ and maintenance area for CO. As shown in Table 6, Alternative 1 would exceed the General Conformity de minimis threshold for NOx (which is a precursor for O_3). In order to accommodate projects subject to general conformity requirements and to streamline the review process, general conformity budgets for NOx and VOC emissions are established in the AQMP. The 2016 AQMP, which is the latest plan approved by U.S. EPA, established set aside accounts to accommodate emissions subject to general conformity requirements. The set-aside accounts include 2 tons per day (tpd) or 730 tons per year (tpy) of NOx and 0.5 tpd or 182.5 tpy of VOC each year starting in 2017 through 2030, and 0.5 tpd (182.5 tpy) of NOx and 0.2 tpd (73 tpy) of VOC each year in 2031 and thereafter.

Alternative 1 exceeds the General Conformity de minimis thresholds of NOx in the years 2025 through 2030. Alternative 1's NOx emissions would be held steady during the lifetime of the project at 31.26 tons per year, or 171.29 pounds per day. As of March 2024, the General Conformity budget for NOx in 2025 is 299 tons. Therefore, Alternative 1's NOx emissions would not exceed the remaining set aside budget. **TBD: Discussion and attachment of general conformity confirmation from the SCAQMD as requested by the project proponent.**

As such, upon approval to use the NOx set-aside accounts from SCAQMD, Alternative 1 will conform to the latest EPA approved AQMP as the emissions from the project are accommodated within the AQMP's emissions budgets, and the proposed project is not expected to result in any new or additional violations of the NAAQS or impede the projected attainment of the NAAQS.

No Action Alternative

Under the No Action Alternative, the project would not be built. There would be no criteria air pollutant emissions generated because operation would not occur. Therefore, there would be no emissions resulting from the No Action Alternative compared to Alternative 1. There would be no impact on air quality.

3 Greenhouse Gases

3.1 Environmental Setting

A greenhouse gas (GHG) is any gas that absorbs infrared radiation in the atmosphere; in other words, GHGs trap heat in the atmosphere. Some GHGs, such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), occur naturally and are emitted into the atmosphere through natural processes and human activities. Of these gases, CO_2 and CH_4 are emitted in the greatest quantities from human activities. Manufactured GHGs, which have a much greater heat-absorption potential than CO_2, include fluorinated gases, such as hydrochlorofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6), which are associated with certain industrial products and processes.

CO_2 is the primary anthropogenic (human-caused) GHG and has been established as the reference gas to demonstrate the relative effect of different GHGs of equal mass. The effect that each of the GHGs has on global warming is the product of the mass of their emissions and their global warming potential (GWP). GWP indicates how much a gas is predicted to contribute to global warming relative to how much warming would be predicted to be caused by the same mass of CO_2. For example, methane and nitrous oxide are substantially more potent GHGs than CO_2, with GWPs of 25 and 298 times that of CO_2 respectively, which has a GWP of 1, as the reference gas.

In emissions inventories, GHG emissions are typically reported as metric tons (MT) of CO_2 equivalent (CO_2e). CO_2e is calculated as the product of the mass emitted of a given GHG and its specific GWP.CO_2e = (metric tons of a GHG) × (GWP of the GHG)

Climate change refers to any significant change in measures of climate, such as temperature, precipitation, or wind patterns, lasting for an extended period of time (decades or longer). The greenhouse effect, which is the trapping and build-up of heat in the atmosphere near the Earth's surface, is a natural process that contributes to regulating the Earth's temperature. Human activities that emit additional GHGs to the atmosphere increase the amount of infrared radiation that gets absorbed before escaping into space, thus enhancing the greenhouse effect and causing the Earth's surface temperature to rise.

Potential Effects of Climate Change

Globally, climate change has the potential to affect numerous environmental resources through uncertain impacts related to future air temperatures and precipitation patterns. The 2014 IPCC Synthesis Report (IPCC 2014) indicated that warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. Signs that global climate change has occurred include warming of the atmosphere and ocean, diminished amounts of snow and ice, rising sea levels, and ocean acidification (IPCC 2014). As global temperatures rise, the county's historically arid climate could intensify, exacerbating water scarcity and altering the delicate balance of its semi-arid landscapes. The Sierra Nevada snowpack, a critical water source, may diminish due to earlier melting, impacting downstream water availability and agricultural practices. Increased temperatures could also lead to extended wildfire seasons, threatening both human settlements and natural habitats. Furthermore, changing precipitation patterns may disrupt traditional water management strategies and necessitate adaptive measures to ensure sustained water resources.

Sources of Greenhouse Gas Emissions

Per the EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2019 (EPA 2021), total United States GHG emissions were approximately 6,558.3 million metric tons (MMT) CO_2e in 2019 (EPA 2021). The primary GHG emitted by human activities in the United States was CO_2, which represented approximately 80.1% of total GHG emissions (5,255.8 MMT CO_2e). The largest source of CO_2, and of overall GHG emissions, was fossil-fuel combustion, which accounted for approximately 92.4% of CO_2 emissions in 2019 (4,856.7 MMT CO_2e). Relative to 1990, gross United States GHG emissions in 2019 were 1.8% higher; however, the gross emissions were down from a high of 15.6% above 1990 levels in 2007. GHG emissions decreased from 2018 to 2019 by 1.7% (113.1 MMT CO_2e) and overall, net emissions in 2019 were 13% below 2005 levels (EPA 2021).

According to California's 2000–2019 GHG emissions inventory (2021 edition), California emitted 418 MMT CO_2e in 2019, including emissions resulting from out-of-state electrical generation (CARB 2021b). The sources of GHG emissions in California include transportation, industry, electric power production from both in-state and out-of-state sources, residential and commercial activities, agriculture, high GWP substances, and recycling and waste. The California GHG emission source categories and their relative contributions in 2019 are presented in Table 7, Greenhouse Gas Emissions Sources in California.

Table 7. Greenhouse Gas Emissions Sources in California

Source Category	Annual GHG Emissions (MMT CO_2e)	Percent of Total[a]
Transportation	166.1	39.7%
Industrial	88.2	21.1%
Electric power	58.8	14.1%
Commercial and Residential	43.8	10.5%
Agriculture	31.8	7.6%
High global-warming potential substances	20.6	4.9%
Recycling and waste	8.9	2.1%
Total	**418.2**	**100%**

Source: CARB 2021b.
Notes: GHG = greenhouse gas; MMT CO_2e = million metric tons of carbon dioxide equivalent.
Emissions reflect the 2018 California GHG inventory.
[a] Percentage of total has been rounded, and total may not sum due to rounding.

Between 2000 and 2019, per-capita GHG emissions in California have dropped from a peak of 14.0 MT CO_2e per person in 2001 to 10.5 MT CO_2e per person in 2019, representing an approximate 25% decrease. In addition, total GHG emissions in 2019 were approximately 7 MMT CO_2e lower than 2018 emissions (CARB 2021b).

3.2 Regulatory Setting

3.2.1 Federal Regulations

Greenhouse Gas Endangerment

On April 2, 2007, in Massachusetts v. USEPA, 549 US 497, the Supreme Court found that GHGs are air pollutants covered by the Clean Air Act (CAA). The Court held that EPA must determine whether emissions of GHGs from new motor vehicles cause or contribute to air pollution, which may reasonably be anticipated to endanger public health or welfare, or whether the science is too uncertain to make a reasoned decision. In making these decisions, EPA is required to follow the language of Section 202(a) of the CAA.

On April 17, 2009, EPA Administrator signed proposed "endangerment" and "cause or contribute" findings for GHGs under Section 202(a) of the CAA. EPA held a 60-day public comment period, considered public comments, and issued final findings. EPA found that six GHGs taken in combination endanger both the public health and the public welfare of current and future generations. EPA also found that the combined emissions of these GHGs from new motor vehicles and new motor vehicle engines contribute to the greenhouse effect as air pollution that endangers public health and welfare under CAA Section 202(a).

Mandatory Reporting of Greenhouse Gases

The Consolidated Appropriations Act of 2008, passed in December 2007, requires the establishment of mandatory GHG reporting requirements. On September 22, 2009, EPA issued the Final Mandatory Reporting of Greenhouse Gases Rule, which became effective January 1, 2010. The rule requires reporting of GHG emissions from large sources and suppliers in the U.S. and is intended to collect accurate and timely emissions data to inform future policy decisions. Under the rule, suppliers of fossil fuels or industrial GHGs, manufacturers of vehicles and engines, and facilities that emit 25,000 metric tons or more per year of GHG emissions are required to submit annual reports to EPA.

Executive Order 13990

On January 20, 2021, President Biden issued Executive Order (EO) 13990, "Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis." Section 7(e) of this EO directs the White House Council on Environmental Quality (CEQ) to rescind the 2019 Draft GHG Guidance and review, revise, and update its 2016 GHG Guidance. Among its key provisions, the order directed federal agencies to review and potentially revise a range of policies, regulations, and actions that were inconsistent with the Biden administration's commitment to combatting climate change and promoting environmental sustainability. The order also sought to reestablish interagency working groups and committees that had been disbanded or sidelined during the previous administration, with a focus on restoring evidence-based decision-making processes.

The Interagency Working Group on the Social Cost of Greenhouse Gases (IWG) is a collaborative effort involving multiple U.S. federal agencies with the goal of providing scientifically sound estimates for the social cost of greenhouse gases (SC-GHG). This metric assigns a monetary value to the long-term damages caused by the emission of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) emissions, considering their impacts on climate change, public health, ecosystems, and the economy. The IWG under the authority of Executive Order

13990 released the "Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990" in February 2021. The Technical Support Document contains methodologies, data and analyses used by the IWG to develop interim estimates for the social cost of carbon (SC-CO2), methane (SC-CH_4), and nitrous oxide (SC-N20) emissions under EO 13990.

Inflation Reduction Act

The Inflation Reduction Act was signed into law by President Biden in August 2022. The bill includes specific investment in energy and climate reform and is projected to reduce GHG emissions within the United States by 40% as compared to 2005 levels by 2030. The bill allocates funds to boost renewable energy infrastructure (e.g., solar panels and wind turbines), includes tax credits for the purchase of electric vehicles, and includes measures that will make homes more energy efficient.

The Inflation Reduction Act authorized the EPA to implement the Greenhouse Gas Reduction Fund (GGRF) program, which a is a historic, $27 billion investment to mobilize financing and private capital to combat the climate crisis and ensure American economic competitiveness. The GGRF will be designed to achieve the following program objectives: reduce GHG emissions and other air pollutants; deliver the benefits of GHG- and air-pollution-reducing projects to American communities, particularly low-income and disadvantaged communities; and mobilize financing and private capital to stimulate additional deployment of greenhouse gas and air pollution reducing projects (EPA 2023).

EPA External Review Draft of Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances. EPA released its "Supplementary Material for the Regulatory Impact Analysis for the Supplemental Proposed Rulemaking, "Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review". The report presented new estimates of the social cost of carbon dioxide (SC-CO_2), social cost of methane (SC-CH_4), and social cost of nitrous oxide (SC-N_2O) based on advances in scientific literature on climate change and its economic impacts and incorporating recommendations made by the National Academies of Science, Engineering and Medicine. EPA is a member of the IWG and participates in IWG's work under EO 13990. While the IWG work continues, EPA's draft report presents a set of SC-GHG estimates that incorporates numerous methodological updates addresses the near-term recommendations of the National Academies. Primary differences between EPA's draft report and IWG's interim estimates are the increase in the SC-GHGs and the discount rates. Uncertainty in the starting discount rate is addressed by using three near-term target rates (1.5, 2.0, and 2.5 percent) based on multiple lines of evidence on observed market interest rates (USEPA 2022).

Interim Guidance on Consideration of Greenhouse Gas Emissions and Climate Change

On January 6, 2023, the CEQ released new guidance to disclose climate impacts in environmental reviews under the National Environmental Policy Act (NEPA). The guidance replaces 2016 emissions guidance that was withdrawn by the previous Administration. CEQ's new climate change guidance recommends that agencies account for greenhouse gas (GHG) emissions in NEPA reviews. It provides Federal agencies a common approach for assessing their Alternative 1s, while recognizing each agency's unique circumstances and authorities.

3.2.2 State Regulations

The Statewide GHG emissions regulatory framework is summarized as follows by category: State climate change targets, building energy, renewable energy and energy procurement, mobile sources, solid waste, water, and other State regulations and goals. The following text describes EOs, assembly bills (ABs), senate bills (SBs), and other regulations and plans that would directly or indirectly reduce GHG emissions. The State's adoption and implementation of various legislation demonstrates California's leadership in addressing the critical challenge of addressing climate change. Of importance, the Project and/or users of the Project would be required to comply with the various regulatory measures that would reduce GHG emissions, which would reduce the Project's contribution to cumulative GHG emissions and associated climate change impacts.

State Climate Change Targets

The State has taken a number of actions to address climate change. These include EOs, legislation, and CARB plans and requirements. These are summarized as follows.

Executive Order S-3-05

EO S-3-05 (June 2005) established California's GHG emissions reduction targets and laid out responsibilities among the State agencies for implementing the EO and for reporting on progress toward the targets. This EO established the following targets:

- By 2010, reduce GHG emissions to 2000 levels
- By 2020, reduce GHG emissions to 1990 levels
- By 2050, reduce GHG emissions to 80% below 1990 levels

Assembly Bill 32

In furtherance of the goals established in EO S-3-05, the Legislature enacted AB 32 (Núñez and Pavley). The bill is referred to as the California Global Warming Solutions Act of 2006 (September 27, 2006). AB 32 provided initial direction on creating a comprehensive multiyear program to limit California's GHG emissions at 1990 levels by 2020 and initiate the transformations required to achieve the State's long-range climate objectives.

Senate Bill 32 and Assembly Bill 197

SB 32 and AB 197 (enacted in 2016) are companion bills. SB 32 codified the 2030 emissions reduction goal of EO B-30-15 by requiring CARB to ensure that Statewide GHG emissions are reduced to 40% below 1990 levels by 2030.

California Air Resources Board's Climate Change Scoping Plan

One specific requirement of AB 32 is for CARB to prepare a "scoping plan" for achieving the maximum technologically feasible and cost-effective GHG emission reductions by 2020 (Health and Safety Code, Section 38561(a)), and to update the plan at least once every 5 years. In 2008, CARB approved the first scoping plan. The *Climate Change Scoping Plan: A Framework for Change* (*Scoping Plan*) included a mix of recommended strategies that combined direct regulations, market-based approaches, voluntary measures, policies, and other emission reduction programs calculated to meet the 2020 Statewide GHG emission limit and initiate the transformations needed to achieve the State's long-range climate objectives.

In 2014, CARB approved the first update to the Scoping Plan. The *First Update to the Climate Change Scoping Plan: Building on the Framework* (*First Update)* defined the State's GHG emission reduction priorities for the next 5 years and laid the groundwork to start the transition to the post-2020 goals set forth in Eos S-3-05 and B-16-2012 (discussed below). The *First Update* concluded that California is on track to meet the 2020 target but recommended a 2030 mid-term GHG reduction target be established to ensure a continuum of action to reduce emissions (CARB 2014).

In 2015, as directed by EO B-30-15, CARB began working on an update to the Scoping Plan to incorporate the 2030 target of 40% below 1990 levels by 2030 to keep California on its trajectory toward meeting or exceeding the long-term goal of reducing GHG emissions to 80% below 1990 levels by 2050 as set forth in S-3-05.

In December 2017, CARB adopted the *2017 Climate Change Scoping Plan Update (2030 Scoping Plan)* (CARB 2017b). The 2030 Scoping Plan builds on the successful framework established in the initial Scoping Plan and First Update, while identifying new, technologically feasible and cost-effective strategies that will serve as the framework to achieve the 2030 GHG target and define the State's climate change priorities to 2030 and beyond.

The 2030 Scoping Plan recommends strategies for implementation at the Statewide level to meet the goals of AB 32, SB 32, and the Eos and establishes an overall framework for the measures that will be adopted to reduce California's GHG emissions. A project is considered consistent with the statutes and Eos if it meets the general policies in reducing GHG emissions to facilitate the achievement of the State's goals and does not impede attainment of those goals. As discussed in several cases, a given project need not be in perfect conformity with each and every planning policy or goals to be consistent. A project would be consistent, if it will further the objectives and not obstruct their attainment.

CARB's 2022 Scoping Plan Update.

The Proposed Final 2022 Scoping Plan for Achieving Carbon Neutrality (2022 Scoping Plan) was issued on November 16, 2022 (CARB 2022b). The 2022 Scoping Plan lays out a path not just to carbon neutrality by 2045 but also to the 2030 GHG emissions reduction target. The modeling indicates that, if the plan described in the Proposed Scenario is fully implemented, and done so on schedule, the State would cut GHG emissions by 85% below 1990 levels, result in a 71% reduction in smog-forming air pollution, reduce fossil fuel consumption by 94%, create 4 million new jobs, among other benefits (CARB 2022b).

The 2022 Scoping Plan details "Local Actions" In Appendix D. The Local Actions includes recommendations intended to build momentum for local government actions that align with the State's climate goals, with a focus on local GHG reduction strategies (commonly referred to as climate action planning) and approval of new land use development projects. The recommendations provided in Appendix D are non-binding and should not be interpreted as a directive to local governments, but rather as evidence-based analytical tools to assist local governments with their role as essential partners in achieving California's climate goals.[6] Absent a qualified GHG reduction plan, Appendix D provides recommendations for key attributes that residential and mixed-use projects should achieve

[6] The threshold approaches outlined in the 2022 Scoping Plan, Appendix D, are recommendations only and are not requirements; they do not supplant lead agencies' discretion to develop their own evidence-based approaches for determining whether a project would have a potentially significant impact on GHG emissions (CARB 2022c).

that would align with the State's climate goals including EV charging infrastructure, infill location, no loss or conversion of natural and working lands, transit-supportive densities or proximity to transit stops, reducing parking requirements, provision of affordable housing (20% of units), and all-electric appliances with no natural gas connection (CARB 2022c). Projects that achieve all key attributes are considered clearly consistent with the State's climate and housing goals and would have a less-than-significant GHG impact (CARB 2022c). However, projects that do not achieve all attributes are not considered to result in a potentially significant GHG emission impact. Although net zero targets can often be valuable and achievable, targets should be considered in the larger context of these goals, and any GHG targets on a local scale should take into consideration the actions and outcomes included in this Scoping Plan (CARB 2022c). The CARB Scoping Plan states that jurisdictions considering "net zero" targets should carefully consider the implications such targets may have on emissions in neighboring communities and the ability of the state to meet collective targets (CARB 2022c).

Executive Order B-55-18

EO B-55-18 (September 2018) establishes a Statewide policy for California to achieve carbon neutrality as soon as possible, and no later than 2045, and achieve and maintain net-negative emissions thereafter. The goal is an addition to the existing Statewide targets of reducing the State's GHG emissions. CARB will work with relevant State agencies to ensure that future Scoping Plans identify and recommend measures to achieve the carbon neutrality goal.

The Inflation Reduction Act of 2022

The Inflation Reduction Act was signed into law by President Biden in August 2022. The bill includes specific investment in energy and climate reform and is projected to reduce GHG emissions within the U.S. by 40 percent as compared to 2005 levels by 2030. The bill allocates funds to boost renewable energy infrastructure (e.g., solar panels and wind turbines), includes tax credits for the purchase of electric vehicles, and includes measures that will make homes more energy efficient.

Assembly Bill 1279

The Legislature enacted AB 1279, the California Climate Crisis Act, in September 2022. The bill declares the policy of the state to achieve net zero GHG emissions as soon as possible, but no later than 2045, and achieve and maintain net negative GHG emissions thereafter. Additionally, the bill requires that by 2045, statewide anthropogenic GHG emissions be reduced to at least 85% below 1990 levels.

Assembly Bill 1757

AB 1757 (September 2022) requires the CNRA to determine a range of targets for natural carbon sequestration, and for nature-based climate solutions that reduce GHG emissions for future years 2030, 2038, and 2045. These targets are to be determined by no later than January 1, 2024, and are established to support the state's goals to achieve carbon neutrality and foster climate adaptation and resilience.

Senate Bill 1020

SB 1020 (September 2022) revises the standards from SB 100, requiring the following percentage of retail sales of electricity to California end-use customers come from eligible renewable energy resources and zero-carbon resources: 90% by December 31, 2035; 95% by December 31, 2040; and 100% by December 31, 2045

Building Energy

Title 24, Part 6

Title 24 of the California Code of Regulations was established in 1978 and serves to enhance and regulate California's building standards. While not initially promulgated to reduce GHG emissions, Part 6 of Title 24 specifically established Building Energy Efficiency Standards that are designed to ensure new and existing buildings in California achieve energy efficiency and preserve outdoor and indoor environmental quality. These regulations are carefully scrutinized and analyzed for technological and economic feasibility (California Public Resources Code, Section 25402(d)) and cost effectiveness (California Public Resources Code, Sections 25402(b)(2) and (b)(3)). As a result, these standards save energy, increase electricity supply reliability, increase indoor comfort, avoid the need to construct new power plants, and help preserve the environment.

The Title 24 standards that CalEEMod incorporates are the 2019 Title 24 Building Energy Efficiency Standards, which became effective January 1, 2020. In general, single-family residences built to the 2019 standards are anticipated to use approximately 7% less energy due to energy efficiency measures than those built to the 2016 standards; once rooftop solar electricity generation is factored in, single-family residences built under the 2019 standards will use approximately 53% less energy than those under the 2016 standards (CEC 2018a). Nonresidential buildings built to the 2019 standards are anticipated to use an estimated 30% less energy than those built to the 2016 standards (CEC 2018a).

On August 11, 2021, the CEC adopted the 2022 Building Energy Efficiency Standards (Energy Code). In December 2021, the 2022 Energy Code was approved by the California Building Standards Commission for inclusion into the California Building Standards Code. The 2022 Energy Code encourages efficient electric heat pumps, establishes electric-ready requirements for new homes, expands solar photovoltaic and battery storage standards, strengthens ventilation standards, and more. Buildings whose permit applications are applied for on or after January 1, 2023, must comply with the 2022 Energy Code. Under the 2022 amendments, California buildings would consume approximately 198,600 GWh of electricity and 6.14 billion therms of fossil fuel natural gas in 2023 compared to approximately 199,500 GWh and 6.17 billion therms of electricity and fossil fuel natural gas, respectively, under the 2019 Energy Code (CEC 2021). On a statewide basis throughout 2023, all measures for newly constructed buildings and altered components of existing buildings collectively would save approximately 33 million therms of fossil fuel natural gas and 1.3 billion kWh of electricity (CEC 2021).

Title 24, Part 11

In addition to the CEC's efforts, in 2008, the California Building Standards Commission adopted the nation's first green building standards. The California Green Building Standards Code (Part 11 of Title 24) is commonly referred to as CALGreen and establishes minimum mandatory standards as well as voluntary standards pertaining to the planning and design of sustainable site development, energy efficiency (in excess of the California Energy Code requirements), water conservation, material conservation, and interior air quality. The 2019 CALGreen standards are the current applicable standards. For nonresidential projects (which the nonresidential portion of the Project is subject to), some of the key mandatory CALGreen 2019 standards involve requirements related to bicycle parking, designated parking for clean air vehicles, electric vehicle (EV) charging stations, shade trees, water conserving plumbing fixtures and fittings, outdoor potable water use in landscaped areas, recycled water supply systems, construction waste management, excavated soil and land clearing debris, and commissioning (24 CCR Part 11).

Title 20

Title 20 of the California Code of Regulations requires manufacturers of appliances to meet State and federal standards for energy and water efficiency. The CEC certifies an appliance based on a manufacturer's demonstration that the appliance meets the standards.

Renewable Energy and Energy Procurement

Senate Bill 1078, Executive Order-14-08, Senate Bill X1-2, Senate Bill 350, and Senate Bill 100

SB 1078 (Sher) (September 2002) established the Renewable Portfolio Standard (RPS) program, which required an annual increase in renewable generation by the utilities equivalent to at least 1% of sales, with an aggregate goal of 20% by 2017. EO S-14-08 (November 2008) required that all retail suppliers of electricity in California serve 33% of their load with renewable energy by 2020. SB X1 2 expanded the RPS by establishing a renewable energy target of 20% of the total electricity sold to retail customers in California per year by December 31, 2013, and 33% by December 31, 2020, and in subsequent years. SB 350 (October 2015) further expanded the RPS by establishing a goal of 50% of the total electricity sold to retail customers in California per year by December 31, 2030. SB 100 (2018) increased the standards set forth in SB 350 establishing that 44% of the total electricity sold to retail customers in California per year by December 31, 2024, 52% by December 31, 2027, and 60% by December 31, 2030, be secured from qualifying renewable energy sources. SB 100 states that it is the policy of the State that eligible renewable energy resources and zero-carbon resources supply 100% of the retail sales of electricity to California. On April 30, 2022 California supplied 100% of its statewide demand with renewables at 2:45 pm (Electrek 2022).

Mobile Sources

State Vehicle Standards (Assembly Bill 1493 and Executive Order B-16-12)

AB 1493 (July 2002) was enacted in a response to the transportation sector accounting for more than half of California's CO_2 emissions. AB 1493 required CARB to set GHG emission standards for passenger vehicles, light-duty trucks, and other vehicles determined by the State board to be vehicles that are primarily used for noncommercial personal transportation in the State. The bill required that CARB set GHG emission standards for motor vehicles manufactured in 2009 and all subsequent model years. CARB adopted the standards in September 2004. EO B-16-12 (March 2012) required that State entities under the governor's direction and control support and facilitate the rapid commercialization of zero-emissions vehicles. It ordered CARB, CEC, California Public Utilities Commission, and other relevant agencies to work with the Plug-in Electric Vehicle Collaborative and the California Fuel Cell Partnership to establish benchmarks to help achieve benchmark goals by 2015, 2020, and 2025. On a Statewide basis, EO B-16-12 established a target reduction of GHG emissions from the transportation sector equaling 80% less than 1990 levels by 2050. This directive did not apply to vehicles that have special performance requirements necessary for the protection of the public safety and welfare. As explained under the "Federal Vehicle Standards" description above, EPA and NHTSA approved the SAFE Vehicles Rule Part One and Two, which revoked California's authority to set its own GHG emissions standards and set zero-emission vehicle mandates in California.

As President Biden issued EO 13990 to review Part One and Part Two of the SAFE Vehicles Rule, this analysis continues to utilize the best available information at this time, as set forth in EMFAC and assumed in CalEEMod.

Heavy Duty Diesel (Title 13, Division 3, Chapter 1, Section 2025)

CARB adopted the final Heavy Duty Truck and Bus Regulation, Title 13, Division 3, Chapter 1, Section 2025, on December 31, 2014, to reduce particulate matter and NO_X emissions from heavy-duty diesel vehicles. The rule requires particulate matter filters be applied to newer heavier trucks and buses by January 1, 2012, with older vehicles required to comply by January 1, 2015. The rule will require nearly all diesel trucks and buses to be compliant with the 2010 model year engine requirement by January 1, 2023. CARB also adopted an Airborne Toxic Control Measure to limit idling of diesel-fueled commercial vehicles on December 12, 2013. This rule requires diesel-fueled vehicles with gross vehicle weights greater than 10,000 pounds to idle no more than 5 minutes at any location (13 CCR 2485).

Executive Order S-1-07

EO S-1-07 (January 2007, implementing regulation adopted in April 2009) sets a declining low carbon fuel standard (LCFS) for GHG emissions measured in CO_2e grams per unit of fuel energy sold in California. The initial target of the LCFS was to reduce the carbon intensity of California passenger vehicle fuels by at least 10% by 2020 (17 CCR 95480 et seq.). In September 2018, CARB approved amendments for the LCFS that require a 20% reduction in carbon intensity by year 2030.

Senate Bill 375

SB 375 (Steinberg) (September 2008) addresses GHG emissions associated with the transportation sector through regional transportation and sustainability plans. SB 375 requires CARB to adopt regional GHG reduction targets for the automobile and light-truck sector for 2020 and 2035 and to update those targets every 8 years. SB 375 requires the State's 18 regional metropolitan planning organizations (MPOs) to prepare a Sustainable Communities Strategy (SCS) as part of their Regional Transportation Plan (RTP) that will achieve the GHG reduction targets set by CARB.

Advanced Clean Cars Program and Zero-Emissions Vehicle Program

The Advanced Clean Cars (ACC) I program (January 2012) is an emissions-control program for model years 2015 through 2025. The program combines the control of smog- and soot-causing pollutants and GHG emissions into a single coordinated package of regulations: the Low-Emission Vehicle (LEV) regulation for criteria air pollutant and GHG emissions and a technology forcing regulation for zero-emission vehicles (ZEV) that contributes to both types of emission reductions (CARB 2021c). The package includes elements to reduce smog-forming pollution, reduce GHG emissions, promote clean cars, and provide the fuels for clean cars. To improve air quality, CARB has implemented new emission standards to reduce smog-forming emissions beginning with 2015 model year vehicles. It is estimated that in 2025 cars will emit 75 percent less smog-forming pollution than the average new car sold in 2015 (CARB 2021c). The ZEV program will act as the focused technology of the ACC I program by requiring manufacturers to produce increasing numbers of ZEVs and plug-in hybrid EVs in the 2018 to 2025 model years.

The ACC II program is currently in development to establish the next set of LEV and ZEV requirements for model years after 2025 to contribute to meeting federal ambient air quality ozone standards and California's carbon neutrality standards (CARB 2021c). The main objectives of ACC II are:

1. Maximize criteria and GHG emission reductions through increased stringency and real-world reductions.
2. Accelerate the transition to ZEVs through both increased stringency of requirements and associated actions to support wide-scale adoption and use.

An ACC II rulemaking package, which will consider technological feasibility, environmental impacts, equity, economic impacts, and consumer impacts, is anticipated to be presented to CARB for consideration in August 2022.

Assembly Bill 1236

AB 1236 (October 2015) required a city, county, or city and county to approve an application for the installation of EV charging stations, as defined, through the issuance of specified permits, unless the city or county makes specified written findings based upon substantial evidence in the record that the proposed installation would have a specific, adverse impact upon the public health or safety, and there is no feasible method to satisfactorily mitigate or avoid the specific, adverse impact. The bill provided for appeal of that decision to the planning commission, as specified. The bill provided that the implementation of consistent Statewide standards to achieve the timely and cost-effective installation of EV charging stations is a matter of Statewide concern. The bill required EV charging stations to meet specified standards.

Executive Order-79-20

EO N-79-20 (September 2020) requires CARB to develop regulations as follows: (1) Passenger vehicle and truck regulations requiring increasing volumes of new ZEVs sold in the State towards the target of 100% of in-State sales by 2035; (2) medium- and heavy-duty vehicle regulations requiring increasing volumes of new zero-emission trucks and buses sold and operated in the State towards the target of 100% of the fleet transitioning to zero-emission vehicles by 2045 everywhere feasible and for all drayage trucks to be zero emission by 2035; and (3) strategies, in coordination with other State agencies, the EPA and local air districts, to achieve 100% zero-emissions from off-road vehicles and equipment operations in the State by 2035. EO N-79-20 called for the development of a Zero-Emissions Vehicle Market Development Strategy, which was released February 2021, to be updated every 3 years, that ensures coordination and implementation of the EO and outlines actions to support new and used ZEV markets. In addition, the EO specifies identification of near-term actions, and investment strategies, to improve clean transportation, sustainable freight, and transit options; and calls for development of strategies, recommendations, and actions by July 15, 2021, to manage and expedite the responsible closure and remediation of former oil extraction sites as the State transitions to a carbon-neutral economy.

Advanced Clean Trucks (ACT) Regulation

The purpose of the ACT Regulation (June 2020) is to accelerate the market for zero-emission vehicles in the medium- and heavy-duty truck sector and to reduce emissions NO_X, fine particulate matter, TACs, GHGs, and other criteria pollutants generated from on-road mobile sources (CARB 2021d). Requiring medium- and heavy-duty vehicles to transition to zero-emissions technology will help California meet established near- and long-term air quality and climate mitigation targets.

Water

Executive Order B-29-15

In response to the ongoing drought in California, EO B-29-15 (April 2015) set a goal of achieving a Statewide reduction in potable urban water usage of 25% relative to water use in 2013. The term of the EO extended through February 28, 2016, although many of the directives have become permanent water-efficiency standards and requirements. The EO includes specific directives that set strict limits on water usage in the State.

Executive Order B-37-16

Issued May 2016, EO B-37-16 directed the State Water Resources Control Board (SWRCB) to adjust emergency water conservation regulations through the end of January 2017 to reflect differing water supply conditions across the State. The SWRCB also developed a proposal to achieve a mandatory reduction of potable urban water usage that builds off the mandatory 25% reduction called for in EO B-29-15. The SWRCB and Department of Water Resources will develop new, permanent water use targets that build upon the existing State law requirements that the State achieve 20% reduction in urban water usage by 2020. EO B-37-16 also specifies that the SWRCB permanently prohibit water-wasting practices such as hosing off sidewalks, driveways, and other hardscapes; washing automobiles with hoses not equipped with a shut-off nozzle; using non-recirculated water in a fountain or other decorative water feature; watering lawns in a manner that causes runoff, or within 48 hours after measurable precipitation; and irrigating ornamental turf on public street medians.

Executive Order N-10-21

In response to a state of emergency due to severe drought conditions, EO N-10-21 (July 2021) called on all Californians to voluntarily reduce their water use by 15% from their 2020 levels. Actions suggested in EO N-10-21 include reducing landscape irrigation, running dishwashers and washing machines only when full, finding and fixing leaks, installing water-efficient showerheads, taking shorter showers, using a shut-off nozzle on hoses, and taking cars to commercial car washes that use recycled water.

Executive Order N-7-22

On March 28, 2022, Governor Newsom directed the State Water Board to consider adopting emergency regulations focused on urban water suppliers under EO N-7-22. If adopted, the potential regulations would require the vast majority of urban water suppliers to enact Level 2 of their water shortage contingency plans. Those plans are developed by the suppliers and provide actions they will take if their water supplies are cut to certain levels. Here, Level 2 would represent the suppliers acting as if their water supply had been reduced by 20%. The executive order also directs the State Water Board to consider adopting emergency regulations defining “non-functional turf” by May 25, 2022. Both the executive order and corresponding press release confirm that the definition should only apply to ornamental turf that is not functional, excluding turf such as school fields, sports fields and parks from the definition. If the definition is adopted, the State Water Board must then consider banning irrigation of the non-functional turf in the commercial, industrial and institutional sectors (with limited exceptions). The proposed ban is anticipated to save several hundred thousand acre-feet of water per year.

Solid Waste

Assembly Bill 939, Assembly Bill 341, Assembly Bill 1826, and Senate Bill 1383

In 1989, AB 939, known as the Integrated Waste Management Act (California Public Resources Code, Sections 40000 et seq.), was passed because of the increase in waste stream and the decrease in landfill capacity. AB 939 mandated a reduction of waste being disposed where jurisdictions were required to meet diversion goals of all solid waste through source reduction, recycling, and composting activities of 25% by 1995 and 50% by the year 2000. AB 341 (Chapter 476, Statutes of 2011) amended the California Integrated Waste Management Act of 1989 to include a provision declaring that it is the policy goal of the State that not less than 75% of solid waste generated be source-reduced, recycled, or composted by the year 2020, and annually thereafter. AB 1826 (Chapter 727, Statutes of 2014, effective 2016) requires businesses to recycle their organic waste (i.e., food waste, green waste, landscape and pruning waste, nonhazardous wood waste, and food-soiled paper waste that is mixed in with food waste) depending on the amount of waste they generate per week. SB 1383 (Chapter 395, Statutes of 2016) establishes targets to achieve a 50% reduction in the level of the Statewide disposal of organic waste from the 2014 level by 2020 and a 75% reduction by 2025. CalRecycle was granted the regulatory authority required to achieve the organic waste disposal reduction targets and establishes an additional target that not less than 20% of currently disposed edible food is recovered for human consumption by 2025 (CalRecycle 2019).

3.3 Insignificance Criteria and Methodology

3.3.1 Insignificance Thresholds and Indicators

The CEQ Guidance recognizes that global climate change is a cumulative impact; a project participates in this potential impact through its incremental contribution combined with the cumulative increase of all other sources of GHGs. There are no federal numeric thresholds that delineate when Alternative 1 may have an adverse impact. As discussed in the interim CEQ Guidance when conducting climate change analyses in NEPA, agencies should consider: (1) the potential effects of Alternative 1 on climate change, including by assessing both GHG emissions and reductions from Alternative 1; and (2) the effects of climate change on Alternative 1 and its environmental impacts. The CEQ guidance recommends quantifying GHG emissions, understanding that GHG are a cumulative impact and not project-only impacts, including indirect emissions when relevant to the project, such as for fossil fuel supply or transport projects, and providing context for GHG emissions using the best available social cost of GHG (SC-GHG) estimates to translate climate impacts into the more accessible metric of dollars.

There is no established dollar-value threshold for the SC-GHGs. However, by assigning a dollar value to the damages associated with GHG emissions, policymakers and decision-makers can better evaluate the costs and benefits of actions aimed at reducing emissions. The SC-GHGs provides a tool to make more informed choices about climate-related policies, regulations, and investments.

The USAF has adopted the Prevention of Significant Deterioration (PSD) threshold for GHG of 75,000 ton per year (tpy) of CO_2e (or 68,039 metric ton per year, mtpy) as an indicator or threshold of insignificance for NEPA air quality impacts in all areas (HQ AFCEC/CZTQ. 2023b). This indicator does not define a significant impact; however, it provides a threshold to identify actions that are insignificant (de minimis, too trivial or minor to merit consideration). Actions with a net change in GHG (CO_2e) emissions below the insignificance indicator (threshold) are considered too insignificant on a global scale to warrant any further analysis beyond producing the in the ACAM GHG & Climate Change Reports. Note that actions (or alternatives) with a net change in GHG (CO_2e) emissions above the insignificance indicator (threshold) are only considered potentially significant and require further assessment (usually qualitative) to determine if the action poses a significant impact.

3.3.2 Approach and Methodology

Emissions of GHGs were estimated for operation of Alternative 1 consistent with the methodology presented in Section 2.4.2. Emissions of CO_2, CH_4, and N_2O were estimated from the combustion sources of Alternative 1. Additional sources of direct and indirect GHG emissions were estimated using the CalEEMod 2022 as discussed below.

Energy Sources

The estimation of operational energy emissions was based on applicant provided data. CalEEMod default energy intensity factors (CO_2, CH_4, and N_2O mass emissions per kilowatt hour) for PG&E is based on the value for PG&E's energy mix in 2019. SB-100 calls for further development of renewable energy, with a target of 44% by 2024, 52% by 2027, and 60% by 2030. Because PG&E is striving to meet the 60% RPS by December 31, 2030, the CO_2 emissions intensity factor is anticipated to be less than assumed in CalEEMod at full buildout from implementation of Alternative 1 (2025), which would reflect the increase in percentage of renewable energy in PG&E's energy portfolio.

Refrigerants

CalEEMod was utilized to estimate fugitive GHG emissions from refrigerants used for air conditioning and refrigeration equipment. Different types of refrigeration equipment are utilized for different types of land uses and CalEEMod generates default refrigerant values based on land use subtype and industry data from the EPA. CalEEMod quantifies refrigerant emissions from leaks during regular operation and routine servicing over the equipment lifetime and then derives average annual emissions from the lifetime estimate but does not quantify emissions from the disposal of refrigeration and air conditioning equipment at the end of its lifetime.

Most of the refrigerants used today are HFCs or blends thereof, which can have high GWP values. However, California is required to reduce HFC emissions 40% below 2013 levels by 2030 under SB 1383, and regulations have been adopted to place GWP limits on HFCs, such as SB 120. While CalEEMod default refrigerant values were assumed for the land use surrogate of commercial research and development land use, it is anticipated to be conservative.

Solid Waste

The Project would generate solid waste, and therefore, result in CO_2e emissions associated with landfill off-gassing. CalEEMod default values for solid waste generation were used to estimate GHG emissions associated with solid waste. Project compliance with Statewide solid waste diversion goals, including the 75% diversion rate by 2020 consistent with AB 341 (25% increase from the solid waste diversion requirements of AB 939, Integrated Waste Management Act), would reduce Project-generated GHG emissions associated with solid waste disposal. No diversion above the CalEEMod default assumptions was assumed.

Water and Wastewater

Supply, conveyance, treatment, and distribution of water for the Project require the use of electricity, which would result in associated indirect GHG emissions. Similarly, wastewater generated by the Project requires the use of electricity for conveyance and treatment, along with GHG emissions generated during wastewater treatment. Water consumption estimates for both indoor and outdoor water use was provided by the project applicant and associated electricity consumption from water use and wastewater generation were estimated using CalEEMod default values.

3.3.3 Greenhouse Gas Emissions Impact Assessment

3.3.3.1 Operational Emissions

Operation of Alternative 1 would generate GHG emissions through motor vehicle trips; landscape maintenance equipment operation and hearths (area sources); energy use (natural gas and electricity); solid waste disposal; and water supply, treatment, and distribution and wastewater treatment. CalEEMod was used to calculate the annual GHG emissions based on the operational assumptions described in Section 3.3.2, Methodology. The estimated operational Project-generated unmitigated GHG emissions from area sources, energy usage, motor vehicles, solid waste generation, water usage and wastewater generation, and off-road equipment are shown in Table 8, Project Operational GHG Emissions.

Table 8. Alternative 1 Operational GHG Emissions

Emission Source	CO_2	CH_4	N_2O	CO_2e
	Metric Tons per Year			
Solvent Use	0.00	0.00	0.00	0.00
Emergency Generators	133.78	0.01	0.00	134.23
Worker Vehicles	1,144.08	0.07	0.05	1,159.23
Fleet Vehicle Use	52.82	0.00	0.00	53.58
Vendor-Contractor Vehicles	25.56	0.00	0.00	25.92
Off-Road Equipment	2,998.48	0.12	0.02	3,008.77
RP-1, RSV Loading, and Payload Fueling	NA	NA	NA	2,838.00
Roll-On-Roll-Off	16,596.41	0.48	0.75	16,832.17
Launch	NA	NA	NA	13,697.79
Booster and Payload Fairing Recovery	153.17	0.00	0.01	155.27
Landings and Static Fire	NA	NA	NA	5,068.18
Energy	2,586.97	0.42	0.05	2,612.55
Refrigerants	0.00	0.00	0.00	0.04
Solid Waste	106.81	10.67	0.00	373.68
Water and Wastewater	25.56	0.03	0.02	31.56
			Total	45,990.97
			Baseline	28,055.95
			Net (Alternative 1 – Baseline)	17,935.02

Notes: GHG = greenhouse gas; CO_2 = carbon dioxide; CH_4 = methane; N_2O = nitrous oxide; CO_2e = carbon dioxide equivalent.
See Appendix A for complete results.

As shown in Table 8, estimated net operational GHG emissions from Alternative 1 would be approximately 17,935 MT CO_2e per year. GHG emissions of Alternative 1 would be below the DAF insignificance indicator for all years.

3.3.3.2 Social Cost of GHGs

The SC-GHG is an economic concept used to quantify the monetary value of the long-term societal damages caused by the emission of GHGs into the atmosphere. This metric seeks to capture the various adverse impacts associated with GHG emissions, such as climate change, health problems, ecosystem damage, and economic losses. By assigning a dollar value to these damages, the SC-GHG provides a tool for policymakers, businesses, and governments to assess the true costs of emitting CO_2, CH_4, N_2O, and other GHGs.

Table 9 provides the social cost of GHGs over the life of Alternative 1 based on the Interim Estimates under Executive Order 13990. As shown in Table 9, under a 5% discount rate, Alternative 1 would have a SC-GHGs of over $1.9 million, under a 3% discount rate over $6.3 million, and at a 2.5% discount rate over $9.2 million. Since publication of the Interim Estimates, USEPA has been working on new estimates for the SC-GHGs. These estimates reflect recent advances in the scientific literature on climate change and its economic impacts and incorporate recommendations made by the National Academies of Science, Engineering, and Medicine (National Academies 2017). Under USEPA's draft estimates for SC-GHGs, Alternative 1 would have a SC-GHG of over $14.7 million under the 2.5% discount rate, under the 2% discount rate over $23.8 million, and at a 1.5% discount rate over $40.1 million. However, by assigning a dollar value to the damages associated with GHG emissions, policymakers and decision-makers can better evaluate the costs and benefits of actions aimed at reducing emissions. The SC-GHGs provides a tool to make more informed choices about climate-related policies, regulations, and investments.

Table 9. Social Cost of GHGs Based On Interim Estimates Under Executive Order 13990 – Alternative 1

Year	SC-CO2 per Metric Ton			SC-CH4 per Metric Ton			SC-N2O per Metric Ton			Total Cost of GHGs		
	5.00%	3.00%	2.50%	5.00%	3.00%	2.50%	5.00%	3.00%	2.50%	5.00%	3.00%	2.50%
2025	$17	$56	$83	$800	$1,700	$2,200	$6,800	$21,000	$30,000	$311,452	$1,025,107	$1,518,985
2026	$17	$57	$84	$828	$1,760	$2,260	$7,000	$21,400	$30,600	$318,792	$1,047,085	$1,540,987
2027	$18	$58	$85	$856	$1,820	$2,320	$7,200	$21,800	$31,200	$326,132	$1,069,063	$1,562,989
2028	$18	$60	$87	$884	$1,880	$2,380	$7,400	$22,200	$31,800	$333,472	$1,091,040	$1,584,991
2029	$19	$61	$88	$912	$1,940	$2,440	$7,600	$22,600	$32,400	$340,812	$1,113,018	$1,606,993
2030	$19	$62	$89	$940	$2,000	$2,500	$7,800	$23,000	$33,000	$348,151	$1,134,996	$1,628,995
									Total	**$1,978,811**	**$6,480,309**	**$9,443,942**

Notes: GHG = greenhouse gas emissions; SC-CO2 = social cost of carbon dioxide; SC-CH4 = social cost of methane; SC-N2O = social cost of nitrous oxide.

Climate Change Impacts

The analysis provided above shows Alternative 1's GHG contributions. As noted previously, Alternative 1 would not exceed the DAF insignificance threshold for GHG emissions. Furthermore, the impact of Alternative 1 is evaluated considering climate change effects and whether Alternative 1 would exacerbate climate change effects and how climate change may impact Alternative 1.

Alternative 1 Impact on the Environment Considering Climate Change Effects

As described in the CEQ Guidance document (CEQ 2023), the analysis of climate change effects should focus on those aspects of the human environment that are impacted by the potential action (i.e., Alternative 1 or its alternatives) on climate change. The Fourth National Climate Assessment (USGCRP 2018) describes key areas where climate change will affect resources that impact human environment. The following assesses how Alternative 1 may affect those areas.

- **Water Resources.** Water for humans and nature has declined because of climate change. There has been intensifying droughts and occasional large floods. The demand on water resources will become problematic as populations increase, infrastructure deteriorates, and groundwater is depleted, which will necessitate flexible water management techniques. Alternative 1 would use water for facility needs as well as launch support. Water usage is anticipated to be minimal and would not contribute to drought conditions or exacerbate climate change effects. Alternative 1 would not have an adverse effect on water.

- **Ecosystems and Ecosystem Services.** Drought and wildfire have contributed to the decline in the Southwest forests and other ecosystem's ability to provide natural habitat, clean water, and economic livelihoods. Alternative 1 would not contribute to drought conditions and does not involve forested lands. Alternative 1 does not include chemicals that would pollute water, soil, or air. Impacts to the ecosystem would be contained within the project boundaries. In addition, Alternative 1 includes BMPs to protect water quality, enhance native plantings (as reclamation activities occur), and minimize air emissions. Alternative 1 would have no effect on ecosystems and ecosystem services.

- **The Coast.** This resource area involves sea level rise, ocean warming, and reduce ocean oxygen. Alternative 1 is near the Pacific Ocean and would be subject to any sea level rise. Alternative 1 would indirectly contribute to the effects on rising sea levels due to an increase in GHGs. However, the contribution to global GHGs from Alternative 1 would be minimal.

- **Indigenous Peoples.** This area involves impacts on the ecosystems indigenous people depend on for their traditional existence and livelihood because of drought, wildfire, and changing oceans. As discussed above, Alternative 1 would not contribute to drought conditions and would not impact ecosystems or oceans.

- **Energy.** This area relates to the ability of hydropower and fossil fuel electricity generation to meet growing energy demands as result of the drought (decreasing hydropower), and rising temperatures (increasing energy demand). Alternative 1 would demand electricity from the grid for facility needs and launch support. Alternative 1 would include on-site generators to provide necessary power as well; thus it would not have adverse effect on energy demand. Alternative 1 would require diesel fuel for plant operations and customer vehicles. In addition, the employee vehicles would demand gasoline fuel. Alternative 1's action fuel demand would not be substantial.

- **Food.** This area relates to the ability of the region to produce food considering water shortages, and heat impacts to crops and livestock. There will be increased competition among agricultural, energy, and municipal uses for water, which may result in food insecurity. As noted above, Alternative 1 would not demand a substantial amount of water that would contribute to drought conditions.

- **Human Health.** This area relates to impacts to human health because of extreme heat, poor air quality, and conditions that foster pathogen growth and spread. Air quality emissions from Alternative 1 are summarized in Section 2.4.3 and are well below federal de minimis levels, which are established to determine if an action will confirm with the applicable State Implementation Plan for meeting air quality standards. Moreover, the majority of the emissions from Alternative 1 are not near any populated areas. It can be reasonably concluded that Alternative 1 would not contribute to poor air quality on a regional basis and would not jeopardize the attainment status of the region. Based on the evaluation, Alternative 1 would not have an adverse effect on human health or ambient air quality standards. Alternative 1 would not have an adverse effect on human health.

Impacts of Climate Change on Alternative 1

The CEQ Guidance (CEQ 2023) recommends evaluating how climate change may affect Alternative 1 so that a project may be developed to be resilient to climate change effects. The following summarizes the impacts of climate change on Alternative 1 and resiliency/adaptation measures that can be incorporated into the project.

- **Drought conditions, lack of water**. Alternative 1 would use water supplied by VSFB. As a private enterprise, the market would determine whether additional costs (if supplies were limited) for water imports would be financially acceptable. Alternative 1 would adapt to changing conditions by either limiting production to decrease water use, identifying additional conservation measures, or identifying additional water supplies as the market conditions dictate either on-site or through imports.

- **Rising temperatures/prolonged heatwaves.** As a private operation, Alternative 1 may implement additional safety measures to protect employee health and ensure continued production. Those measures may include additional rest/cooling areas, drinking water stations, etc. The operator of the facility would comply with California Occupational Safety and Health Administration regulations. Under the Occupational Safety and Health Act, employers are responsible for providing workplaces free of known safety and health hazards including heat-related hazards. The facility would have flexibility to adapt to changing conditions by increasing measures on-site to protect employee health or having to delay work if conditions became too extreme.

- **Major storm events/flooding.** Climate change will affect how precipitation occurs in the region, with some prolonged storm events potentially causing localized flooding. As a private operation, if the project site becomes flooded, the operator has flexibility to adapt operations to adjust to flood conditions by delaying work until the site is operable again.

In summary, many of the climate change effects on Alternative 1 may be addressed through changes in production and/or enhanced/changed operational measures. As a private operation, Alternative 1 has flexibility to adapt to these climate change stressors, such that no adverse effect would occur.

3.3.3.3 Relevant Climate Action Plans

The following provides a discussion of how Alternative 1 help meet or detract from achieving relevant climate action goals and commitments within the applicable plans. This section discusses the Long-Term Strategy of the United States, Pathways to Net-Zero Greenhouse Gas Emissions by 2050 and the CARB's Scoping Plan.

White House Long Term Strategy of the United States, Pathways to Net-Zero Greenhouse Gas Emissions by 2050

This 2021 Long-Term Strategy represents the next step: it lays out how the United States can reach its ultimate goal of net-zero emissions no later than 2050. Achieving net-zero emissions is how we—and our fellow nations around the globe—will keep a 1.5°C limit on global temperature rise within reach and prevent unacceptable climate change impacts and risks. The Long-Term Strategy shows that reaching net zero no later than 2050 will require actions spanning every sector of the economy. There are many potential pathways to get there, and all path-ways start with delivering on our 2030 Nationally Determined Contribution. This will put the United States firmly on track to reach net-zero by 2050 and support the overarching vision of building a more sustainable, resilient, and equitable economy. The United States can deliver net-zero emissions across all sectors and GHGs through multiple pathways, but all viable routes to net-zero involve five key transformations:

1. **DECARBONIZE ELECTRICITY.** Electricity delivers diverse services to all sectors of the American economy. The transition to a clean electricity system has been accelerating in recent years— driven by plummeting costs for solar and wind technologies, federal and subnational policies, and consumer demand. Building on this success, the United States has set a goal of 100% clean electricity by 2035, a crucial foundation for net-zero emissions no later than 2050. Alternative 1 and alternatives would not inhibit the decarbonization of the electric grid.
2. **ELECTRIFY END USES AND SWITCH TO OTHER CLEAN FUELS.** We can affordably and efficiently electrify most of the economy, from cars to buildings and industrial processes. In areas where electrification presents technology challenges—for instance aviation, shipping, and some industrial processes— we can prioritize clean fuels like carbon-free hydrogen and sustainable biofuels. Alternative 1 and alternatives would utilize advanced Tier 3 and Tier 4 engines and as technological advances are commercialized will adopt use of clean fuels and/or technology as applicable.
3. **CUT ENERGY WASTE.** Moving to cleaner sources of energy is made faster, cheaper, and easier when existing and new technologies use less energy to provide the same or better service. This can be achieved through diverse, proven approaches, ranging from more efficient appliances and the integration of efficiency into new and existing buildings, to sustainable manufacturing processes. Alternative 1 and alternatives would not inhibit the transition to cleaner sources of energy.
4. **REDUCE METHANE AND OTHER NON-CO_2 EMISSIONS.** Non-CO_2 gases such as methane, hydrofluorocarbons (HFCs), nitrous oxide (N_2O), and others, contribute significantly to warming— with methane alone contributing fully half of current net global warming of 1.0°C. There are many profitable or low-cost options to reduce non-CO_2 sources, such as implementing methane leak detection and repair for oil and gas systems and shifting from HFCs to climate-friendly working fluids in cooling equipment. The U.S. is committed to taking comprehensive and immediate actions to reduce methane domestically. And through the Global Methane Pledge, the U.S. and partners seek to reduce global methane emissions by at least 30% by 2030, which would eliminate over 0.2°C of warming by 2050. The U.S. will also prioritize research and development to unlock the innovation needed for deep emissions reductions beyond

currently available technologies. Alternative 1 and alternatives predominantly generate emissions of CO_2. However, Alternative 1 and alternatives would not inhibit the reduction in non-CO_2 gases.

5. **SCALE UP CO_2 REMOVAL.** In the three decades to 2050, our emissions from energy production can be brought close to zero, but certain emissions such as non-CO_2 from agriculture will be difficult to decarbonize completely by mid-century. Reaching net-zero emissions will therefore require removing carbon dioxide from the atmosphere, using processes and technologies that are rigorously evaluated and validated. This requires scaling up land carbon sinks as well as engineered strategies. Alternative 1 and alternatives would not inhibit the removal of carbon dioxide from the atmosphere.

Alternative 1 and alternatives would not conflict with the goals within the White House' Strategy to remove GHGs.

CARB's Scoping Plan

Project Consistency with State Reduction Targets and CARB's Scoping Plan

The California State Legislature passed the Global Warming Solutions Act of 2006 (Assembly Bill 32 [AB 32]) to provide initial direction to limit California's GHG emissions to 1990 levels by 2020 and initiate the state's long-range climate objectives. Since the passage of AB 32, the State has adopted GHG emissions reduction targets for future years beyond the initial 2020 horizon year. For the proposed project, the relevant GHG emissions reduction targets include those established by Senate Bill 32 (SB 32) and AB 1279, which require GHG emissions be reduced to 40%below 1990 levels by 2030, and 85% below 1990 levels by 2045, respectively. In addition, AB 1279 requires the state achieve net zero GHG emissions by no later than 2045 and achieve and maintain net negative GHG emissions thereafter.

As defined by AB 32, the CARB is required to develop The Scoping Plan, which provides the framework for actions to achieve the State's GHG emission targets. The Scoping Plan is required to be updated every 5 years and requires CARB and other state agencies to adopt regulations and initiatives that will reduce GHG emissions statewide. The first Scoping Plan was adopted in 2008, and was updated in 2014, 2017, and most recently in 2022. While the Scoping Plan is not directly applicable to specific projects, nor is it intended to be used for project-level evaluations, it is the official framework for the measures and regulations that will be implemented to reduce California's GHG emissions in alignment with the adopted targets. Therefore, a project would be found to not conflict with the statutes if it would meet the Scoping Plan policies and would not impede attainment of the goals therein.

CARB's 2017 Scoping Plan update was the first to address the state's strategy for achieving the 2030 GHG reduction target set forth in SB 32 (CARB 2017b), and the most recent CARB 2022 Scoping Plan update outlines the state's plan to reduce emissions and achieve carbon neutrality by 2045 in alignment with AB 1279 and assesses progress is making toward the 2030 SB 32 target (CARB 2022). As such, given that SB 32 and AB 1279 are the relevant GHG emission targets, the 2017 and 2022 Scoping Plan updates that outline the strategy to achieve those targets, are the most applicable to the proposed project.

The 2017 *Climate Change Scoping Plan Update* (Second Update) included measures to promote renewable energy and energy efficiency (including the mandates of SB 350), increase stringency of the Low Carbon Fuel Standard (LCFS), measures identified in the Mobile Source and Freight Strategies, measures identified in the proposed Short-Lived Climate Pollutant Plan, and increase stringency of SB 375 targets. The *2022 Scoping Plan for Achieving Carbon Neutrality* (Third Update) builds upon and accelerates programs currently in place, including moving to zero-emission transportation; phasing out use of fossil gas use for heating homes and buildings; reducing chemical and refrigerants with high GWP; providing communities with sustainable options for walking, biking, and public transit; and displacement of fossil-fuel fired electrical generation through use of renewable energy alternatives (e.g., solar arrays and wind turbines) (CARB 2022).

Many of the measures and programs included in the Scoping Plan would result in the reduction of project-related GHG emissions with no action required at the project-level, including GHG emission reductions through increased energy efficiency and renewable energy production (SB 350), reduction in carbon intensity of transportation fuels (LCFS), and the accelerated efficiency and electrification of the statewide vehicle fleet (Mobile Source Strategy). Given that Alternative 1 and alternatives are also not anticipated to result in substantial increase in mobile trips, they would also not conflict with the Second Update's goal of reducing GHG emissions through reductions in VMT statewide.

The 2045 carbon neutrality goal required CARB to expand Alternative 1s in the Third Update to include those that capture and store carbon in addition to those that reduce only anthropogenic sources of GHG emissions. The Third Update emphasizes that reliance on carbon sequestration in the state's natural and working lands will not be sufficient to address residual GHG emissions, and achieving carbon neutrality will require research, development, and deployment of additional methods to capture atmospheric GHG emissions (e.g., mechanical direct air capture). Given that the specific path to neutrality will require development of technologies and programs that are not currently known or available, the project's role in supporting the statewide goal would be speculative and cannot be wholly identified at this time.

Overall, Alternative 1 and alternatives would comply with all regulations adopted in furtherance of the Scoping Plan to the extent applicable and required by law. As mentioned above, several Scoping Plan measures would result in reductions of project-related GHG emissions with no action required at the project-level, including those related to energy efficiency, reduced fossil fuel use, and renewable energy production. As demonstrated above, the proposed project would not conflict with CARB's 2017 or 2022 Scoping Plan updates and with the state's ability to achieve the 2030 and 2045 GHG reduction and carbon neutrality goals. Further, the proposed project's consistency with the applicable measures and programs would assist in meeting the GHG reduction targets in California.

No Action Alternative

Under the No Action Alternative, the project would not be built. No increase in GHG would occur. Therefore, there would be no GHG emissions resulting from the No Action Alternative compared to Alternative 1. There would be no impact on climate and meteorology.

4 References Cited

AFCEC. (Air Force Civil Engineer Center). 2013. Air Conformity Applicability Model. Solutionenv.com.

CalRecycle (California Department of Resources Recycling and Recovery). 2019. *Short-Lived Climate Pollutants (SLCP): Organic Waste Methane Emissions Reductions*. Last Updated April 16, 2019. Accessed January 2022. https://www.calrecycle.ca.gov/Climate/SLCP/

CAPCOA (California Air Pollution Control Officers Association). 2022. *California Emissions Estimator Model (CalEEMod) User's Guide Version 2022.* Prepared by Trinity Consultants and the California Air Districts. http://www.caleemod.com/.

CARB (California Air Resources Board). 2000. *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles*. October 2000. Accessed May 2019. http://www.arb.ca.gov/diesel/documents/rrpfinal.pdf.

CARB. 2008. *Climate Change Scoping Plan: A Framework for Change*. October, approved December 12, 2008. Accessed June 20, 2018. http://climatechange.ca.gov/eaac/documents/state_reports/Adopted_ Scoping_Plan.pdf.

CARB. 2014. *First Update to the Climate Change Scoping Plan Building on the Framework Pursuant to AB 32 – The California Global Warming Solutions Act of 2006*. May 2014. Accessed February 17, 2016. http://www.arb.ca.gov/cc/scopingplan/2013_update/first_update_climate_change_scoping_plan.pdf.

CARB. 2017a. Inhalable Particulate Matter and Health ($PM_{2.5}$ and PM_{10}). Page last reviewed August 10, 2017. Accessed May 2019. https://www.arb.ca.gov/research/aaqs/common-pollutants/pm/pm.htm.

CARB. 2017b. *2017 Climate Change Scoping Plan Update*. November 2017. Accessed December 2017. https://www.arb.ca.gov/cc/scopingplan/scoping_plan_2017.pdf.

CARB. 2019a. "Glossary." Accessed April 2022. https://ww2.arb.ca.gov/about/glossary.

CARB. 2019b. "Ozone & Health." Accessed April 2022. https://ww2.arb.ca.gov/resources/ozone-and-health.

CARB. 2019c. "Nitrogen Dioxide & Health." Accessed April 2022. https://ww2.arb.ca.gov/resources/nitrogen-dioxide-and-health.

CARB. 2019d. "Carbon Monoxide & Health." Accessed April 2022. https://ww2.arb.ca.gov/resources/carbon-monoxide-and-health.

CARB. 2019e. "Sulfur Dioxide & Health." Accessed April 2022. https://ww2.arb.ca.gov/resources/sulfur-dioxide-and-health.

CARB. 2019f. "Overview: Diesel Exhaust and Health." Accessed April 2022. https://www.arb.ca.gov/research/diesel/diesel-health.htm.

CARB. 2021a. Vinyl Chloride & Health. Accessed April 2021. https://ww2.arb.ca.gov/resources/vinyl-chloride-and-health.

CARB. 2021b. Current California GHG Emission Inventory Data: 2000-2019 GHG Inventory (2021 Edition). Accessed July 2021 at https://ww2.arb.ca.gov/ghg-inventory-data?utm_medium=email&utm_source=govdelivery.

CARB. 2021c. Advanced Clean Cars Program. Accessed December 2021 at https://ww2.arb.ca.gov/our-work/programs/advanced-clean-cars-program/about.

CARB. 2021d. Advanced Clean Trucks Fact Sheet. August 20, 2021. Accessed at https://ww2.arb.ca.gov/sites/default/files/2021-08/200625factsheet_ADA.pdf

CARB. 2022a. "Ambient air quality data." [digital CARB data]. iADAM: Air Quality Data Statistics. http://www.arb.ca.gov/adam/topfour/topfour1.php.

CARB. 2022b. 2022 Scoping Plan for Achieving Carbon Neutrality. November 16. https://ww2.arb.ca.gov/sites/default/files/2022-12/2022-sp.pdf.

CARB. 2022c. California Air Resources Board 2022 Scoping Plan—Appendix D, Local Actions. November 2022. Accessed May 15, 2023. https://ww2.arb.ca.gov/sites/default/files/2022-11/2022-sp-appendix-d-local-actions.pdf.

CARB. 2023. Summaries of Historical Area Designations for State Standards. https://ww2.arb.ca.gov/our-work/programs/state-and-federal-area-designations/state-area-designations/summary-tables.

CEC (California Energy Commission). 2018a. 2019 Building Energy Efficiency Standards Fact Sheet. March 2018. https://www.energy.ca.gov/title24/2019standards/documents/2018_Title_24_2019_Building_Standards_FAQ.pdf

CEC. 2018b. Impact Analysis for the 2019 Update to the California Energy Efficiency Standards for Residential and Non-Residential Buildings. June.

CEC. 2021. Draft Environmental Impact Report Amendments to the Building Energy Efficiency Standards. May 19. Accessed July 2022. https://efiling.energy.ca.gov/GetDocument.aspx?tn=237853&DocumentContentId=71096.

Council on Environmental Quality (CEQ). 2023. Guidance: National Environmental Policy Act Guidance on Consideration of Greenhouse Gas Emissions and Climate Change. January. https://www.regulations.gov/document/CEQ-2022-0005-0001

CNRA (California Natural Resources Agency). 2009. *Final Statement of Reasons for Regulatory Action: Amendments to the State CEQA Guidelines Addressing Analysis and Mitigation of Greenhouse Gas Emissions Pursuant to SB 97*. December 2009. Accessed March 10, 2017. http://resources.ca.gov/ceqa/docs/Final_Statement_of_Reasons.pdf.

Department of Air Force. 2023. Falcon 9 Cadence Increase at Vandenberg Space Force Base, California. 31 March. https://files.ceqanet.opr.ca.gov/286761-1/attachment/b65kIGAAnH5v0R0m9xim5ACNy4OW3UJBvzdugC_vULNIpHPIjaMsC7nzfrnw2oKE3tX42zCgoZJsItQp0.

Electrek. 2022. California Runs on 100% Clean Energy for the First Time, with Solar Dominating. May 2. https://electrek.co/2022/05/02/california-runs-on-100-clean-energy-for-the-first-time-with-solar-dominating/#:~:text=May%202-,California%20runs%20on%20100%25%20clean%20energy%20for,first%20time%2C%20with%20solar%20dominating&text=For%20the%20first%20time%20ever,driven%20largely%20by%20solar%20power.

EPA (United States Environmental Protection Agency). 2013. *Integrated Science Assessment for Ozone and Related Photochemical Oxidants*. EPA/600/
R-10/076F. February 2013. Accessed May 2019. https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=247492.

EPA. 2016. 40 CFR § 93.153(b)(1) and (b)(2). August 24. https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C/part-93#93.153.

EPA. 2021. *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990–2019*. EPA 430-R-21-005. April 2021. Accessed July 2021 at https://www.epa.gov/sites/default/files/2021-04/documents/us-ghg-inventory-2021-main-text.pdf.

EPA. 2022. “AirData: Access to Air Pollution Data.” https://www.epa.gov/outdoor-air-quality-data/monitor-values-report.

EPA. 2023. Current Nonattainment Counties for All Criteria Pollutants. Updated February 28, 2021. Accessed March 2021. https://www3.epa.gov/airquality/greenbook/ancl.html.

HQ AFCEC/CZTQ (Air Force Civil Engineer Center, Compliance Technical Support Branch). 2023a. Level II, Air Quality Quantitative Assessment, Insignificance Indicators. April. https://www.aqhelp.com/Documents/FINAL%20-%20Level%20II%20Air%20Quality%20Quantitative%20Assessment%20Insignificance%20Indicators%20-%20April%202023%20v2.pdf.

HQ AFCEC/CZTQ. 2023b. DAF Greenhouse Gas (GHG) & Climate Change Assessment Guide. December. https://www.aqhelp.com/Documents/FINAL-%20GHG-CLIMATE%20CHANGE%20ASSESSMENT%20GUIDANCE%20Dec%202023.pdf.

IPCC. 2014. “Summary for Policymakers.” In *Climate Change 2014 Synthesis Report.* A Report of the Intergovernmental Panel on Climate Change. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Accessed March 10, 2017. http://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf.

NRC (National Research Council). 2005. *Interim Report of the Committee on Changes in New Source Review Programs for Stationary Sources of Air Pollutants*. Washington, DC: The National Academies Press. https://doi.org/10.17226/11208.

NASA (National Aeronautics and Space Administration). 2011. 2011 *Environmental Assessment for Launch of NASA Routine Payloads. https://repository.library.noaa.gov/view/noaa/12540*

NOAA (National Oceanic and Atmospheric Administration). 2017. Maritime Zones and Boundaries. https://www.noaa.gov/maritime-zones-and-boundaries.

Propper et al. 2015. Environmental Science & Technology49(19):11329–11339.

SCAQMD (South Coast Air Quality Management District). 1993. CEQA Air Quality Handbook.

SCAQMD. 2017. 2016 Air Quality Management Plan. March. https://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2016-air-quality-management-plan/final-2016-aqmp/final2016aqmp.pdf?sfvrsn=15.

U.S. Global Change Research Program (USGCRP). 2018. Fourth National Climate Assessment, Volume II Impacts, Risks, and Adaptation in the United States. November. https://nca2018.globalchange.gov/downloads/NCA4_2018_FullReport.pdf.

WRCC (Western Regional Climate Center). 2016. *Santa Barbara Muni Ap, California (047905)*. Accessed August 2018. https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca7905.

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Appendix A
Modeling Files

Table of Contents

DETAIL AIR CONFORMITY APPLICABILITY MODEL REPORT

1. General Information

- Action Location
Base: VANDENBERG AFB
State: California
County(s): Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Action Title: Falcon Program at Vandenberg Space Force Base - Baseline

- Project Number/s (if applicable):

- Projected Action Start Date: 1 / 2023

- Action Purpose and Need:
Space Exploration Technologies Corporation (SpaceX) has applied to the United States Space Force (USSF) to increase Falcon flight opportunities at Vandenberg Space Force Base (VSFB) in support of manifested and anticipated vehicle operations for Falcon 9. SpaceX currently launches commercial and government payloads from VSFB at SLC-4 and has been allocated SLC-6 by the USSF. SpaceX supports, and is under contract for, the full spectrum of U.S. Government space mission requirements, including crew and cargo transportation for the National Aeronautics and Space Administration (NASA) and spacecraft launches for NASA and the U.S. Department of Defense (DOD).

- Action Description:
The baseline includes 36 Falcon 9 launches from VSFB per year. This includes both land and sea landings of the Falcon 9, fair recovery, booster roll-on roll-off, and SLC-4 operations.

- Point of Contact
Name: Adam Poll
Title: Civilian/Senior Air Quality Specialist
Organization: Dudek
Email: apoll@dudek.com
Phone Number: 8053088516

- Activity List:

Activity Type		Activity Title
2.	Degreaser	Solvent use
3.	Emergency Generator	ES DICE1-3
4.	Emergency Generator	ES DICE4
5.	Emergency Generator	ES DICE 5
6.	Emergency Generator	Prime Engine
7.	Personnel	Worker Vehicles
8.	Personnel	Fleet Vehicle Use
9.	Personnel	Vendor-Contractor Vehicles
10.	Construction / Demolition	Operational Equipment Use

Emission factors and air emission estimating methods come from the United States Air Force's Air Emissions Guide for Air Force Stationary Sources, Air Emissions Guide for Air Force Mobile Sources, and Air Emissions Guide for Air Force Transitory Sources.

2. Degreaser

2.1 General Information & Timeline Assumptions

DETAIL AIR CONFORMITY APPLICABILITY MODEL REPORT

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: Solvent use

- Activity Description:
solvent use

- Activity Start Date
Start Month: 1
Start Year: 2023

- Activity End Date
Indefinite: Yes
End Month: N/A
End Year: N/A

- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	5.926830
SO_x	0.000000
NO_x	0.000000
CO	0.000000

Pollutant	Emissions Per Year (TONs)
PM 10	0.000000
PM 2.5	0.000000
Pb	0.000000
NH_3	0.000000

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)
CH_4	0.000000
N_2O	0.000000

Pollutant	Emissions Per Year (TONs)
CO_2	0.000000
CO_2e	0.000000

2.2 Degreaser Assumptions

- Degreaser
Net solvent usage (total less recycle) (gallons/year): 1820

- Default Settings Used: Yes

- Degreaser Consumption
Solvent used: Mineral Spirits CAS#64475-85-0 (default)
Specific gravity of solvent: 0.78 (default)
Solvent VOC content (%): 100 (default)
Efficiency of control device (%): 0 (default)

2.3 Degreaser Formula(s)

- Degreaser Emissions per Year
DE_{VOC}= (VOC / 100) * NS * SG * 8.35 * (1 - (CD / 100)) / 2000

DE_{VOC}: Degreaser VOC Emissions (TONs per Year)
VOC: Solvent VOC content (%)
(VOC / 100): Conversion Factor percent to decimal
NS: Net solvent usage (total less recycle) (gallons/year)

SG: Specific gravity of solvent
8.35: Conversion Factor the density of water
CD: Efficiency of control device (%)
(1 - (CD / 100)): Conversion Factor percent to decimal (Not effected by control device)
2000: Conversion Factor pounds to tons

3. Emergency Generator

3.1 General Information & Timeline Assumptions

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: ES DICE1-3

- Activity Description:
DICE1-3

- Activity Start Date
Start Month: 1
Start Year: 2023

- Activity End Date
Indefinite: Yes
End Month: N/A
End Year: N/A

- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	0.020916
SO_x	0.000365
NO_x	0.756604
CO	0.200982

Pollutant	Emissions Per Year (TONs)
PM 10	0.023633
PM 2.5	0.023633
Pb	0.000000
NH_3	0.000000

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)
CH_4	0.001352
N_2O	0.000270

Pollutant	Emissions Per Year (TONs)
CO_2	33.594375
CO_2e	38.852625

3.2 Emergency Generator Assumptions

- Emergency Generator
Type of Fuel used in Emergency Generator: Diesel
Number of Emergency Generators: 3

- Default Settings Used: No

- Emergency Generators Consumption
Emergency Generator's Horsepower: 779
Average Operating Hours Per Year (hours): 25

3.3 Emergency Generator Emission Factor(s)

- Emergency Generators Criteria Pollutant Emission Factor (lb/hp-hr)

VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3
0.000716	0.0000125	0.0259	0.00688	0.000809	0.000809		

- Emergency Generators Greenhouse Gasses Pollutant Emission Factor (lb/hp-hr)

CH_4	N_2O	CO_2	CO_2e
0.000046297	0.000009259	1.15	1.33

3.4 Emergency Generator Formula(s)

- Emergency Generator Emissions per Year

AE_{POL}= (NGEN * HP * OT * EF_{POL}) / 2000

AE_{POL}: Activity Emissions (TONs per Year)
NGEN: Number of Emergency Generators
HP: Emergency Generator's Horsepower (hp)
OT: Average Operating Hours Per Year (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hp-hr)

4. Emergency Generator

4.1 General Information & Timeline Assumptions

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: ES DICE4

- Activity Description:
ES DICE4

- Activity Start Date
Start Month: 1
Start Year: 2023

- Activity End Date
Indefinite: Yes
End Month: N/A
End Year: N/A

- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	0.012799
SO_x	0.010781
NO_x	0.052756
CO	0.035232

Pollutant	Emissions Per Year (TONs)
PM 10	0.011515
PM 2.5	0.011515
Pb	0.000000
NH_3	0.000000

DETAIL AIR CONFORMITY APPLICABILITY MODEL REPORT

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)
CH_4	0.000212
N_2O	0.000042

Pollutant	Emissions Per Year (TONs)
CO_2	5.275625
CO_2e	6.101375

4.2 Emergency Generator Assumptions

- Emergency Generator
Type of Fuel used in Emergency Generator: Diesel
Number of Emergency Generators: 1

- Default Settings Used: No

- Emergency Generators Consumption
Emergency Generator's Horsepower: 367
Average Operating Hours Per Year (hours): 25

4.3 Emergency Generator Emission Factor(s)

- Emergency Generators Criteria Pollutant Emission Factor (lb/hp-hr)

VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3
0.00279	0.00235	0.0115	0.00768	0.00251	0.00251		

- Emergency Generators Greenhouse Gasses Pollutant Emission Factor (lb/hp-hr)

CH_4	N_2O	CO_2	CO_2e
0.000046297	0.000009259	1.15	1.33

4.4 Emergency Generator Formula(s)

- Emergency Generator Emissions per Year
AE_{POL}= (NGEN * HP * OT * EF_{POL}) / 2000

AE_{POL}: Activity Emissions (TONs per Year)
NGEN: Number of Emergency Generators
HP: Emergency Generator's Horsepower (hp)
OT: Average Operating Hours Per Year (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hp-hr)

5. Emergency Generator

5.1 General Information & Timeline Assumptions

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: ES DICE 5

- Activity Description:
ES DICE 5

DETAIL AIR CONFORMITY APPLICABILITY MODEL REPORT

- Activity Start Date
Start Month: 1
Start Year: 2023

- Activity End Date
Indefinite: Yes
End Month: N/A
End Year: N/A

- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	0.011160
SO_x	0.009400
NO_x	0.046000
CO	0.030720

Pollutant	Emissions Per Year (TONs)
PM 10	0.010040
PM 2.5	0.010040
Pb	0.000000
NH_3	0.000000

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)
CH_4	0.000185
N_2O	0.000037

Pollutant	Emissions Per Year (TONs)
CO_2	4.600000
CO_2e	5.320000

5.2 Emergency Generator Assumptions

- Emergency Generator
Type of Fuel used in Emergency Generator: Diesel
Number of Emergency Generators: 1

- Default Settings Used: No

- Emergency Generators Consumption
Emergency Generator's Horsepower: 320
Average Operating Hours Per Year (hours): 25

5.3 Emergency Generator Emission Factor(s)

- Emergency Generators Criteria Pollutant Emission Factor (lb/hp-hr)

VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3
0.00279	0.00235	0.0115	0.00768	0.00251	0.00251		

- Emergency Generators Greenhouse Gasses Pollutant Emission Factor (lb/hp-hr)

CH_4	N_2O	CO_2	CO_2e
0.000046297	0.000009259	1.15	1.33

5.4 Emergency Generator Formula(s)

- Emergency Generator Emissions per Year

AE_{POL}= (NGEN * HP * OT * EF_{POL}) / 2000

AE_{POL}: Activity Emissions (TONs per Year)
NGEN: Number of Emergency Generators
HP: Emergency Generator's Horsepower (hp)
OT: Average Operating Hours Per Year (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hp-hr)

DETAIL AIR CONFORMITY APPLICABILITY MODEL REPORT

6. Emergency Generator

6.1 General Information & Timeline Assumptions

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: Prime Engine

- Activity Description:
Prime Engine

- Activity Start Date
Start Month: 1
Start Year: 2023

- Activity End Date
Indefinite: Yes
End Month: N/A
End Year: N/A

- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	0.252305
SO_x	0.212515
NO_x	1.039968
CO	0.694518

Pollutant	Emissions Per Year (TONs)
PM 10	0.226984
PM 2.5	0.226984
Pb	0.000000
NH_3	0.000000

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)
CH_4	0.004187
N_2O	0.000837

Pollutant	Emissions Per Year (TONs)
CO_2	103.996800
CO_2e	120.274560

6.2 Emergency Generator Assumptions

- Emergency Generator
Type of Fuel used in Emergency Generator: Diesel
Number of Emergency Generators: 1

- Default Settings Used: No

- Emergency Generators Consumption
Emergency Generator's Horsepower: 314
Average Operating Hours Per Year (hours): 576

6.3 Emergency Generator Emission Factor(s)

- Emergency Generators Criteria Pollutant Emission Factor (lb/hp-hr)

VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3
0.00279	0.00235	0.0115	0.00768	0.00251	0.00251		

- Emergency Generators Greenhouse Gasses Pollutant Emission Factor (lb/hp-hr)

CH_4	N_2O	CO_2	CO_2e
0.000046297	0.000009259	1.15	1.33

6.4 Emergency Generator Formula(s)

- Emergency Generator Emissions per Year

AE_{POL}= (NGEN * HP * OT * EF_{POL}) / 2000

AE_{POL}: Activity Emissions (TONs per Year)
NGEN: Number of Emergency Generators
HP: Emergency Generator's Horsepower (hp)
OT: Average Operating Hours Per Year (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hp-hr)

7. Personnel

7.1 General Information & Timeline Assumptions

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: Worker Vehicles

- Activity Description:
Worker Vehicles

- Activity Start Date
Start Month: 1
Start Year: 2023

- Activity End Date
Indefinite: Yes
End Month: N/A
End Year: N/A

- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	0.269893
SO_x	0.002877
NO_x	0.148110
CO	1.748344

Pollutant	Emissions Per Year (TONs)
PM 10	0.015638
PM 2.5	0.005678
Pb	0.000000
NH_3	0.030252

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)
CH_4	0.019539
N_2O	0.012402

Pollutant	Emissions Per Year (TONs)
CO_2	291.190113
CO_2e	295.373763

7.2 Personnel Assumptions

DETAIL AIR CONFORMITY APPLICABILITY MODEL REPORT

- Number of Personnel

Active Duty Personnel:	0
Civilian Personnel:	0
Support Contractor Personnel:	155
Air National Guard (ANG) Personnel:	0
Reserve Personnel:	0

- Default Settings Used: Yes

- Average Personnel Round Trip Commute (mile): 20 (default)

- Personnel Work Schedule

Active Duty Personnel:	5 Days Per Week (default)
Civilian Personnel:	5 Days Per Week (default)
Support Contractor Personnel:	5 Days Per Week (default)
Air National Guard (ANG) Personnel:	4 Days Per Week (default)
Reserve Personnel:	4 Days Per Month (default)

7.3 Personnel On Road Vehicle Mixture

- On Road Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	37.55	60.32	0	0.03	0.2	0	1.9
GOVs	54.49	37.73	4.67	0	0	3.11	0

7.4 Personnel Emission Factor(s)

- On Road Vehicle Criteria Pollutant Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	NH_3
LDGV	0.16904	0.00283	0.09975	1.33620	0.01659	0.00589	0.03317
LDGT	0.22348	0.00353	0.18982	1.84661	0.01814	0.00661	0.03551
HDGV	0.27952	0.00543	0.30809	2.13074	0.02887	0.01031	0.03592
LDDV	0.02840	0.00215	0.26527	0.33316	0.03307	0.02166	0.00310
LDDT	0.01793	0.00291	0.08851	0.15977	0.02554	0.01387	0.00310
HDDV	0.11489	0.01085	2.41615	0.54050	0.11955	0.05993	0.17455
MC	5.54743	0.00207	0.76123	18.49768	0.01924	0.00825	0.00852

- On Road Vehicle Greenhouse Gasses Emission Factors (grams/mile)

	CH_4	N_2O	CO_2	CO_2e
LDGV	0.01403	0.01042	286.76828	290.22297
LDGT	0.01924	0.01494	357.01221	361.94499
HDGV	0.02515	0.02098	549.42311	556.30477
LDDV	0.00132	0.03569	226.51907	237.18712
LDDT	0.00083	0.04832	306.71107	321.13196
HDDV	0.00534	0.18045	1145.32741	1199.23397
MC	0.26904	0.04866	209.32706	230.55474

7.5 Personnel Formula(s)

- Personnel Vehicle Miles Travel for Work Days per Year

$VMT_P = NP * WD * AC$

VMT_P: Personnel Vehicle Miles Travel (miles/year)
NP: Number of Personnel

WD: Work Days per Year
AC: Average Commute (miles)

- Total Vehicle Miles Travel per Year
$VMT_{Total} = VMT_{AD} + VMT_{C} + VMT_{SC} + VMT_{ANG} + VMT_{AFRC}$

VMT_{Total}: Total Vehicle Miles Travel (miles)
VMT_{AD}: Active Duty Personnel Vehicle Miles Travel (miles)
VMT_{C}: Civilian Personnel Vehicle Miles Travel (miles)
VMT_{SC}: Support Contractor Personnel Vehicle Miles Travel (miles)
VMT_{ANG}: Air National Guard Personnel Vehicle Miles Travel (miles)
VMT_{AFRC}: Reserve Personnel Vehicle Miles Travel (miles)

- Vehicle Emissions per Year
$V_{POL} = (VMT_{Total} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{Total}: Total Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Personnel On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

8. Personnel

8.1 General Information & Timeline Assumptions

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: Fleet Vehicle Use

- Activity Description:
Fleet Vehicle Use

- Activity Start Date
Start Month: 1
Start Year: 2023

- Activity End Date
Indefinite: Yes
End Month: N/A
End Year: N/A

- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	0.053979
SO_x	0.000575
NO_x	0.029622
CO	0.349669

Pollutant	Emissions Per Year (TONs)
PM 10	0.003128
PM 2.5	0.001136
Pb	0.000000
NH_3	0.006050

DETAIL AIR CONFORMITY APPLICABILITY MODEL REPORT

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)
CH_4	0.003908
N_2O	0.002480

Pollutant	Emissions Per Year (TONs)
CO_2	58.238023
CO_2e	59.074753

8.2 Personnel Assumptions

- Number of Personnel

Active Duty Personnel: 0
Civilian Personnel: 0
Support Contractor Personnel: 31
Air National Guard (ANG) Personnel: 0
Reserve Personnel: 0

- Default Settings Used: Yes

- Average Personnel Round Trip Commute (mile): 20 (default)

- Personnel Work Schedule

Active Duty Personnel: 5 Days Per Week (default)
Civilian Personnel: 5 Days Per Week (default)
Support Contractor Personnel: 5 Days Per Week (default)
Air National Guard (ANG) Personnel: 4 Days Per Week (default)
Reserve Personnel: 4 Days Per Month (default)

8.3 Personnel On Road Vehicle Mixture

- On Road Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	37.55	60.32	0	0.03	0.2	0	1.9
GOVs	54.49	37.73	4.67	0	0	3.11	0

8.4 Personnel Emission Factor(s)

- On Road Vehicle Criteria Pollutant Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	NH_3
LDGV	0.16904	0.00283	0.09975	1.33620	0.01659	0.00589	0.03317
LDGT	0.22348	0.00353	0.18982	1.84661	0.01814	0.00661	0.03551
HDGV	0.27952	0.00543	0.30809	2.13074	0.02887	0.01031	0.03592
LDDV	0.02840	0.00215	0.26527	0.33316	0.03307	0.02166	0.00310
LDDT	0.01793	0.00291	0.08851	0.15977	0.02554	0.01387	0.00310
HDDV	0.11489	0.01085	2.41615	0.54050	0.11955	0.05993	0.17455
MC	5.54743	0.00207	0.76123	18.49768	0.01924	0.00825	0.00852

- On Road Vehicle Greenhouse Gasses Emission Factors (grams/mile)

	CH_4	N_2O	CO_2	CO_2e
LDGV	0.01403	0.01042	286.76828	290.22297
LDGT	0.01924	0.01494	357.01221	361.94499
HDGV	0.02515	0.02098	549.42311	556.30477
LDDV	0.00132	0.03569	226.51907	237.18712
LDDT	0.00083	0.04832	306.71107	321.13196
HDDV	0.00534	0.18045	1145.32741	1199.23397
MC	0.26904	0.04866	209.32706	230.55474

8.5 Personnel Formula(s)

- Personnel Vehicle Miles Travel for Work Days per Year
$VMT_P = NP * WD * AC$

VMT_P: Personnel Vehicle Miles Travel (miles/year)
NP: Number of Personnel
WD: Work Days per Year
AC: Average Commute (miles)

- Total Vehicle Miles Travel per Year
$VMT_{Total} = VMT_{AD} + VMT_C + VMT_{SC} + VMT_{ANG} + VMT_{AFRC}$

VMT_{Total}: Total Vehicle Miles Travel (miles)
VMT_{AD}: Active Duty Personnel Vehicle Miles Travel (miles)
VMT_C: Civilian Personnel Vehicle Miles Travel (miles)
VMT_{SC}: Support Contractor Personnel Vehicle Miles Travel (miles)
VMT_{ANG}: Air National Guard Personnel Vehicle Miles Travel (miles)
VMT_{AFRC}: Reserve Personnel Vehicle Miles Travel (miles)

- Vehicle Emissions per Year
$V_{POL} = (VMT_{Total} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{Total}: Total Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Personnel On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

9. Personnel

9.1 General Information & Timeline Assumptions

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: Vendor-Contractor Vehicles

- Activity Description:
Vendor-Contractor Vehicles

- Activity Start Date
Start Month: 1
Start Year: 2023

- Activity End Date
Indefinite: Yes
End Month: N/A
End Year: N/A

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- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	0.026119
SO_x	0.000278
NO_x	0.014333
CO	0.169195

Pollutant	Emissions Per Year (TONs)
PM 10	0.001513
PM 2.5	0.000549
Pb	0.000000
NH_3	0.002928

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)
CH_4	0.001891
N_2O	0.001200

Pollutant	Emissions Per Year (TONs)
CO_2	28.179688
CO_2e	28.584558

9.2 Personnel Assumptions

- Number of Personnel

Active Duty Personnel: 0
Civilian Personnel: 0
Support Contractor Personnel: 15
Air National Guard (ANG) Personnel: 0
Reserve Personnel: 0

- Default Settings Used: Yes

- Average Personnel Round Trip Commute (mile): 20 (default)

- Personnel Work Schedule

Active Duty Personnel: 5 Days Per Week (default)
Civilian Personnel: 5 Days Per Week (default)
Support Contractor Personnel: 5 Days Per Week (default)
Air National Guard (ANG) Personnel: 4 Days Per Week (default)
Reserve Personnel: 4 Days Per Month (default)

9.3 Personnel On Road Vehicle Mixture

- On Road Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	37.55	60.32	0	0.03	0.2	0	1.9
GOVs	54.49	37.73	4.67	0	0	3.11	0

9.4 Personnel Emission Factor(s)

- On Road Vehicle Criteria Pollutant Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	NH_3
LDGV	0.16904	0.00283	0.09975	1.33620	0.01659	0.00589	0.03317
LDGT	0.22348	0.00353	0.18982	1.84661	0.01814	0.00661	0.03551
HDGV	0.27952	0.00543	0.30809	2.13074	0.02887	0.01031	0.03592
LDDV	0.02840	0.00215	0.26527	0.33316	0.03307	0.02166	0.00310
LDDT	0.01793	0.00291	0.08851	0.15977	0.02554	0.01387	0.00310
HDDV	0.11489	0.01085	2.41615	0.54050	0.11955	0.05993	0.17455
MC	5.54743	0.00207	0.76123	18.49768	0.01924	0.00825	0.00852

- On Road Vehicle Greenhouse Gasses Emission Factors (grams/mile)

	CH_4	N_2O	CO_2	CO_2e
LDGV	0.01403	0.01042	286.76828	290.22297

LDGT	0.01924	0.01494	357.01221	361.94499
HDGV	0.02515	0.02098	549.42311	556.30477
LDDV	0.00132	0.03569	226.51907	237.18712
LDDT	0.00083	0.04832	306.71107	321.13196
HDDV	0.00534	0.18045	1145.32741	1199.23397
MC	0.26904	0.04866	209.32706	230.55474

9.5 Personnel Formula(s)

- Personnel Vehicle Miles Travel for Work Days per Year
$VMT_P = NP * WD * AC$

VMT_P: Personnel Vehicle Miles Travel (miles/year)
NP: Number of Personnel
WD: Work Days per Year
AC: Average Commute (miles)

- Total Vehicle Miles Travel per Year
$VMT_{Total} = VMT_{AD} + VMT_C + VMT_{SC} + VMT_{ANG} + VMT_{AFRC}$

VMT_{Total}: Total Vehicle Miles Travel (miles)
VMT_{AD}: Active Duty Personnel Vehicle Miles Travel (miles)
VMT_C: Civilian Personnel Vehicle Miles Travel (miles)
VMT_{SC}: Support Contractor Personnel Vehicle Miles Travel (miles)
VMT_{ANG}: Air National Guard Personnel Vehicle Miles Travel (miles)
VMT_{AFRC}: Reserve Personnel Vehicle Miles Travel (miles)

- Vehicle Emissions per Year
$V_{POL} = (VMT_{Total} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{Total}: Total Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Personnel On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

10. Construction / Demolition

10.1 General Information & Timeline Assumptions

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: Operational Equipment Use

- Activity Description:
Operational Equipment Use

- Activity Start Date
Start Month: 1
Start Month: 2023

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- Activity End Date
Indefinite: False
End Month: 0
End Month: 2053

- Activity Emissions:

Pollutant	Total Emissions (TONs)
VOC	1.153989
SO_x	0.030527
NO_x	10.831199
CO	12.802533

Pollutant	Total Emissions (TONs)
PM 10	0.375290
PM 2.5	0.345271
Pb	0.000000
NH_3	0.000000

- Activity Emissions of GHG:

Pollutant	Total Emissions (TONs)
CH_4	0.134105
N_2O	0.026833

Pollutant	Total Emissions (TONs)
CO_2	3305.934839
CO_2e	3317.279945

- Global Scale Activity Emissions for SCGHG:

Pollutant	Total Emissions (TONs)
CH_4	0.134105
N_2O	0.026833

Pollutant	Total Emissions (TONs)
CO_2	3305.934839
CO_2e	3317.279945

10.1 Site Grading Phase

10.1.1 Site Grading Phase Timeline Assumptions

- Phase Start Date
Start Month: 1
Start Quarter: 1
Start Year: 2023

- Phase Duration
Number of Month: 360
Number of Days: 0

10.1.2 Site Grading Phase Assumptions

- General Site Grading Information
Area of Site to be Graded (ft^2): 0
Amount of Material to be Hauled On-Site (yd^3): 0
Amount of Material to be Hauled Off-Site (yd^3): 0

- Site Grading Default Settings
Default Settings Used: No
Average Day(s) worked per week: 5

- Construction Exhaust

Equipment Name	Number Of Equipment	Hours Per Day
Aerial Lifts Composite	4	1
Forklifts Composite	5	1
Off-Highway Trucks Composite	3	1
Rough Terrain Forklifts Composite	4	1

- Vehicle Exhaust

Average Hauling Truck Capacity (yd^3): 20

Average Hauling Truck Round Trip Commute (mile): 0

- Vehicle Exhaust Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	0	0	0	0	0	100.00	0

- Worker Trips

Average Worker Round Trip Commute (mile): 0

- Worker Trips Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	50.00	50.00	0	0	0	0	0

10.1.3 Site Grading Phase Emission Factor(s)

- Construction Exhaust Criteria Pollutant Emission Factors (g/hp-hour)

Aerial Lifts Composite [HP: 46] [LF: 0.31]						
	VOC	SO_x	NO_x	CO	PM 10	PM 2.5
Emission Factors	0.16245	0.00542	2.89521	3.11979	0.02309	0.02124
Forklifts Composite [HP: 82] [LF: 0.2]						
	VOC	SO_x	NO_x	CO	PM 10	PM 2.5
Emission Factors	0.31648	0.00487	2.98060	3.63043	0.18246	0.16787
Off-Highway Trucks Composite [HP: 376] [LF: 0.38]						
	VOC	SO_x	NO_x	CO	PM 10	PM 2.5
Emission Factors	0.18613	0.00488	1.32512	1.21081	0.04772	0.04390
Rough Terrain Forklifts Composite [HP: 96] [LF: 0.4]						
	VOC	SO_x	NO_x	CO	PM 10	PM 2.5
Emission Factors	0.12495	0.00488	1.83570	3.21682	0.04497	0.04138

- Construction Exhaust Greenhouse Gasses Pollutant Emission Factors (g/hp-hour)

Aerial Lifts Composite [HP: 46] [LF: 0.31]				
	CH_4	N_2O	CO_2	CO_2e
Emission Factors	0.02381	0.00476	586.92167	588.93584
Forklifts Composite [HP: 82] [LF: 0.2]				
	CH_4	N_2O	CO_2	CO_2e
Emission Factors	0.02138	0.00428	527.09658	528.90544
Off-Highway Trucks Composite [HP: 376] [LF: 0.38]				
	CH_4	N_2O	CO_2	CO_2e
Emission Factors	0.02144	0.00429	528.56916	530.38307
Rough Terrain Forklifts Composite [HP: 96] [LF: 0.4]				
	CH_4	N_2O	CO_2	CO_2e
Emission Factors	0.02144	0.00429	528.43465	530.24810

- Vehicle Exhaust & Worker Trips Criteria Pollutant Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	NH_3
LDGV	0.16904	0.00283	0.09975	1.33620	0.01659	0.00589	0.03317
LDGT	0.22348	0.00353	0.18982	1.84661	0.01814	0.00661	0.03551
HDGV	0.27952	0.00543	0.30809	2.13074	0.02887	0.01031	0.03592
LDDV	0.02840	0.00215	0.26527	0.33316	0.03307	0.02166	0.00310
LDDT	0.01793	0.00291	0.08851	0.15977	0.02554	0.01387	0.00310
HDDV	0.11489	0.01085	2.41615	0.54050	0.11955	0.05993	0.17455

MC	5.54743	0.00207	0.76123	18.49768	0.01924	0.00825	0.00852

- Vehicle Exhaust & Worker Trips Greenhouse Gasses Emission Factors (grams/mile)

	CH_4	N_2O	CO_2	CO_2e
LDGV	0.01403	0.01042	286.76828	290.22297
LDGT	0.01924	0.01494	357.01221	361.94499
HDGV	0.02515	0.02098	549.42311	556.30477
LDDV	0.00132	0.03569	226.51907	237.18712
LDDT	0.00083	0.04832	306.71107	321.13196
HDDV	0.00534	0.18045	1145.32741	1199.23397
MC	0.26904	0.04866	209.32706	230.55474

10.1.4 Site Grading Phase Formula(s)

- Fugitive Dust Emissions per Phase

$PM10_{FD}$ = (20 * ACRE * WD) / 2000

$PM10_{FD}$: Fugitive Dust PM 10 Emissions (TONs)
20: Conversion Factor Acre Day to pounds (20 lb / 1 Acre Day)
ACRE: Total acres (acres)
WD: Number of Total Work Days (days)
2000: Conversion Factor pounds to tons

- Construction Exhaust Emissions per Phase

CEE_{POL} = (NE * WD * H * HP * LF * EF_{POL} * 0.002205) / 2000

CEE_{POL}: Construction Exhaust Emissions (TONs)
NE: Number of Equipment
WD: Number of Total Work Days (days)
H: Hours Worked per Day (hours)
HP: Equipment Horsepower
LF: Equipment Load Factor
EF_{POL}: Emission Factor for Pollutant (g/hp-hour)
0.002205: Conversion Factor grams to pounds
2000: Conversion Factor pounds to tons

- Vehicle Exhaust Emissions per Phase

VMT_{VE} = (HA_{OnSite} + $HA_{OffSite}$) * (1 / HC) * HT

VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
HA_{OnSite}: Amount of Material to be Hauled On-Site (yd^3)
$HA_{OffSite}$: Amount of Material to be Hauled Off-Site (yd^3)
HC: Average Hauling Truck Capacity (yd^3)
(1 / HC): Conversion Factor cubic yards to trips (1 trip / HC yd^3)
HT: Average Hauling Truck Round Trip Commute (mile/trip)

V_{POL} = (VMT_{VE} * 0.002205 * EF_{POL} * VM) / 2000

V_{POL}: Vehicle Emissions (TONs)
VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Vehicle Exhaust On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

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- Worker Trips Emissions per Phase
$VMT_{WT} = WD * WT * 1.25 * NE$

VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
WD: Number of Total Work Days (days)
WT: Average Worker Round Trip Commute (mile)
1.25: Conversion Factor Number of Construction Equipment to Number of Works
NE: Number of Construction Equipment

$V_{POL} = (VMT_{WT} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

AIR CONFORMITY APPLICABILITY MODEL REPORT
RECORD OF AIR ANALYSIS (ROAA)

1. General Information:

The Air Force's Air Conformity Applicability Model (ACAM) was used to perform a net change in emissions analysis to assess the potential air quality impact/s associated with the action. The analysis was performed in accordance with the Air Force Manual 32-7002, *Environmental Compliance and Pollution Prevention*; the *Environmental Impact Analysis Process* (EIAP, 32 CFR 989); the *General Conformity Rule* (GCR, 40 CFR 93 Subpart B); and the *USAF Air Quality Environmental Impact Analysis Process (EIAP) Guide*. This report provides a summary of the ACAM analysis.

a. Action Location:
Base: VANDENBERG AFB
State: California
County(s): Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

b. Action Title: Falcon Program at Vandenberg Space Force Base - Baseline

c. Project Number/s (if applicable):

d. Projected Action Start Date: 1 / 2023

e. Action Description:

The baseline includes 36 Falcon 9 launches from VSFB per year. This includes both land and sea landings of the Falcon 9, fair recovery, booster roll-on roll-off, and SLC-4 operations.

f. Point of Contact:

Name:	Adam Poll
Title:	Civilian/Senior Air Quality Specialist
Organization:	Dudek
Email:	apoll@dudek.com
Phone Number:	8053088516

2. Air Impact Analysis:

Based on the attainment status at the action location, the requirements of the GCR are:

_____ applicable
__X__ not applicable

Total reasonably foreseeable net direct and indirect emissions associated with the action were estimated through ACAM on a calendar-year basis for the start of the action through achieving "steady state" (hsba.e., no net gain/loss in emission stabilized and the action is fully implemented) emissions. The ACAM analysis uses the latest and most accurate emission estimation techniques available; all algorithms, emission factors, and methodologies used are described in detail in the *USAF Air Emissions Guide for Air Force Stationary Sources*, the *USAF Air Emissions Guide for Air Force Mobile Sources*, and the *USAF Air Emissions Guide for Air Force Transitory Sources*.

"Insignificance Indicators" were used in the analysis to provide an indication of the significance of the proposed Action's potential impacts to local air quality. The insignificance indicators are trivial (de minimis) rate thresholds that have been demonstrated to have little to no impact to air quality. These insignificance indicators are the 250 ton/yr Prevention of Significant Deterioration (PSD) major source threshold and 25 ton/yr for lead for actions occurring in areas that are "Attainment" (hsba.e., not exceeding any National Ambient Air Quality Standard (NAAQS)). These indicators do not define a significant impact; however, they do provide a threshold to identify actions that are insignificant. Any action with net emissions below the insignificance indicators for all criteria pollutants is considered so insignificant that the action will not cause or contribute to an exceedance on one or more

NAAQS. For further detail on insignificance indicators, refer to *Level II, Air Quality Quantitative Assessment, Insignificance Indicators*.

The action's net emissions for every year through achieving steady state were compared against the Insignificance Indicators and are summarized below.

Analysis Summary:

2023

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2024

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2025

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2026

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No

CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2027

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2028

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2029

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2030

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No

SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2031

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2032

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2033

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2034

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No

PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2035

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2036

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2037

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2038

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No

PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2039

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2040

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2041

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2042

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No

Pb	0.000	25	No
NH3	0.039	250	No

2043

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2044

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2045

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2046

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No

NH3	0.039	250	No

2047

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2048

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2049

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2050

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

AIR CONFORMITY APPLICABILITY MODEL REPORT
RECORD OF AIR ANALYSIS (ROAA)

2051

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2052

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2053

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.574	250	No
NOx	2.087	250	No
CO	3.229	250	No
SOx	0.237	250	No
PM 10	0.292	250	No
PM 2.5	0.280	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2054 - (Steady State)

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.574	250	No
NOx	2.087	250	No
CO	3.229	250	No
SOx	0.237	250	No
PM 10	0.292	250	No
PM 2.5	0.280	250	No
Pb	0.000	25	No
NH3	0.039	250	No

AIR CONFORMITY APPLICABILITY MODEL REPORT
RECORD OF AIR ANALYSIS (ROAA)

None of the estimated annual net emissions associated with this action are above the insignificance indicators; therefore, the action will not cause or contribute to an exceedance of one or more NAAQSs and will have an insignificant impact on air quality. No further air assessment is needed.

Adam Poll, Civilian/Senior Air Quality Specialist	Nov 01 2023
Name, Title	**Date**

AIR CONFORMITY APPLICABILITY MODEL REPORT
GREENHOUSE GAS (GHG) EMISSIONS

1. General Information: The Air Force's Air Conformity Applicability Model (ACAM) was used to perform an analysis to estimate GHG emissions and assess the theoretical Social Cost of Greenhouse Gases (SC GHG) associated with the action. The analysis was performed in accordance with the Air Force Manual 32-7002, Environmental Compliance and Pollution Prevention; the Environmental Impact Analysis Process (EIAP, 32 CFR 989); and the USAF Air Quality Environmental Impact Analysis Process (EIAP) Guide. This report provides a summary of GHG emissions and SC GHG analysis.

a. Action Location:

Base: VANDENBERG AFB
State: California
County(s): Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

b. Action Title: Falcon Program at Vandenberg Space Force Base - Baseline

c. Project Number/s (if applicable):

d. Projected Action Start Date: 1 / 2023

e. Action Description:

The baseline includes 36 Falcon 9 launches from VSFB per year. This includes both land and sea landings of the Falcon 9, fair recovery, booster roll-on roll-off, and SLC-4 operations.

f. Point of Contact:

Name: Adam Poll
Title: Civilian/Senior Air Quality Specialist
Organization: Dudek
Email: apoll@dudek.com
Phone Number: 8053088516

2. Analysis: Total combined direct and indirect GHG emissions associated with the action were estimated through ACAM on a calendar-year basis from the action start through the expected life cycle of the action. The life cycle for Air Force actions with "steady state" emissions (SS, net gain/loss in emission stabilized and the action is fully implemented) is assumed to be 10 years beyond the SS emissions year or 20 years beyond SS emissions year for aircraft operations related actions.

GHG Emissions Analysis Summary:

GHGs produced by fossil-fuel combustion are primarily carbon dioxide (CO2), methane (CH4), and nitrous oxide (NO2). These three GHGs represent more than 97 percent of all U.S. GHG emissions. Emissions of GHGs are typically quantified and regulated in units of CO2 equivalents (CO2e). The CO2e takes into account the global warming potential (GWP) of each GHG. The GWP is the measure of a particular GHG's ability to absorb solar radiation as well as its residence time within the atmosphere. The GWP allows comparison of global warming impacts between different gases; the higher the GWP, the more that gas contributes to climate change in comparison to CO2. All GHG emissions estimates were derived from various emission sources using the methods, algorithms, emission factors, and GWPs from the most current Air Emissions Guide for Air Force Stationary Sources, Air Emissions Guide for Air Force Mobile Sources, and/or Air Emissions Guide for Air Force Transitory Sources.

The Air Force has adopted the Prevention of Significant Deterioration (PSD) threshold for GHG of 75,000 ton per year (ton/yr) of CO2e (or 68,039 metric ton per year, mton/yr) as an indicator or "threshold of insignificance" for NEPA air quality impacts in all areas. This indicator does not define a significant impact; however, it provides a threshold to identify actions that are insignificant (de minimis, too trivial or minor to merit consideration). Actions with a net change in GHG (CO2e) emissions below the insignificance indicator (threshold) are considered too insignificant on a global scale to warrant any further analysis. Note that actions with a net change in GHG (CO2e) emissions above the insignificance indicator (threshold) are only considered potentially significant and require further assessment to determine if the action poses a significant impact. For further detail on insignificance indicators see Level II, Air Quality Quantitative Assessment, Insignificance Indicators (April 2023).

The following table summarizes the action-related GHG emissions on a calendar-year basis through the projected life cycle of the action.

Action-Related Annual GHG Emissions (mton/yr)						
YEAR	**CO2**	**CH4**	**N2O**	**CO2e**	**Threshold**	**Exceedance**
2023	576	0.03242644	0.01647825	603	68,039	No
2024	576	0.03242644	0.01647825	603	68,039	No
2025	576	0.03242644	0.01647825	603	68,039	No
2026	576	0.03242644	0.01647825	603	68,039	No
2027	576	0.03242644	0.01647825	603	68,039	No
2028	576	0.03242644	0.01647825	603	68,039	No
2029	576	0.03242644	0.01647825	603	68,039	No
2030	576	0.03242644	0.01647825	603	68,039	No
2031	576	0.03242644	0.01647825	603	68,039	No
2032	576	0.03242644	0.01647825	603	68,039	No
2033	576	0.03242644	0.01647825	603	68,039	No
2034	576	0.03242644	0.01647825	603	68,039	No
2035	576	0.03242644	0.01647825	603	68,039	No
2036	576	0.03242644	0.01647825	603	68,039	No
2037	576	0.03242644	0.01647825	603	68,039	No
2038	576	0.03242644	0.01647825	603	68,039	No
2039	576	0.03242644	0.01647825	603	68,039	No
2040	576	0.03242644	0.01647825	603	68,039	No
2041	576	0.03242644	0.01647825	603	68,039	No
2042	576	0.03242644	0.01647825	603	68,039	No
2043	576	0.03242644	0.01647825	603	68,039	No
2044	576	0.03242644	0.01647825	603	68,039	No
2045	576	0.03242644	0.01647825	603	68,039	No
2046	576	0.03242644	0.01647825	603	68,039	No
2047	576	0.03242644	0.01647825	603	68,039	No
2048	576	0.03242644	0.01647825	603	68,039	No
2049	576	0.03242644	0.01647825	603	68,039	No
2050	576	0.03242644	0.01647825	603	68,039	No
2051	576	0.03242644	0.01647825	603	68,039	No
2052	576	0.03242644	0.01647825	603	68,039	No
2053	476	0.02837117	0.01566684	502	68,039	No
2054 [SS Year]	476	0.02837117	0.01566684	502	68,039	No
2055	476	0.02837117	0.01566684	502	68,039	No
2056	476	0.02837117	0.01566684	502	68,039	No
2057	476	0.02837117	0.01566684	502	68,039	No
2058	476	0.02837117	0.01566684	502	68,039	No
2059	476	0.02837117	0.01566684	502	68,039	No
2060	476	0.02837117	0.01566684	502	68,039	No
2061	476	0.02837117	0.01566684	502	68,039	No
2062	476	0.02837117	0.01566684	502	68,039	No
2063	476	0.02837117	0.01566684	502	68,039	No
2064	476	0.02837117	0.01566684	502	68,039	No

AIR CONFORMITY APPLICABILITY MODEL REPORT
GREENHOUSE GAS (GHG) EMISSIONS

The following U.S. and State's GHG emissions estimates (next two tables) are based on a five-year average (2016 through 2020) of individual state-reported GHG emissions (Reference: State Climate Summaries 2022, NOAA National Centers for Environmental Information, National Oceanic and Atmospheric Administration. https://statesummaries.ncics.org/downloads/).

State's Annual GHG Emissions (mton/yr)				
YEAR	CO2	CH4	N2O	CO2e
2023	336,950,322	1,567,526	55,459	338,573,307
2024	336,950,322	1,567,526	55,459	338,573,307
2025	336,950,322	1,567,526	55,459	338,573,307
2026	336,950,322	1,567,526	55,459	338,573,307
2027	336,950,322	1,567,526	55,459	338,573,307
2028	336,950,322	1,567,526	55,459	338,573,307
2029	336,950,322	1,567,526	55,459	338,573,307
2030	336,950,322	1,567,526	55,459	338,573,307
2031	336,950,322	1,567,526	55,459	338,573,307
2032	336,950,322	1,567,526	55,459	338,573,307
2033	336,950,322	1,567,526	55,459	338,573,307
2034	336,950,322	1,567,526	55,459	338,573,307
2035	336,950,322	1,567,526	55,459	338,573,307
2036	336,950,322	1,567,526	55,459	338,573,307
2037	336,950,322	1,567,526	55,459	338,573,307
2038	336,950,322	1,567,526	55,459	338,573,307
2039	336,950,322	1,567,526	55,459	338,573,307
2040	336,950,322	1,567,526	55,459	338,573,307
2041	336,950,322	1,567,526	55,459	338,573,307
2042	336,950,322	1,567,526	55,459	338,573,307
2043	336,950,322	1,567,526	55,459	338,573,307
2044	336,950,322	1,567,526	55,459	338,573,307
2045	336,950,322	1,567,526	55,459	338,573,307
2046	336,950,322	1,567,526	55,459	338,573,307
2047	336,950,322	1,567,526	55,459	338,573,307
2048	336,950,322	1,567,526	55,459	338,573,307
2049	336,950,322	1,567,526	55,459	338,573,307
2050	336,950,322	1,567,526	55,459	338,573,307
2051	336,950,322	1,567,526	55,459	338,573,307
2052	336,950,322	1,567,526	55,459	338,573,307
2053	336,950,322	1,567,526	55,459	338,573,307
2054 [SS Year]	336,950,322	1,567,526	55,459	338,573,307
2055	336,950,322	1,567,526	55,459	338,573,307
2056	336,950,322	1,567,526	55,459	338,573,307
2057	336,950,322	1,567,526	55,459	338,573,307
2058	336,950,322	1,567,526	55,459	338,573,307
2059	336,950,322	1,567,526	55,459	338,573,307
2060	336,950,322	1,567,526	55,459	338,573,307
2061	336,950,322	1,567,526	55,459	338,573,307
2062	336,950,322	1,567,526	55,459	338,573,307
2063	336,950,322	1,567,526	55,459	338,573,307
2064	336,950,322	1,567,526	55,459	338,573,307

U.S. Annual GHG Emissions (mton/yr)				
YEAR	CO2	CH4	N2O	CO2e
2023	5,136,454,179	25,626,912	1,500,708	5,163,581,798

2024	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2025	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2026	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2027	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2028	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2029	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2030	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2031	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2032	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2033	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2034	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2035	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2036	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2037	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2038	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2039	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2040	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2041	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2042	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2043	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2044	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2045	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2046	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2047	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2048	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2049	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2050	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2051	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2052	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2053	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2054 [SS Year]	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2055	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2056	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2057	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2058	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2059	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2060	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2061	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2062	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2063	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2064	5,136,454,179	25,626,912	1,500,708	5,163,581,798

GHG Relative Significance Assessment:

A Relative Significance Assessment uses the rule of reason and the concept of proportionality along with the consideration of the affected area (yGba.e., global, national, and regional) and the degree (intensity) of the proposed action's effects. The Relative Significance Assessment provides real-world context and allows for a reasoned choice against alternatives through a relative comparison analysis. The analysis weighs each alternative's annual net change in GHG emissions proportionally against (or relative to) global, national, and regional emissions.

The action's surroundings, circumstances, environment, and background (context associated with an action) provide the setting for evaluating the GHG intensity (impact significance). From an air quality perspective, context of an action is the local area's ambient air quality relative to meeting the NAAQSs, expressed as attainment, nonattainment, or maintenance areas (this designation is considered the attainment status). GHGs are non-hazardous to health at normal ambient concentrations and, at a cumulative global scale, action-related GHG emissions can only potentially cause warming of the climatic system. Therefore, the action-related GHGs generally have an insignificant impact to local air quality.

However, the affected area (context) of GHG/climate change is global. Therefore, the intensity or degree of the proposed action's GHG/climate change effects are gauged through the quantity of GHG associated with the action as compared to a baseline of the state, U.S., and global GHG inventories. Each action (or alternative) has significance, based on their annual net change in GHG emissions, in relation to or proportionally to the global, national, and regional annual GHG emissions.

To provide real-world context to the GHG and climate change effects on a global scale, an action's net change in GHG emissions is compared relative to the state (where action will occur) and U.S. annual emissions. The following table provides a relative comparison of an action's net change in GHG emissions vs. state and U.S. projected GHG emissions for the same time period.

Total GHG Relative Significance (mton)					
		CO2	**CH4**	**N2O**	**CO2e**
2023-2064	State Total	14,151,913,505	65,836,095	2,329,292	14,220,078,892
2023-2064	U.S. Total	215,731,075,518	1,076,330,291	63,029,721	216,870,435,529
2023-2064	Action	23,005	1.313247	0.682349	24,102
Percent of State Totals		0.00016256%	0.00000199%	0.00002929%	0.00016949%
Percent of U.S. Totals		0.00001066%	0.00000012%	0.00000108%	0.00001111%

Climate Change Assessment (as SC GHG):

On a global scale, the potential climate change effects of an action are indirectly addressed and put into context through providing the theoretical SC GHG associated with an action. The SC GHG is an administrative and theoretical tool intended to provide additional context to a GHG's potential impacts through approximating the long-term monetary damage that may result from GHG emissions affect on climate change. It is important to note that the SC GHG is a monetary quantification, in 2020 U.S. dollars, of the theoretical economic damages that could result from emitting GHGs into the atmosphere.

The SC GHG estimates are derived using the methodology and discount factors in the "Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990," released by the Interagency Working Group on Social Cost of Greenhouse Gases (IWG SC GHGs) in February 2021.

The speciated IWG Annual SC GHG Emission associated with an action (or alternative) are first estimated as annual unit cost (cost per metric ton, $/mton). Results of the annual IWG Annual SC GHG Emission Assessments are tabulated in the IWG Annual SC GHG Cost per Metric Ton Table below:

IWG SC GHG Discount Factor: 2.5%

IWG Annual SC GHG Cost per Metric Ton ($/mton [In 2020 $])			
YEAR	**CO2**	**CH4**	**N2O**
2023	$80.00	$2,100.00	$29,000.00
2024	$82.00	$2,200.00	$29,000.00
2025	$83.00	$2,200.00	$30,000.00
2026	$84.00	$2,300.00	$30,000.00
2027	$86.00	$2,300.00	$31,000.00
2028	$87.00	$2,400.00	$32,000.00

2029	$88.00	$2,500.00	$32,000.00
2030	$89.00	$2,500.00	$33,000.00
2031	$91.00	$2,600.00	$33,000.00
2032	$92.00	$2,600.00	$34,000.00
2033	$94.00	$2,700.00	$35,000.00
2034	$95.00	$2,800.00	$35,000.00
2035	$96.00	$2,800.00	$36,000.00
2036	$98.00	$2,900.00	$36,000.00
2037	$99.00	$3,000.00	$37,000.00
2038	$100.00	$3,000.00	$38,000.00
2039	$102.00	$3,100.00	$38,000.00
2040	$103.00	$3,100.00	$39,000.00
2041	$104.00	$3,200.00	$39,000.00
2042	$106.00	$3,300.00	$40,000.00
2043	$107.00	$3,300.00	$41,000.00
2044	$108.00	$3,400.00	$41,000.00
2045	$110.00	$3,500.00	$42,000.00
2046	$111.00	$3,500.00	$43,000.00
2047	$112.00	$3,600.00	$43,000.00
2048	$114.00	$3,700.00	$44,000.00
2049	$115.00	$3,700.00	$45,000.00
2050	$116.00	$3,800.00	$45,000.00
2051	$118.00	$3,827.00	$45,817.00
2052	$119.00	$3,888.00	$46,423.00
2053	$120.00	$3,950.00	$47,028.00
2054 [SS Year]	$122.00	$4,011.00	$47,634.00
2055	$123.00	$4,072.00	$48,240.00
2056	$124.00	$4,134.00	$48,845.00
2057	$126.00	$4,195.00	$49,451.00
2058	$127.00	$4,257.00	$50,057.00
2059	$128.00	$4,318.00	$50,662.00
2060	$130.00	$4,379.00	$51,268.00
2061	$131.00	$4,441.00	$51,874.00
2062	$132.00	$4,502.00	$52,479.00
2063	$134.00	$4,563.00	$53,085.00
2064	$135.00	$4,625.00	$53,691.00

Action-related SC GHG were estimated by calendar-year for the projected action's lifecycle. Annual estimates were found by multiplying the annual emission for a given year by the corresponding IWG Annual SC GHG Emission value (see table above).

Action-Related Annual SC GHG ($K/yr [In 2020 $])				
YEAR	**CO2**	**CH4**	**N2O**	**GHG**
2023	$46.10	$0.07	$0.48	$46.65
2024	$47.26	$0.07	$0.48	$47.81
2025	$47.83	$0.07	$0.49	$48.40
2026	$48.41	$0.07	$0.49	$48.98
2027	$49.56	$0.07	$0.51	$50.15
2028	$50.14	$0.08	$0.53	$50.74
2029	$50.72	$0.08	$0.53	$51.32
2030	$51.29	$0.08	$0.54	$51.92
2031	$52.44	$0.08	$0.54	$53.07
2032	$53.02	$0.08	$0.56	$53.67
2033	$54.17	$0.09	$0.58	$54.84

2034	$54.75	$0.09	$0.58	$55.42
2035	$55.33	$0.09	$0.59	$56.01
2036	$56.48	$0.09	$0.59	$57.17
2037	$57.05	$0.10	$0.61	$57.76
2038	$57.63	$0.10	$0.63	$58.35
2039	$58.78	$0.10	$0.63	$59.51
2040	$59.36	$0.10	$0.64	$60.10
2041	$59.94	$0.10	$0.64	$60.68
2042	$61.09	$0.11	$0.66	$61.85
2043	$61.67	$0.11	$0.68	$62.45
2044	$62.24	$0.11	$0.68	$63.03
2045	$63.39	$0.11	$0.69	$64.20
2046	$63.97	$0.11	$0.71	$64.79
2047	$64.55	$0.12	$0.71	$65.37
2048	$65.70	$0.12	$0.73	$66.54
2049	$66.28	$0.12	$0.74	$67.14
2050	$66.85	$0.12	$0.74	$67.72
2051	$68.00	$0.12	$0.75	$68.88
2052	$68.58	$0.13	$0.76	$69.47
2053	$57.16	$0.11	$0.74	$58.01
2054 [SS Year]	$58.11	$0.11	$0.75	$58.97
2055	$58.59	$0.12	$0.76	$59.46
2056	$59.07	$0.12	$0.77	$59.95
2057	$60.02	$0.12	$0.77	$60.91
2058	$60.50	$0.12	$0.78	$61.40
2059	$60.97	$0.12	$0.79	$61.89
2060	$61.92	$0.12	$0.80	$62.85
2061	$62.40	$0.13	$0.81	$63.34
2062	$62.88	$0.13	$0.82	$63.83
2063	$63.83	$0.13	$0.83	$64.79
2064	$64.31	$0.13	$0.84	$65.28

The following two tables summarize the U.S. and State's Annual SC GHG by calendar-year. The U.S. and State's Annual SC GHG are in 2020 dollars and were estimated by each year for the projected action lifecycle. Annual SC GHG estimates were found by multiplying the U.S. and State's annual five-year average GHG emissions for a given year by the corresponding IWG Annual SC GHG Cost per Metric Ton value.

State's Annual SC GHG ($K/yr [In 2020 $])				
YEAR	**CO2**	**CH4**	**N2O**	**GHG**
2023	$26,956,025.72	$3,291,804.77	$1,608,320.85	$31,856,151.35
2024	$27,629,926.37	$3,448,557.38	$1,608,320.85	$32,686,804.60
2025	$27,966,876.69	$3,448,557.38	$1,663,780.19	$33,079,214.26
2026	$28,303,827.01	$3,605,309.99	$1,663,780.19	$33,572,917.19
2027	$28,977,727.65	$3,605,309.99	$1,719,239.53	$34,302,277.18
2028	$29,314,677.97	$3,762,062.60	$1,774,698.87	$34,851,439.44
2029	$29,651,628.30	$3,918,815.21	$1,774,698.87	$35,345,142.37
2030	$29,988,578.62	$3,918,815.21	$1,830,158.21	$35,737,552.04
2031	$30,662,479.26	$4,075,567.81	$1,830,158.21	$36,568,205.29
2032	$30,999,429.58	$4,075,567.81	$1,885,617.55	$36,960,614.95
2033	$31,673,330.22	$4,232,320.42	$1,941,076.89	$37,846,727.54
2034	$32,010,280.55	$4,389,073.03	$1,941,076.89	$38,340,430.47
2035	$32,347,230.87	$4,389,073.03	$1,996,536.23	$38,732,840.13
2036	$33,021,131.51	$4,545,825.64	$1,996,536.23	$39,563,493.38
2037	$33,358,081.83	$4,702,578.25	$2,051,995.57	$40,112,655.65

2038	$33,695,032.15	$4,702,578.25	$2,107,454.91	$40,505,065.31
2039	$34,368,932.80	$4,859,330.86	$2,107,454.91	$41,335,718.56
2040	$34,705,883.12	$4,859,330.86	$2,162,914.25	$41,728,128.23
2041	$35,042,833.44	$5,016,083.46	$2,162,914.25	$42,221,831.16
2042	$35,716,734.08	$5,172,836.07	$2,218,373.59	$43,107,943.75
2043	$36,053,684.40	$5,172,836.07	$2,273,832.93	$43,500,353.41
2044	$36,390,634.73	$5,329,588.68	$2,273,832.93	$43,994,056.34
2045	$37,064,535.37	$5,486,341.29	$2,329,292.27	$44,880,168.93
2046	$37,401,485.69	$5,486,341.29	$2,384,751.61	$45,272,578.59
2047	$37,738,436.01	$5,643,093.90	$2,384,751.61	$45,766,281.52
2048	$38,412,336.66	$5,799,846.51	$2,440,210.95	$46,652,394.11
2049	$38,749,286.98	$5,799,846.51	$2,495,670.29	$47,044,803.77
2050	$39,086,237.30	$5,956,599.11	$2,495,670.29	$47,538,506.70
2051	$39,760,137.94	$5,998,922.32	$2,540,980.57	$48,300,040.83
2052	$40,097,088.26	$6,094,541.41	$2,574,588.93	$48,766,218.60
2053	$40,434,038.58	$6,191,728.03	$2,608,141.83	$49,233,908.44
2054 [SS Year]	$41,107,939.23	$6,287,347.12	$2,641,750.19	$50,037,036.54
2055	$41,444,889.55	$6,382,966.21	$2,675,358.55	$50,503,214.31
2056	$41,781,839.87	$6,480,152.83	$2,708,911.45	$50,970,904.15
2057	$42,455,740.51	$6,575,771.92	$2,742,519.81	$51,774,032.24
2058	$42,792,690.84	$6,672,958.53	$2,776,128.17	$52,241,777.54
2059	$43,129,641.16	$6,768,577.62	$2,809,681.07	$52,707,899.85
2060	$43,803,541.80	$6,864,196.72	$2,843,289.43	$53,511,027.95
2061	$44,140,492.12	$6,961,383.33	$2,876,897.79	$53,978,773.25
2062	$44,477,442.44	$7,057,002.42	$2,910,450.69	$54,444,895.56
2063	$45,151,343.09	$7,152,621.51	$2,944,059.05	$55,248,023.65
2064	$45,488,293.41	$7,249,808.13	$2,977,667.41	$55,715,768.95

U.S. Annual SC GHG ($K/yr [In 2020 $])				
YEAR	CO2	CH4	N2O	GHG
2023	$410,916,334.32	$53,816,514.53	$43,520,521.44	$508,253,370.29
2024	$421,189,242.68	$56,379,205.70	$43,520,521.44	$521,088,969.82
2025	$426,325,696.86	$56,379,205.70	$45,021,229.08	$527,726,131.63
2026	$431,462,151.04	$58,941,896.86	$45,021,229.08	$535,425,276.98
2027	$441,735,059.39	$58,941,896.86	$46,521,936.72	$547,198,892.97
2028	$446,871,513.57	$61,504,588.03	$48,022,644.35	$556,398,745.96
2029	$452,007,967.75	$64,067,279.20	$48,022,644.35	$564,097,891.30
2030	$457,144,421.93	$64,067,279.20	$49,523,351.99	$570,735,053.12
2031	$467,417,330.29	$66,629,970.37	$49,523,351.99	$583,570,652.65
2032	$472,553,784.47	$66,629,970.37	$51,024,059.62	$590,207,814.46
2033	$482,826,692.83	$69,192,661.54	$52,524,767.26	$604,544,121.62
2034	$487,963,147.01	$71,755,352.70	$52,524,767.26	$612,243,266.97
2035	$493,099,601.18	$71,755,352.70	$54,025,474.90	$618,880,428.78
2036	$503,372,509.54	$74,318,043.87	$54,025,474.90	$631,716,028.31
2037	$508,508,963.72	$76,880,735.04	$55,526,182.53	$640,915,881.29
2038	$513,645,417.90	$76,880,735.04	$57,026,890.17	$647,553,043.11
2039	$523,918,326.26	$79,443,426.21	$57,026,890.17	$660,388,642.63
2040	$529,054,780.44	$79,443,426.21	$58,527,597.80	$667,025,804.45
2041	$534,191,234.62	$82,006,117.38	$58,527,597.80	$674,724,949.80
2042	$544,464,142.97	$84,568,808.54	$60,028,305.44	$689,061,256.96
2043	$549,600,597.15	$84,568,808.54	$61,529,013.08	$695,698,418.77
2044	$554,737,051.33	$87,131,499.71	$61,529,013.08	$703,397,564.12
2045	$565,009,959.69	$89,694,190.88	$63,029,720.71	$717,733,871.28
2046	$570,146,413.87	$89,694,190.88	$64,530,428.35	$724,371,033.10

2047	$575,282,868.05	$92,256,882.05	$64,530,428.35	$732,070,178.44
2048	$585,555,776.41	$94,819,573.22	$66,031,135.98	$746,406,485.61
2049	$590,692,230.59	$94,819,573.22	$67,531,843.62	$753,043,647.42
2050	$595,828,684.76	$97,382,264.38	$67,531,843.62	$760,742,792.77
2051	$606,101,593.12	$98,074,191.00	$68,757,921.76	$772,933,705.88
2052	$611,238,047.30	$99,637,432.61	$69,667,350.59	$780,542,830.50
2053	$616,374,501.48	$101,226,301.14	$70,575,278.71	$788,176,081.32
2054 [SS Year]	$626,647,409.84	$102,789,542.75	$71,484,707.53	$800,921,660.12
2055	$631,783,864.02	$104,352,784.36	$72,394,136.36	$808,530,784.74
2056	$636,920,318.20	$105,941,652.89	$73,302,064.48	$816,164,035.56
2057	$647,193,226.55	$107,504,894.50	$74,211,493.31	$828,909,614.36
2058	$652,329,680.73	$109,093,763.02	$75,120,922.14	$836,544,365.89
2059	$657,466,134.91	$110,657,004.63	$76,028,850.26	$844,151,989.80
2060	$667,739,043.27	$112,220,246.25	$76,938,279.08	$856,897,568.60
2061	$672,875,497.45	$113,809,114.77	$77,847,707.91	$864,532,320.13
2062	$678,011,951.63	$115,372,356.38	$78,755,636.03	$872,139,944.04
2063	$688,284,859.99	$116,935,598.00	$79,665,064.86	$884,885,522.84
2064	$693,421,314.17	$118,524,466.52	$80,574,493.68	$892,520,274.37

Relative Comparison of SC GHG:

To provide additional real-world context to the potential climate change impact associate with an action, a Relative Comparison of SC GHG Assessment is also performed. While the SC GHG estimates capture an indirect approximation of global climate damages, the Relative Comparison of SC GHG Assessment provides a better perspective from a regional and global scale.

The Relative Comparison of SC GHG Assessment uses the rule of reason and the concept of proportionality along with the consideration of the affected area (yGba.e., global, national, and regional) and the SC GHG as the degree (intensity) of the proposed action's effects. The Relative Comparison Assessment provides real-world context and allows for a reasoned choice among alternatives through a relative contrast analysis which weighs each alternative's SC GHG proportionally against (or relative to) existing global, national, and regional SC GHG. The below table provides a relative comparison between an action's SC GHG vs. state and U.S. projected SC GHG for the same time period:

Total SC-GHG ($K [In 2020 $])					
		CO2	**CH4**	**N2O**	**GHG**
2023-2064	State Total	$1,523,352,403.67	$221,431,869.47	$95,753,544.95	$1,840,537,818.08
2023-2064	U.S. Total	$23,221,909,343.26	$3,620,108,797.74	$2,591,052,771.77	$29,433,070,912.77
2023-2064	Action	$2,452.34	$4.37	$27.96	$2,484.67
Percent of State Totals		0.00016098%	0.00000197%	0.00002920%	0.00013500%
Percent of U.S. Totals		0.00001056%	0.00000012%	0.00000108%	0.00000844%

From a global context, the action alternative's total SC GHG percentage of total global SC GHG for the same time period is: 0.00000113%.*

* Global value based on the U.S. emits 13.4% of all global GHG annual emissions (2018 Emissions Data, Center for Climate and Energy Solutions, accessed 7-6-2023, https://www.c2es.org/content/international-emissions).

Adam Poll, Civilian/Senior Air Quality Specialist — Nov 01 2023

Name, Title — **Date**

AIR CONFORMITY APPLICABILITY MODEL REPORT
GREENHOUSE GAS (GHG) EMISSIONS

Table 1: Permitted Emission Limits

Equipment	NO_x	ROC	CO	SO_x	PM	PM_{10}	$PM_{2.5}$
Falcon 9 RP-1							
lb/day		0.34					
TPY		0.01					
RSV Loading							
lb/day		69.12					
TPY		0.03					
Payload Fueling							
lb/day	14.84	0.15					
TPY	0.34	0.00					
Solvent Use							
lb/day		56.97					
TPY		7.42					
Total Emissions							
lb/day	**14.84**	**126.59**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
TPY	**0.34**	**7.46**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Falcon 9 Potential to Emit Calculations

Attachment: A-1
Permit Number: PTO 15069
Facility: SpaceX

RP-1 and System Input Data

Information	*Value*	*Units*	*Reference*
Specific Gravity at System Temp................	0.840	--	Material Specifications
Vapor Pressure @ 20 °F............................	0.00088	psi	Material Specifications
Vapor Molecular Weight............................	148.00	lb/lb-mol	Material Specifications
Gas Constant...	10.73	scf-psi/°R-lb-mol	Ideal Gas Laws
System and RP-1 Temperature..................	474.67	°R	Permit Application
RP-1 Emission Factor..........................	0.00003	lb/ft^3	Calculated Value

Maximum Process Event Summary

Event Name	*Value*	*Units*	*Reference*
Launches...	36	events/year	Permit Application
Static Launch and Abort Events.....................	30	events/year	Permit Application
Event Vehicle RP-1 Throughput Volume..........	48,600	gals/event	Permit Application
Event Fill Line Throughput Volume................	1,543	gals/event	Permit Application
Daily Launch Volume.................................	50,143	gals/day	Calculated Value
Daily Static Launch and Abort Volume..........	50,143	gals/day	Calculated Value
Daily Launch Volume.................................	6,703	ft^3/day	Calculated Value
Daily Static Launch and Abort Volume..........	13,406	ft^3/day	Calculated Value
Annual Launch Volume...............................	1,805,132	gals/year	Calculated Value
Annual Static Launch and Abort Volume..........	1,504,277	gals/year	Calculated Value
Annual Launch Volume...............................	241,312	ft^3/yr	Calculated Value
Annual Static Launch and Abort Volume.........	201,093	ft^3/yr	Calculated Value

ROC Potential to Emit

Process	lb/day	TPY
Launches	0.17	0.00
Static Launches/Abort	0.34	0.00
Total PTE	**0.34**	**0.01**

Notes:
1. One Falcon 9 launch or static launch/abort permitted per day. PTE reflects the worst case scenario.

Processed By: KMB

Date: 2/11/2020

RSV Loading Potential to Emit Calculations

Attachment: A-3
Permit Number: PTO 15069
Facility: SpaceX

RP-1 and System Input Data

Information	*Value*	*Units*	*Reference*
Specific Gravity at System Temp................	0.809	--	Material Specifications
Vapor Pressure @ 70 °F..............................	0.011	psi	Material Specifications
Vapor Molecular Weight.............................	148.00	lb/lb-mol	Material Specifications
Gas Constant..	10.73	scf-psi/°R-lb-mol	Ideal Gas Laws
System and RP-1 Temperature.................	529.67	°R	Permit Application
RP-1 Emission Factor..........................	0.00029	lb/ft^3	Calculated Value

RP-1 Fuel Consumption

Consumption Operations	*Value*	*Units*	*Reference*
Worst Case Daily RP-1 Consumption............	178,000	gals/day	Equal to Total RP-1 Tank Calcs
Worst Case Annual RP-1 Consumption.......	1,805,132	gals	Falcon 9 Annual Launch Volume
Falcon 9 RP-1 Consumption.........................	241,312	ft^3	Calculated Values

ROC Potential to Emit

lb/day	TPY
69.12	0.03

Processed By: KMB

Date: 2/11/2020

Payload Fueling Potential to Emit Calculations

Attachment: A-4
Permit Number: PTO 15069
Facility: SpaceX

Payload/Unloading Input Data

Information	*Value*	*Units*	*Reference*
Flow Rate (loading/unloading).............	5.00	scf/min	Permit Application
MMH Molecular Weight.....................	60.10	lb/lb-mol	Permit Application
N_2O_4 Molecular Weight..................	92.01	lb/lb-mol	Permit Application
Molar Denisty..........................	0.00264	lb-mole/scf	Permit Application
Processing Time........................	4	hours	Permit Application
Loading Annual Operations................	36	events/year	Permit Application
Unloading Annual Operations.............	10	events/year	Permit Application
Loading Control Efficiency...........	99.95	%	Permit Application
Unloading Control Efficiency..........	95.70	%	Permit Application
NO_x Fugitives Per Event.................	2.31	lb/event	Permit Application
ROC Fugitives Per Event.................	0.058	lb/event	Permit Application

Payload Loading Controlled Potential to Emit

Propellant	Pollutant	lb/day	TPY
N_2O_4	NO_x	12.53	0.23
MMH	ROC	0.10	0.00
N_2O_4	NO_x (Fugitives)	2.31	0.04
MMH	ROC (Fugitives)	0.06	0.00

Payload Unloading Controlled Potential to Emit

Propellant	Pollutant	lb/day	TPY
N_2O_4	NO_x	12.53	0.06
MMH	ROC	0.10	0.00
N_2O_4	NO_x (Fugitives)	2.31	0.01
MMH	ROC (Fugitives)	0.06	0.00

Total Potential to Emit

Propellant	Pollutant	lb/day	TPY
N_2O_4	NO_x	14.84	0.34
MMH	ROC	0.15	0.00

Notes:
1. One payload loading or unloading event permitted per day.
   PTE reflects the worst case scenario.

Processed By: KMB

Date: 2/11/2020

Project Emissions Roll-On Roll-Off - Baseline Los Angeles County

Source Category	VOC	NO_x	CO	SO_x	PM_{10}	$PM_{2.5}$	Pb	CO2	CH4	N2O	CO2e
	ton/yr							MT/yr			
Marine Vessel	0.28	3.77	3.63	0.05	0.08	0.08	0.00	469.39	0.02	0.01	471.83
Off-Road	0.03	0.64	0.84	0.00	0.02	0.02	0.00	142.66	0.04	0.02	149.29
Total	**0.32**	**4.41**	**4.47**	**0.05**	**0.10**	**0.10**	**0.00**	**612.06**	**0.06**	**0.03**	**621.12**

SpaceX Marine Transport Project Baseline Los Angeles County

Marine Emission Estimates - Elizabeth C Day 1 and 4

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (days/yr)	Emission Factors (g/kW-hr) VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
Tugboat	Transit	Propulsion	3	0.1%S	2	1,300	970	0.50	4.00	72	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03
Tugboat	Transit	Auxiliary	3	0.1%S	2	99	74	0.31	4.00	72	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03
Tugboat	Maneuvering	Propulsion	3	0.1%S	2	1,300	970	0.50	0.50	72	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03
Tugboat	Maneuvering	Auxiliary	3	0.1%S	2	99	74	0.31	0.50	72	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03
Emission Subtotals																				

Boat Classification	Phase	Engine	Maximum Daily Emissions (lb/day) VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
Tugboat	Transit	Propulsion	3.35	44.55	42.77	0.58	0.94	0.94	0.01	6,122.46	0.25	0.09
Tugboat	Transit	Auxiliary	0.15	2.03	2.02	0.03	0.05	0.05	0.00	265.41	0.01	0.00
Tugboat	Maneuvering	Propulsion	0.42	5.57	5.35	0.07	0.12	0.12	0.00	765.31	0.03	0.01
Tugboat	Maneuvering	Auxiliary	0.02	0.25	0.25	0.00	0.01	0.01	0.00	33.18	0.00	0.00
Emission Subtotals			**3.94**	**52.40**	**50.39**	**0.69**	**1.11**	**1.11**	**0.01**	**7,186.35**	**0.29**	**0.10**

Boat Classification	Phase	Engine	Annual Emissions (ton/yr) VOC	NOx	CO	SOx	PM10	PM2.5	Pb	(MT/yr) CO2	CH4	N20	CO2E
Tugboat	Transit	Propulsion	0.12	1.60	1.54	0.02	0.03	0.03	0.00	199.95	0.01	0.00	200.99
Tugboat	Transit	Auxiliary	0.01	0.07	0.07	0.00	0.00	0.00	0.00	8.67	0.00	0.00	8.72
Tugboat	Maneuvering	Propulsion	0.02	0.20	0.19	0.00	0.00	0.00	0.00	24.99	0.00	0.00	25.12
Tugboat	Maneuvering	Auxiliary	0.00	0.01	0.01	0.00	0.00	0.00	0.00	1.08	0.00	0.00	1.09
Emission Subtotals			**0.14**	**1.89**	**1.81**	**0.02**	**0.04**	**0.04**	**0.00**	**234.70**	**0.01**	**0.00**	**235.92**

Note:
The project would operate from the Port of Long Beach within SCAQMD waters up to 30 nautical miles, assuming average transit speed of 7.5 knots.

Marine Emission Estimates - Elizabeth C Day 2 and 5

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (days/yr)	Emission Factors (g/kW-hr) VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
Tugboat	Transit	Propulsion	3	0.1%S	2	1,300	970	0.50	4.50	72	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03
Tugboat	Transit	Auxiliary	3	0.1%S	2	99	74	0.31	4.50	72	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03
Emission Subtotals																				

Boat Classification	Phase	Engine	Maximum Daily Emissions (lb/day) VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
Tugboat	Transit	Propulsion	3.77	50.12	48.12	0.65	1.06	1.06	0.01	6,887.77	0.28	0.10
Tugboat	Transit	Auxiliary	0.17	2.29	2.28	0.03	0.05	0.05	0.00	298.58	0.01	0.00
Emission Subtotals			**3.94**	**52.40**	**50.39**	**0.69**	**1.11**	**1.11**	**0.01**	**7,186.35**	**0.29**	**0.10**

Boat Classification	Phase	Engine	Annual Emissions (ton/yr) VOC	NOx	CO	SOx	PM10	PM2.5	Pb	(MT/yr) CO2	CH4	N20	CO2E
Tugboat	Transit	Propulsion	0.14	1.80	1.73	0.02	0.04	0.04	0.00	224.95	0.01	0.00	226.11
Tugboat	Transit	Auxiliary	0.01	0.08	0.08	0.00	0.00	0.00	0.00	9.75	0.00	0.00	9.81
Emission Subtotals			**0.14**	**1.89**	**1.81**	**0.02**	**0.04**	**0.04**	**0.00**	**234.70**	**0.01**	**0.00**	**235.92**

Note:
The project would operate within SCAQMD waters up to 33.75 nautical miles, assuming average transit speed of 7.5 knots.

Emission Factors

Marine Propulsion

Engine Type	Engine Family	Model	Tier	Fuel	VOC (g/kW-hr)	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
Slow Speed Diesel		<=1999	Tier 0	0.1%S	0.600	17.01	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		<=1999	Tier 0	0.1%S	0.500	13.16	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2000-2010	Tier 1	0.1%S	0.600	15.98	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2000-2010	Tier 1	0.1%S	0.500	12.22	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2011-2015	Tier 2	0.1%S	0.600	14.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2011-2015	Tier 2	0.1%S	0.500	10.53	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2016+	Tier 3	0.1%S	0.600	3.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2016+	Tier 3	0.1%S	0.500	2.63	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
EPA Certification	HCEXN19.0AAA		Tier 3	0.1%S	0.392	5.21	5.0	0.07	0.11	0.11	0.0006067	716		

Notes:
Emission factors from Table 2.3 and 2.4 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
Load factors for propulsion engines based on Table 3.1 of the of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 1 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.

Marine Auxiliary

Engine Type	Model	Tier	Fuel	VOC (g/kW-hr)	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
Aux High Speed Diesel	<=1999	Tier 0	0.1%S	0.600	10.9	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	<=1999	Tier 0	0.1%S	0.600	13.82	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	9.78	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	12.22	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	7.71	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	10.53	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	1.97	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	2.63	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux Med Speed Diesel Tier 3 Standard	2011-2015	Tier 3	0.1%S	0.378	5.022	5	0.068	0.12	0.12	0.0006067			

Notes:
Emission factors from Table 2.9 and 2.10 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
Load factors for propulsion engines based on Table 3.1 of the of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 5 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.

Marine exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\, EF_i \times Eng_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF = *Emission factor in grams per horse-power hour*
Eng = *Number of engines*
AvgHP = *Maximum rated average horsepower*
Load = *Load factor*
Activity = *Hours of operation*
i = *Equipment type*

SpaceX Marine Transport Project Baseline Los Angeles County

Off-Road Emission Estimates

Construction Equipment	OFFROAD Model Category	Engine Tier	Quantity	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (day/yr)	Emission Factors (g/BHP-hr) VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O	Daily Emissions (lb/day) VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	Annual Emissions (MT/yr) CO2	CH4	N2O	CO2E
Crane-LR 1300	Crane	3	1	603	450	0.29	16	72	0.12	2.32	2.6	0.005	0.088	0.088	510.334	0.152	0.068138	0.74	14.31	16.04	0.03	0.54	0.54	3,147.87	0.94	0.42	102.81	0.03	0.01	107.66
Crane-Tadano ATF 220G	Crane	4	1	197	147	0.29	8	72	0.0600	0.2600	3.7000	0.0050	0.0080	0.0080	514.2600	0.1540	0.0690	0.06	0.26	3.73	0.01	0.01	0.01	518.16	0.16	0.07	16.92	0.01	0.00	17.73
KMAG	Off-Highway Truck	3	1	453	338	0.3	4.0	72	0.1200	2.3200	2.6000	0.0050	0.0088	0.0088	528.8080	0.1540	0.0690	0.14	2.78	3.12	0.01	0.01	0.01	634	0.18	0.08	20.71	0.01	0.00	21.66
Generator-Barge	Generator Sets	4	1	49	37	0.74	1.5	72	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081	0.01	0.33	0.49	0.00	0.00	0.00	68	0.00	0.00	2.23	0.00	0.00	2.24
Emission Subtotals																		**0.96**	**17.68**	**23.37**	**0.04**	**0.56**	**0.56**	**4,368.26**	**1.28**	**0.57**	**142.66**	**0.04**	**0.02**	**149.29**

Notes:

Emission factors are default emission factors from CalEEMod 2016.3.2, which relies on OFFROAD 2011.

Load factor for generator and cranes are defaults from CalEEMod 2016.3.2.

Load factor for KMAG based on average speed over route compared to rated maximum travel speed.

See Table D-12 of the Carl Moyer Program Guidelines. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/msprog/moyer/guidelines/2011/2011cmp_guidelinesVER4.pdf?_ga=2.218661721.1589730523.1723135078-1780396104.1706050686

Emission Factors

Equipment Type	Year	Low HP	High HP	VOC (g/BHP-hr)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
KMAG	Tier 3	300	599	0.1200	2.3200	2.6000	0.0050	0.0088	0.0088	528.8080	0.1540	0.0690
Generator Sets	Tier 4 Final	25	49	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081
Crane-LR 1300	Tier 3	600	750	0.1200	2.3200	2.6000	0.0050	0.0880	0.0880	510.3340	0.1520	0.0681
Crane-Tadano ATF 220G	Tier 4 Final	120	174	0.0600	0.2600	3.7000	0.0050	0.0080	0.0080	514.2600	0.1540	0.0690

Off-road mobile equipment exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\, EF_i \times Pop_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF	=	*Emission factor in grams per horse-power hour*
Pop	=	*Population, or the number of pieces of equipment*
AvgHP	=	*Maximum rated average horsepower*
Load	=	*Load factor*
Activity	=	*Hours of operation*
i	=	*Equipment type*

Baseline Emissions Roll-On Roll-Off Santa Barbara County

Source Category	VOC	NO_x	CO	SO_x	PM_{10}	$PM_{2.5}$	Pb	CO2	CH4	N2O	CO2e
	ton/yr							MT/yr			
Marine Vessel	0.76	10.09	9.72	0.13	0.22	0.22	0.00	1256.24	0.05	0.02	1262.79
Off-Road	0.02	0.43	0.61	0.00	0.02	0.01	0.00	91.95	0.02	0.01	94.46
Total	**0.78**	**10.52**	**10.32**	**0.13**	**0.23**	**0.22**	**0.00**	**1,348.19**	**0.07**	**0.02**	**1,357.25**

SpaceX Marine Transport Project Baseline Santa Barbara County

Marine Emission Estimates - Elizabeth C Day 2

											Emission Factors										Maximum Daily Emissions										Annual Emissions										
Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating	Engine Rating	Load Factor	Operation	Operation	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
						(hp)	(kW)		(hr/day)	(days/yr)	(g/kW-hr)										(lb/day)										(ton/year)							(MT/yr)			
Tugboat	Transit	Propulsion	3	0.1%S	2	1,300	969	0.50	9.50	36	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03	7.96	105.74	101.52	1.38	2.23	2.23	0.01	14,532.24	0.59	0.20	0.14	1.90	1.83	0.02	0.04	0.04	0.00	237.30	0.01	0.00	238.53
Tugboat	Transit	Auxiliary	3	0.1%S	2	99	74	0.31	9.50	36	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03	0.36	4.83	4.80	0.07	0.12	0.12	0.00	630.34	0.03	0.01	0.01	0.09	0.09	0.00	0.00	0.00	0.00	10.29	0.00	0.00	10.35
Emission Subtotals																					**8.32**	**110.56**	**106.32**	**1.45**	**2.35**	**2.35**	**0.01**	**15,162.58**	**0.62**	**0.21**	**0.15**	**1.99**	**1.91**	**0.03**	**0.04**	**0.04**	**0.00**	**247.60**	**0.01**	**0.00**	**248.88**

Note:
The project would operate within the SBCAPCD jurisdiction for 37.2 nautical miles.

Marine Emission Estimates - Elizabeth C Day 3

											Emission Factors										Maximum Daily Emissions										Annual Emissions										
Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating	Engine Rating	Load Factor	Operation	Operation	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
						(hp)	(kW)		(hr/day)	(days/yr)	(g/kW-hr)										(lb/day)										(ton/year)							(MT/yr)			
Tugboat	Transit	Propulsion	3	0.1%S	2	1,300	969	0.50	2.30	36	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03	1.93	25.60	24.58	0.33	0.54	0.54	0.00	3,518.33	0.14	0.05	0.03	0.46	0.44	0.01	0.01	0.01	0.00	57.45	0.00	0.00	57.75
Tugboat	Transit	Auxiliary	3	0.1%S	2	99	74	0.31	2.30	36	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03	0.09	1.17	1.16	0.02	0.03	0.03	0.00	152.61	0.01	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	2.49	0.00	0.00	2.51
Tugboat	Maneuvering	Propulsion	3	0.1%S	2	1,300	969	0.50	4.50	36	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03	3.77	50.09	48.09	0.65	1.06	1.06	0.01	6,883.69	0.28	0.10	0.07	0.90	0.87	0.01	0.02	0.02	0.00	112.41	0.00	0.00	112.99
Tugboat	Maneuvering	Auxiliary	3	0.1%S	2	99	74	0.31	4.50	36	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03	0.17	2.29	2.28	0.03	0.05	0.05	0.00	298.58	0.01	0.00	0.00	0.04	0.04	0.00	0.00	0.00	0.00	4.88	0.00	0.00	4.90
Tugboat	Contingency	Propulsion	3	0.1%S	2	1,300	969	0.50	0.33	36	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03	0.28	3.67	3.53	0.05	0.08	0.08	0.00	504.80	0.02	0.01	0.00	0.07	0.06	0.00	0.00	0.00	0.00	8.24	0.00	0.00	8.29
Tugboat	Contingency	Auxiliary	3	0.1%S	2	99	74	0.31	0.33	36	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03	0.01	0.17	0.17	0.00	0.00	0.00	0.00	21.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.00	0.00	0.36
Emission Subtotals																					**6.25**	**82.98**	**79.80**	**1.09**	**1.76**	**1.76**	**0.01**	**11,379.92**	**0.46**	**0.16**	**0.11**	**1.49**	**1.44**	**0.02**	**0.03**	**0.03**	**0.00**	**185.83**	**0.01**	**0.00**	**186.79**

Note:
The project would operate within the SBCAPCD jurisdiction for 34 nautical miles.

Marine Emission Estimates - Elizabeth C Day 4

											Emission Factors										Maximum Daily Emissions										Annual Emissions										
Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating	Engine Rating	Load Factor	Operation	Operation	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
						(hp)	(kW)		(hr/day)	(days/yr)	(g/kW-hr)										(lb/day)										(ton/year)							(MT/yr)			
Tugboat	Transit	Propulsion	3	0.1%S	2	1,300	969	0.50	9.50	36	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03	7.96	105.74	101.52	1.38	2.23	2.23	0.01	14,532.24	0.59	0.20	0.14	1.90	1.83	0.02	0.04	0.04	0.00	237.30	0.01	0.00	238.53
Tugboat	Transit	Auxiliary	3	0.1%S	2	99	74	0.31	9.50	36	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03	0.36	4.83	4.80	0.07	0.12	0.12	0.00	630.34	0.03	0.01	0.01	0.09	0.09	0.00	0.00	0.00	0.00	10.29	0.00	0.00	10.35
Emission Subtotals																					**8.32**	**110.56**	**106.32**	**1.45**	**2.35**	**2.35**	**0.01**	**15,162.58**	**0.62**	**0.21**	**0.15**	**1.99**	**1.91**	**0.03**	**0.04**	**0.04**	**0.00**	**247.60**	**0.01**	**0.00**	**248.88**

Note:
The project would operate within the SBCAPCD jurisdiction for 37.2 nautical miles.

Marine Emission Estimates - Bernardine C Day 1

											Emission Factors										Maximum Daily Emissions										Annual Emissions										
Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating	Engine Rating	Load Factor	Operation	Operation	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
						(hp)	(kW)		(hr/day)	(days/yr)	(g/kW-hr)										(lb/day)										(ton/yr)							(MT/yr)			
Tugboat	Transit	Propulsion	3	0.1%S	2	500	373	0.50	24.00	36	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03	7.73	102.74	98.64	1.34	2.17	2.17	0.01	14,120.40	0.57	0.20	0.14	1.85	1.78	0.02	0.04	0.04	0.00	230.58	0.01	0.00	231.77
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	36	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03	0.46	6.10	6.07	0.08	0.15	0.15	0.00	796.22	0.04	0.01	0.01	0.11	0.11	0.00	0.00	0.00	0.00	13.00	0.00	0.00	13.08
Tugboat	Hoteling	Auxiliary	3	0.1%S	1	99	74	0.31	0.00	36	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03	-	-	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-
Emission Subtotals																					**8.19**	**108.84**	**104.71**	**1.42**	**2.32**	**2.32**	**0.01**	**14,916.62**	**0.61**	**0.21**	**0.15**	**1.96**	**1.88**	**0.03**	**0.04**	**0.04**	**0.00**	**243.58**	**0.01**	**0.00**	**244.85**

Note:
The project would operate within the SBCAPCD jurisdiction for 64 nautical miles from Port of Hueneme.

Marine Emission Estimates - Bernardine C Day 2 and 4

											Emission Factors										Maximum Daily Emissions										Annual Emissions										
Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating	Engine Rating	Load Factor	Operation	Operation	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
						(hp)	(kW)		(hr/day)	(days/yr)	(g/kW-hr)										(lb/day)										(ton/yr)							(MT/yr)			
Tugboat	Hoteling	Propulsion	3	0.1%S	2	500	373	0.50	0.00	72	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03	-	-	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-
Tugboat	Hoteling	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	72	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03	0.46	6.10	6.07	0.08	0.15	0.15	0.00	796.22	0.04	0.01	0.02	0.22	0.22	0.00	0.01	0.01	0.00	28.66	0.00	0.00	28.83
Emission Subtotals																					**0.46**	**6.10**	**6.07**	**0.08**	**0.15**	**0.15**	**0.00**	**796.22**	**0.04**	**0.01**	**0.02**	**0.22**	**0.22**	**0.00**	**0.01**	**0.01**	**0.00**	**28.66**	**0.00**	**0.00**	**28.83**

Note: The project would be docked at VSFB harbor.

Marine Emission Estimates - Bernardine C Day 3

											Emission Factors										Maximum Daily Emissions										Annual Emissions										
Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating	Engine Rating	Load Factor	Operation	Operation	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
						(hp)	(kW)		(hr/day)	(days/yr)	(g/kW-hr)										(lb/day)										(ton/yr)							(MT/yr)			
Tugboat	Manuevering	Propulsion	3	0.1%S	2	500	373	0.50	4.50	36	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03	1.45	19.26	18.49	0.25	0.41	0.41	0.00	2,647.57	0.11	0.04	0.03	0.35	0.33	0.00	0.01	0.01	0.00	43.23	0.00	0.00	43.46
Tugboat	Manuevering	Auxiliary	3	0.1%S	1	99	74	0.31	4.50	36	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03	0.09	1.14	1.14	0.02	0.03	0.03	0.00	149.29	0.01	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	2.44	0.00	0.00	2.45
Tugboat	Contingency	Propulsion	3	0.1%S	2	500	373	0.50	0.33	36	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03	0.11	1.41	1.36	0.02	0.03	0.03	0.00	194.16	0.01	0.00	0.00	0.03	0.02	0.00	0.00	0.00	0.00	3.17	0.00	0.00	3.19
Tugboat	Contingency	Auxiliary	3	0.1%S	1	99	74	0.31	0.33	36	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03	0.01	0.08	0.08	0.00	0.00	0.00	0.00	10.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.18
Tugboat	Hoteling	Auxiliary	3	0.1%S	1	99	74	0.31	19.17	36	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03	0.37	4.87	4.85	0.07	0.12	0.12	0.00	635.98	0.03	0.01	0.01	0.09	0.09	0.00	0.00	0.00	0.00	10.39	0.00	0.00	10.44
Emission Subtotals																					**2.02**	**26.77**	**25.92**	**0.35**	**0.58**	**0.58**	**0.00**	**3,637.95**	**0.15**	**0.05**	**0.04**	**0.48**	**0.47**	**0.01**	**0.01**	**0.01**	**0.00**	**59.41**	**0.00**	**0.00**	**59.72**

Note:
The project would operate within the SBCAPCD jurisdiction for 61.7 nautical miles.

Marine Emission Estimates - Bernardine C Day 5

											Emission Factors										Maximum Daily Emissions										Annual Emissions										
Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating	Engine Rating	Load Factor	Operation	Operation	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
						(hp)	(kW)		(hr/day)	(days/yr)	(g/kW-hr)										(lb/day)										(ton/yr)							(MT/yr)			
Tugboat	Transit	Propulsion	3	0.1%S	2	500	373	0.50	24.00	36	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03	7.73	102.74	98.64	1.34	2.17	2.17	0.01	14,120.40	0.57	0.20	0.14	1.85	1.78	0.02	0.04	0.04	0.00	230.58	0.01	0.00	231.77
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	36	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03	0.46	6.10	6.07	0.08	0.15	0.15	0.00	796.22	0.04	0.01	0.01	0.11	0.11	0.00	0.00	0.00	0.00	13.00	0.00	0.00	13.08
Emission Subtotals																					**8.19**	**108.84**	**104.71**	**1.42**	**2.32**	**2.32**	**0.01**	**14,916.62**	**0.61**	**0.21**	**0.15**	**1.96**	**1.88**	**0.03**	**0.04**	**0.04**	**0.00**	**243.58**	**0.01**	**0.00**	**244.85**

Note:
The project would operate within the SBCAPCD jurisdiction for 64 nautical miles from Port of Hueneme.

CO2	CH4	N20	CO2E
1,256.24	**0.05**	**0.02**	**1,262.79**

Marine Propulsion

Engine Type	Engine Family	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
					(g/kW-hr)									
Slow Speed Diesel		<=1999	Tier 0	0.1%S	0.600	17.01	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		<=1999	Tier 0	0.1%S	0.500	13.16	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2000-2010	Tier 1	0.1%S	0.600	15.98	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2000-2010	Tier 1	0.1%S	0.500	12.22	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2011-2015	Tier 2	0.1%S	0.600	14.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029

Medium Speed Diesel		2011-2015	Tier 2	0.1%S	0.500	10.53	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2016+	Tier 3	0.1%S	0.600	3.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2016+	Tier 3	0.1%S	0.500	2.63	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
EPA Certification	HCEXN19.0AAA		Tier 3	0.1%S	0.392	5.21	5.0	0.07	0.11	0.11	0.0006067	716		

Notes:
Emission factors from Table 2.3 and 2.4 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
Load factors for propulsion engines based on Table 3.1 of the of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 1 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.

Marine Auxiliary

Engine Type	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
				(g/kW-hr)									
Aux High Speed Diesel	<=1999	Tier 0	0.1%S	0.600	10.9	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	<=1999	Tier 0	0.1%S	0.600	13.82	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	9.78	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	12.22	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	7.71	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	10.53	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	1.97	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	2.63	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux Med Speed Diesel Tier 3 Standard	2011-2015	Tier 3	0.1%S	0.378	5.022	5	0.068	0.12	0.12	0.0006067			

Notes:
Emission factors from Table 2.9 and 2.10 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
Load factors for propulsion engines based on Table 3.1 of the of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 5 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.

Marine exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\, EF_i \times Eng_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF	=	*Emission factor in grams per horse-power hour*
Eng	=	*Number of engines*
AvgHP	=	*Maximum rated average horsepower*
Load	=	*Load factor*
Activity	=	*Hours of operation*
i	=	*Equipment type*

SpaceX Marine Transport Project Baseline Santa Barbara County

Off-Road Emission Estimates

Day 2

Construction Equipment	OFFROAD Model Category	Engine Tier	Quantity	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (day/yr)	Emission Factors VOC (g/BHP-hr)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
Crane-HTC-3140LB J8	Crane-transport	4	1	550	410	0.29	0.5	72	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	470.5495	0.1522	0.0682
Crane-HTC-3140LB J8	Crane-lift	4	1	215	160	0.29	0	72	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	472.9057	0.1529	0.0690
Generator-Barge	Generator Sets	4	1	49	37	0.74	7.8	72	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081

Construction Equipment	Daily Emissions VOC (lb/day)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20
Crane-HTC-3140LB J8	0.01	0.05	0.39	0.00	0.00	0.00	82.73	0.03	0.01
Crane-HTC-3140LB J8	-	-	-	-	-	-	-	-	-
Generator-Barge	0.07	1.71	2.56	0.00	0.00	0.00	354	0.01	0.01
Emission Subtotals	**0.09**	**1.76**	**2.94**	**0.00**	**0.01**	**0.01**	**437.07**	**0.04**	**0.02**

Construction Equipment	Annual Emissions VOC (ton/year)	NOx	CO	SOx	PM10	PM2.5	CO2 (MT/yr)	CH4	N2O	CO2E
Crane-HTC-3140LB J8	0.00	0.00	0.01	0.00	0.00	0.00	2.70	0.00	0.00	2.84
Crane-HTC-3140LB J8	-	-	-	-	-	-	-	-	-	-
Generator-Barge	0.00	0.06	0.09	0.00	0.00	0.00	11.57	0.00	0.00	11.63
Emission Subtotals	**0.00**	**0.06**	**0.11**	**0.00**	**0.00**	**0.00**	**14.27**	**0.00**	**0.00**	**14.47**

Notes:

Emission factors are default emission factors from CalEEMod 2016.3.2, which relies on OFFROAD 2011.
Load factor for generator are defaults from CalEEMod 2016.3.2.
Load factor for KMAG based on average speed over route compared to rated maximum travel speed.
Fugitive dust emissions from paved roads assumes the KMAG is loaded.
See Table D-12 of the Carl Moyer Program Guidelines. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/msprog/moyer/guidelines/2011/2011cmp_guidelinesVER4.pdf?_ga=2.218661721.1589730523.1723135078-1780396104.1706050686

Day 3

Construction Equipment	OFFROAD Model Category	Engine Tier	Quantity	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (day/yr)	Emission Factors VOC (g/BHP-hr)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
KMAG	Off-Highway Truck	3	1	453	338	0.3	7.5	72	0.1200	2.3200	2.6000	0.0050	0.0088	0.0088	528.8080	0.1540	0.0690
Crane-HTC-3140LB J8	Crane-transport	4	1	550	410	0.29	0.5	72	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	470.5495	0.1522	0.0682
Crane-HTC-3140LB J8	Crane-lift	4	1	215	160	0.29	2	72	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	472.9057	0.1529	0.0690
Generator-Barge	Generator Sets	4	1	49	37	0.74	21.5	72	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081

Construction Equipment	Daily Emissions VOC (lb/day)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20
KMAG	0.27	5.22	5.85	0.01	0.50	0.14	1,189	0.35	0.16
Crane-HTC-3140LB J8	0.01	0.05	0.39	0.00	0.00	0.00	82.73	0.03	0.01
Crane-HTC-3140LB J8	0.02	0.07	0.60	0.00	0.00	0.00	130.01	0.04	0.02
Generator-Barge	0.21	4.73	7.05	0.01	0.01	0.01	977	0.03	0.01
Emission Subtotals	**0.50**	**10.06**	**13.88**	**0.02**	**0.51**	**0.15**	**2,378.38**	**0.45**	**0.20**

Construction Equipment	Annual Emissions VOC (ton/year)	NOx	CO	SOx	PM10	PM2.5	CO2 (MT/yr)	CH4	N2O	CO2E
KMAG	0.01	0.19	0.21	0.00	0.02	0.00	38.83	0.01	0.01	40.62
Crane-HTC-3140LB J8	0.00	0.00	0.01	0.00	0.00	0.00	2.70	0.00	0.00	2.84
Crane-HTC-3140LB J8	0.00	0.00	0.02	0.00	0.00	0.00	4.25	0.00	0.00	4.46
Generator-Barge	0.01	0.17	0.25	0.00	0.00	0.00	31.90	0.00	0.00	32.06
Emission Subtotals	**0.02**	**0.36**	**0.50**	**0.00**	**0.02**	**0.01**	**77.67**	**0.01**	**0.01**	**79.99**
							91.95	0.02	0.01	94.46

Notes:

Emission factors are default emission factors from CalEEMod 2016.3.2, which relies on OFFROAD 2011.
Load factor for generator are defaults from CalEEMod 2016.3.2.
Load factor for KMAG based on average speed over route compared to rated maximum travel speed.
Fugitive dust emissions from paved roads assumes the KMAG is loaded.
See Table D-12 of the Carl Moyer Program Guidelines. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/msprog/moyer/guidelines/2011/2011cmp_guidelinesVER4.pdf?_ga=2.218661721.1589730523.1723135078-1780396104.1706050686

Emission Factors

Equipment Type	Year	Low HP	High HP	VOC (g/BHP-hr)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
KMAG	Tier 3	300	599	0.1200	2.3200	2.6000	0.0050	0.0088	0.0088	528.8080	0.1540	0.0690
Crane-HTC-3140LB J8	Tier 4 Final	175	299	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	472.9057	0.1529	0.0690
Crane-HTC-3140LB J8	Tier 4 Final	300	599	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	470.5495	0.1522	0.0682
Generator Sets	Tier 4 Final	25	49	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081

Off-road mobile equipment exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\, EF_i \times Pop_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF	=	*Emission factor in grams per horse-power hour*
Pop	=	*Population, or the number of pieces of equipment*
AvgHP	=	*Maximum rated average horsepower*
Load	=	*Load factor*
Activity	=	*Hours of operation*
i	=	*Equipment type*

SpaceX Baseline - Ventura County

Marine Emission Estimates - Elizabeth C Day 2 and Day 4

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (days/yr)
Tugboat	Transit	Propulsion	3	0.1%S	2	1,300	970	0.50	2.10	72
Tugboat	Transit	Auxiliary	3	0.1%S	2	99	74	0.31	2.10	72
Generator-Barge	Transit	Generator Sets	4	0.1%S	1	49	37	0.74	2.10	72
Emission Subtotals										

Emission Factors

Boat Classification	Engine	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
		(g/kW-hr)									
Tugboat	Propulsion	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03
Tugboat	Auxiliary	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03
		(g/hp-hr)									
Generator-Barge	Generator Sets	0.12	2.75	4.10	0.01	0.01	0.01	-	568.30	0.02	0.01

Maximum Daily Emissions

Boat Classification	Engine	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
		(lb/day)									
Tugboat	Propulsion	1.76	23.39	22.45	0.31	0.49	0.49	0.00	3,214.29	0.13	0.04
Tugboat	Auxiliary	0.08	1.07	1.06	0.01	0.03	0.03	0.00	139.34	0.01	0.00
Generator-Barge	Generator Sets	0.02	0.46	0.69	0.00	0.00	0.00	-	95.40	0.00	0.00
Emission Subtotals		**1.86**	**24.92**	**24.20**	**0.32**	**0.52**	**0.52**	**0.00**	**3,449.03**	**0.14**	**0.05**

Annual Emissions

Boat Classification	Engine	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
		(ton/yr)							(MT/yr)			
Tugboat	Propulsion	0.06	0.84	0.81	0.01	0.02	0.02	0.00	104.97	0.00	0.00	105.52
Tugboat	Auxiliary	0.00	0.04	0.04	0.00	0.00	0.00	0.00	4.55	0.00	0.00	4.58
Generator-Barge	Generator Sets	0.00	0.02	0.02	0.00	0.00	0.00	-	3.12	0.00	0.00	3.15
Emission Subtotals		**0.07**	**0.90**	**0.87**	**0.01**	**0.02**	**0.02**	**0.00**	**112.64**	**0.00**	**0.00**	**113.24**

Note:
The project would operate within the VCAPCD jurisdiction for 16 nautical miles.

Marine Emission Estimates - Bernardine C Day 1 and 5

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (days/yr)
Tugboat	Transit	Propulsion	3	0.1%S	2	500	373	0.50	5.50	72
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	5.50	72
Emission Subtotals										

Emission Factors

Boat Classification	Engine	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
		(g/kW-hr)									
Tugboat	Propulsion	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03
Tugboat	Auxiliary	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03

Maximum Daily Emissions

Boat Classification	Engine	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
		(lb/day)									
Tugboat	Propulsion	1.77	23.55	22.60	0.31	0.50	0.50	0.00	3,235.92	0.13	0.05
Tugboat	Auxiliary	0.11	1.40	1.39	0.02	0.03	0.03	0.00	182.47	0.01	0.00
Emission Subtotals		**1.88**	**24.94**	**24.00**	**0.33**	**0.53**	**0.53**	**0.00**	**3,418.39**	**0.14**	**0.05**

Annual Emissions

Boat Classification	Engine	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
		(ton/yr)							(MT/yr)			
Tugboat	Propulsion	0.06	0.85	0.81	0.01	0.02	0.02	0.00	105.68	0.00	0.00	106.23
Tugboat	Auxiliary	0.00	0.05	0.05	0.00	0.00	0.00	0.00	5.96	0.00	0.00	5.99
Emission Subtotals		**0.07**	**0.90**	**0.86**	**0.01**	**0.02**	**0.02**	**0.00**	**111.64**	**0.00**	**0.00**	**112.22**

Note:
The project would operate within the VCAPCD jurisdiction for 13.6 nautical miles.

Emission Factors

Marine Propulsion

Engine Type	Engine Family	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
					(g/kW-hr)									
Slow Speed Diesel		<=1999	Tier 0	0.1%S	0.600	17.01	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		<=1999	Tier 0	0.1%S	0.500	13.16	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2000-2010	Tier 1	0.1%S	0.600	15.98	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2000-2010	Tier 1	0.1%S	0.500	12.22	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2011-2015	Tier 2	0.1%S	0.600	14.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2011-2015	Tier 2	0.1%S	0.500	10.53	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2016+	Tier 3	0.1%S	0.600	3.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2016+	Tier 3	0.1%S	0.500	2.63	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
EPA Certification	HCEXN19.0AAA		Tier 3	0.1%S	0.392	5.21	5.0	0.07	0.11	0.11	0.0006067	716		

Notes:
Emission factors from Table 2.3 and 2.4 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
Load factors for propulsion engines based on Table 3.1 of the of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 1 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.

Marine Auxiliary

Engine Type	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
				(g/kW-hr)									
Aux High Speed Diesel	<=1999	Tier 0	0.1%S	0.600	10.9	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	<=1999	Tier 0	0.1%S	0.600	13.82	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	9.78	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	12.22	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	7.71	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	10.53	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	1.97	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	2.63	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux Med Speed Diesel Tier 3 Standard	2011-2015	Tier 3	0.1%S	0.378	5.022	5	0.068	0.12	0.12	0.0006067			
				(g/hp-hr)									
Generator Sets		Tier 4 Final	0.1%S	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	-	568.2990	0.0180	0.0081

Notes:
Emission factors from Table 2.9 and 2.10 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
Load factors for propulsion engines based on Table 3.1 of the of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 5 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.
Emission factors for generator sets are default emission factors from CalEEMod 2016.3.2, which relies on OFFROAD 2011 and the Carl Moyer Progam Guidelines.
See Table D-12 of the Carl Moyer Program Guidelines. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/msprog/moyer/guidelines/2011/2011cmp_guidelinesVER4.pdf?_ga=2.218661721.1589730523.1723135078-1780396104.1706050686

Marine exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma \, EF_i \times Eng_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF	=	*Emission factor in grams per horse-power hour*
Eng	=	*Number of engines*
AvgHP	=	*Maximum rated average horsepower*
Load	=	*Load factor*
Activity	=	*Hours of operation*
i	=	*Equipment type*

DETAIL AIR CONFORMITY APPLICABILITY MODEL REPORT

1. General Information

- Action Location
Base: VANDENBERG AFB
State: California
County(s): Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Action Title: Falcon Program at Vandenberg Space Force Base

- Project Number/s (if applicable):

- Projected Action Start Date: 1 / 2025

- Action Purpose and Need:
Space Exploration Technologies Corporation (SpaceX) has applied to the United States Space Force (USSF) to increase Falcon flight opportunities at Vandenberg Space Force Base (VSFB) in support of manifested and anticipated vehicle operations for Falcon 9. SpaceX currently launches commercial and government payloads from VSFB at SLC-4. SpaceX supports, and is under contract for, the full spectrum of U.S. Government space mission requirements, including crew and cargo transportation for the National Aeronautics and Space Administration (NASA) and spacecraft launches for NASA and the U.S. Department of Defense (DOD).

- Action Description:
The Proposed Action is to increase the annual Falcon launch cadence at VSFB through launches at SLC-4 to support future commercial and U.S. government launch service needs. SpaceX would launch Falcon 9 from SLC-4. Falcon 9 is approximately 229 feet tall and produces approximately 1.7 million pounds of thrust at liftoff. A discussion of Falcon 9 can be found in the 2016 EA and associated supplemental environmental documents. The number of launches would increase from 36 to 50 per year under the Proposed Action.

- Point of Contact
Name: Adam Poll
Title: Civilian/Senior Air Quality Specialist
Organization: Dudek
Email: apoll@dudek.com
Phone Number: 8053088516

- Activity List:

Activity Type		Activity Title
2.	Degreaser	Solvent use
3.	Emergency Generator	ES DICE1-3
4.	Emergency Generator	ES DICE4
5.	Emergency Generator	ES DICE 5
6.	Emergency Generator	Prime Engine
7.	Personnel	Worker Vehicles
8.	Personnel	Fleet Vehicle Use
9.	Personnel	Vendor-Contractor Vehicles
10.	Construction / Demolition	Operational Equipment Use

Emission factors and air emission estimating methods come from the United States Air Force's Air Emissions Guide for Air Force Stationary Sources, Air Emissions Guide for Air Force Mobile Sources, and Air Emissions Guide for Air Force Transitory Sources.

2. Degreaser

DETAIL AIR CONFORMITY APPLICABILITY MODEL REPORT

2.1 General Information & Timeline Assumptions

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: Solvent use

- Activity Description:
solvent use

- Activity Start Date
Start Month: 1
Start Year: 2025

- Activity End Date
Indefinite: Yes
End Month: N/A
End Year: N/A

- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	5.926830
SO_x	0.000000
NO_x	0.000000
CO	0.000000

Pollutant	Emissions Per Year (TONs)
PM 10	0.000000
PM 2.5	0.000000
Pb	0.000000
NH_3	0.000000

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)
CH_4	0.000000
N_2O	0.000000

Pollutant	Emissions Per Year (TONs)
CO_2	0.000000
CO_2e	0.000000

2.2 Degreaser Assumptions

- Degreaser
Net solvent usage (total less recycle) (gallons/year): 1820

- Default Settings Used: Yes

- Degreaser Consumption
Solvent used: Mineral Spirits CAS#64475-85-0 (default)
Specific gravity of solvent: 0.78 (default)
Solvent VOC content (%): 100 (default)
Efficiency of control device (%): 0 (default)

2.3 Degreaser Formula(s)

- Degreaser Emissions per Year
DE_{VOC}= (VOC / 100) * NS * SG * 8.35 * (1 - (CD / 100)) / 2000

DE_{VOC}: Degreaser VOC Emissions (TONs per Year)
VOC: Solvent VOC content (%)

(VOC / 100): Conversion Factor percent to decimal
NS: Net solvent usage (total less recycle) (gallons/year)
SG: Specific gravity of solvent
8.35: Conversion Factor the density of water
CD: Efficiency of control device (%)
(1 - (CD / 100)): Conversion Factor percent to decimal (Not effected by control device)
2000: Conversion Factor pounds to tons

3. Emergency Generator

3.1 General Information & Timeline Assumptions

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: ES DICE1-3

- Activity Description:
DICE1-3

- Activity Start Date
Start Month: 1
Start Year: 2025

- Activity End Date
Indefinite: Yes
End Month: N/A
End Year: N/A

- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	0.048804
SO_x	0.000852
NO_x	1.765409
CO	0.468958

Pollutant	Emissions Per Year (TONs)
PM 10	0.055143
PM 2.5	0.055143
Pb	0.000000
NH_3	0.000000

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)
CH_4	0.003156
N_2O	0.000631

Pollutant	Emissions Per Year (TONs)
CO_2	78.386875
CO_2e	90.656125

3.2 Emergency Generator Assumptions

- Emergency Generator
Type of Fuel used in Emergency Generator: Diesel
Number of Emergency Generators: 7

- Default Settings Used: No

- Emergency Generators Consumption

Emergency Generator's Horsepower: 779
Average Operating Hours Per Year (hours): 25

3.3 Emergency Generator Emission Factor(s)

- Emergency Generators Criteria Pollutant Emission Factor (lb/hp-hr)

VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3
0.000716	0.0000125	0.0259	0.00688	0.000809	0.000809		

- Emergency Generators Greenhouse Gasses Pollutant Emission Factor (lb/hp-hr)

CH_4	N_2O	CO_2	CO_2e
0.000046297	0.000009259	1.15	1.33

3.4 Emergency Generator Formula(s)

- Emergency Generator Emissions per Year

AE_{POL}= (NGEN * HP * OT * EF_{POL}) / 2000

AE_{POL}: Activity Emissions (TONs per Year)
NGEN: Number of Emergency Generators
HP: Emergency Generator's Horsepower (hp)
OT: Average Operating Hours Per Year (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hp-hr)

4. Emergency Generator

4.1 General Information & Timeline Assumptions

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: ES DICE4

- Activity Description:
ES DICE4

- Activity Start Date
Start Month: 1
Start Year: 2025

- Activity End Date
Indefinite: Yes
End Month: N/A
End Year: N/A

- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	0.012799
SO_x	0.010781
NO_x	0.052756

Pollutant	Emissions Per Year (TONs)
PM 10	0.011515
PM 2.5	0.011515
Pb	0.000000

CO	0.035232		NH_3	0.000000

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)		Pollutant	Emissions Per Year (TONs)
CH_4	0.000212		CO_2	5.275625
N_2O	0.000042		CO_2e	6.101375

4.2 Emergency Generator Assumptions

- Emergency Generator
Type of Fuel used in Emergency Generator: Diesel
Number of Emergency Generators: 1

- Default Settings Used: No

- Emergency Generators Consumption
Emergency Generator's Horsepower: 367
Average Operating Hours Per Year (hours): 25

4.3 Emergency Generator Emission Factor(s)

- Emergency Generators Criteria Pollutant Emission Factor (lb/hp-hr)

VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3
0.00279	0.00235	0.0115	0.00768	0.00251	0.00251		

- Emergency Generators Greenhouse Gasses Pollutant Emission Factor (lb/hp-hr)

CH_4	N_2O	CO_2	CO_2e
0.000046297	0.000009259	1.15	1.33

4.4 Emergency Generator Formula(s)

- Emergency Generator Emissions per Year
$AE_{POL}= (NGEN * HP * OT * EF_{POL}) / 2000$

AE_{POL}: Activity Emissions (TONs per Year)
NGEN: Number of Emergency Generators
HP: Emergency Generator's Horsepower (hp)
OT: Average Operating Hours Per Year (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hp-hr)

5. Emergency Generator

5.1 General Information & Timeline Assumptions

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: ES DICE 5

- Activity Description:

DETAIL AIR CONFORMITY APPLICABILITY MODEL REPORT

ES DICE 5

- Activity Start Date
Start Month: 1
Start Year: 2025

- Activity End Date
Indefinite: Yes
End Month: N/A
End Year: N/A

- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	0.011160
SO_x	0.009400
NO_x	0.046000
CO	0.030720

Pollutant	Emissions Per Year (TONs)
PM 10	0.010040
PM 2.5	0.010040
Pb	0.000000
NH_3	0.000000

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)
CH_4	0.000185
N_2O	0.000037

Pollutant	Emissions Per Year (TONs)
CO_2	4.600000
CO_2e	5.320000

5.2 Emergency Generator Assumptions

- Emergency Generator
Type of Fuel used in Emergency Generator: Diesel
Number of Emergency Generators: 1

- Default Settings Used: No

- Emergency Generators Consumption
Emergency Generator's Horsepower: 320
Average Operating Hours Per Year (hours): 25

5.3 Emergency Generator Emission Factor(s)

- Emergency Generators Criteria Pollutant Emission Factor (lb/hp-hr)

VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3
0.00279	0.00235	0.0115	0.00768	0.00251	0.00251		

- Emergency Generators Greenhouse Gasses Pollutant Emission Factor (lb/hp-hr)

CH_4	N_2O	CO_2	CO_2e
0.000046297	0.000009259	1.15	1.33

5.4 Emergency Generator Formula(s)

- Emergency Generator Emissions per Year

AE_{POL}= (NGEN * HP * OT * EF_{POL}) / 2000

AE_{POL}: Activity Emissions (TONs per Year)
NGEN: Number of Emergency Generators
HP: Emergency Generator's Horsepower (hp)
OT: Average Operating Hours Per Year (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hp-hr)

6. Emergency Generator

6.1 General Information & Timeline Assumptions

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: Prime Engine

- Activity Description:
Prime Engine

- Activity Start Date
Start Month: 1
Start Year: 2025

- Activity End Date
Indefinite: Yes
End Month: N/A
End Year: N/A

- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	1.009221
SO_x	0.850061
NO_x	4.159872
CO	2.778071

Pollutant	Emissions Per Year (TONs)
PM 10	0.907937
PM 2.5	0.907937
Pb	0.000000
NH_3	0.000000

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)
CH_4	0.016747
N_2O	0.003349

Pollutant	Emissions Per Year (TONs)
CO_2	415.987200
CO_2e	481.098240

6.2 Emergency Generator Assumptions

- Emergency Generator
Type of Fuel used in Emergency Generator: Diesel
Number of Emergency Generators: 4

- Default Settings Used: No

- Emergency Generators Consumption
Emergency Generator's Horsepower: 314
Average Operating Hours Per Year (hours): 576

6.3 Emergency Generator Emission Factor(s)

- Emergency Generators Criteria Pollutant Emission Factor (lb/hp-hr)

VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3

0.00279	0.00235	0.0115	0.00768	0.00251	0.00251		

- Emergency Generators Greenhouse Gasses Pollutant Emission Factor (lb/hp-hr)

CH_4	N_2O	CO_2	CO_2e
0.000046297	0.000009259	1.15	1.33

6.4 Emergency Generator Formula(s)

- Emergency Generator Emissions per Year

AE_{POL}= (NGEN * HP * OT * EF_{POL}) / 2000

AE_{POL}: Activity Emissions (TONs per Year)
NGEN: Number of Emergency Generators
HP: Emergency Generator's Horsepower (hp)
OT: Average Operating Hours Per Year (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hp-hr)

7. Personnel

7.1 General Information & Timeline Assumptions

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: Worker Vehicles

- Activity Description:
Worker Vehicles

- Activity Start Date
Start Month: 1
Start Year: 2025

- Activity End Date
Indefinite: Yes
End Month: N/A
End Year: N/A

- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	1.130506
SO_x	0.012463
NO_x	0.552950
CO	6.932431

Pollutant	Emissions Per Year (TONs)
PM 10	0.070047
PM 2.5	0.025131
Pb	0.000000
NH_3	0.141851

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)
CH_4	0.077682
N_2O	0.049520

Pollutant	Emissions Per Year (TONs)
CO_2	1261.385763
CO_2e	1278.088142

7.2 Personnel Assumptions

- Number of Personnel

Active Duty Personnel: 0
Civilian Personnel: 0
Support Contractor Personnel: 700
Air National Guard (ANG) Personnel: 0
Reserve Personnel: 0

- Default Settings Used: Yes

- Average Personnel Round Trip Commute (mile): 20 (default)

- Personnel Work Schedule

Active Duty Personnel: 5 Days Per Week (default)
Civilian Personnel: 5 Days Per Week (default)
Support Contractor Personnel: 5 Days Per Week (default)
Air National Guard (ANG) Personnel: 4 Days Per Week (default)
Reserve Personnel: 4 Days Per Month (default)

7.3 Personnel On Road Vehicle Mixture

- On Road Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	37.55	60.32	0	0.03	0.2	0	1.9
GOVs	54.49	37.73	4.67	0	0	3.11	0

7.4 Personnel Emission Factor(s)

- On Road Vehicle Criteria Pollutant Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	NH_3
LDGV	0.15014	0.00272	0.08183	1.15414	0.01648	0.00579	0.03482
LDGT	0.19850	0.00338	0.15423	1.58574	0.01798	0.00647	0.03664
HDGV	0.25262	0.00518	0.25160	1.83327	0.02830	0.01002	0.03696
LDDV	0.02453	0.00212	0.21377	0.31526	0.03028	0.01896	0.00310
LDDT	0.01608	0.00283	0.07126	0.15320	0.02417	0.01248	0.00310
HDDV	0.10482	0.01080	2.21934	0.52071	0.11665	0.05708	0.18048
MC	5.55535	0.00206	0.72741	17.74481	0.01913	0.00815	0.00862

- On Road Vehicle Greenhouse Gasses Emission Factors (grams/mile)

	CH_4	N_2O	CO_2	CO_2e
LDGV	0.01196	0.00928	275.34289	278.40759
LDGT	0.01652	0.01302	342.02606	346.32025
HDGV	0.02149	0.01816	523.58650	529.53564
LDDV	0.00114	0.03522	223.57891	234.10442
LDDT	0.00075	0.04708	298.82532	312.87385
HDDV	0.00487	0.17970	1140.57202	1194.24362
MC	0.25786	0.04719	207.94492	228.45331

7.5 Personnel Formula(s)

- Personnel Vehicle Miles Travel for Work Days per Year

$VMT_P = NP * WD * AC$

VMT_P: Personnel Vehicle Miles Travel (miles/year)
NP: Number of Personnel
WD: Work Days per Year
AC: Average Commute (miles)

- Total Vehicle Miles Travel per Year
$VMT_{Total} = VMT_{AD} + VMT_C + VMT_{SC} + VMT_{ANG} + VMT_{AFRC}$

VMT_{Total}: Total Vehicle Miles Travel (miles)
VMT_{AD}: Active Duty Personnel Vehicle Miles Travel (miles)
VMT_C: Civilian Personnel Vehicle Miles Travel (miles)
VMT_{SC}: Support Contractor Personnel Vehicle Miles Travel (miles)
VMT_{ANG}: Air National Guard Personnel Vehicle Miles Travel (miles)
VMT_{AFRC}: Reserve Personnel Vehicle Miles Travel (miles)

- Vehicle Emissions per Year
$V_{POL} = (VMT_{Total} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{Total}: Total Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Personnel On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

8. Personnel

8.1 General Information & Timeline Assumptions

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: Fleet Vehicle Use

- Activity Description:
Fleet Vehicle Use

- Activity Start Date
Start Month: 1
Start Year: 2025

- Activity End Date
Indefinite: Yes
End Month: N/A
End Year: N/A

- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	0.080750
SO_x	0.000890
NO_x	0.039496

Pollutant	Emissions Per Year (TONs)
PM 10	0.005003
PM 2.5	0.001795
Pb	0.000000

CO	0.495174		NH_3	0.010132

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)		Pollutant	Emissions Per Year (TONs)
CH_4	0.005549		CO_2	90.098983
N_2O	0.003537		CO_2e	91.292010

8.2 Personnel Assumptions

- Number of Personnel

Active Duty Personnel:	0
Civilian Personnel:	0
Support Contractor Personnel:	50
Air National Guard (ANG) Personnel:	0
Reserve Personnel:	0

- Default Settings Used: Yes

- Average Personnel Round Trip Commute (mile): 20 (default)

- Personnel Work Schedule

Active Duty Personnel:	5 Days Per Week (default)
Civilian Personnel:	5 Days Per Week (default)
Support Contractor Personnel:	5 Days Per Week (default)
Air National Guard (ANG) Personnel:	4 Days Per Week (default)
Reserve Personnel:	4 Days Per Month (default)

8.3 Personnel On Road Vehicle Mixture

- On Road Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	37.55	60.32	0	0.03	0.2	0	1.9
GOVs	54.49	37.73	4.67	0	0	3.11	0

8.4 Personnel Emission Factor(s)

- On Road Vehicle Criteria Pollutant Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	NH_3
LDGV	0.15014	0.00272	0.08183	1.15414	0.01648	0.00579	0.03482
LDGT	0.19850	0.00338	0.15423	1.58574	0.01798	0.00647	0.03664
HDGV	0.25262	0.00518	0.25160	1.83327	0.02830	0.01002	0.03696
LDDV	0.02453	0.00212	0.21377	0.31526	0.03028	0.01896	0.00310
LDDT	0.01608	0.00283	0.07126	0.15320	0.02417	0.01248	0.00310
HDDV	0.10482	0.01080	2.21934	0.52071	0.11665	0.05708	0.18048
MC	5.55535	0.00206	0.72741	17.74481	0.01913	0.00815	0.00862

- On Road Vehicle Greenhouse Gasses Emission Factors (grams/mile)

	CH_4	N_2O	CO_2	CO_2e
LDGV	0.01196	0.00928	275.34289	278.40759
LDGT	0.01652	0.01302	342.02606	346.32025
HDGV	0.02149	0.01816	523.58650	529.53564
LDDV	0.00114	0.03522	223.57891	234.10442
LDDT	0.00075	0.04708	298.82532	312.87385
HDDV	0.00487	0.17970	1140.57202	1194.24362

MC	0.25786	0.04719	207.94492	228.45331

8.5 Personnel Formula(s)

- Personnel Vehicle Miles Travel for Work Days per Year
$VMT_P = NP * WD * AC$

VMT_P: Personnel Vehicle Miles Travel (miles/year)
NP: Number of Personnel
WD: Work Days per Year
AC: Average Commute (miles)

- Total Vehicle Miles Travel per Year
$VMT_{Total} = VMT_{AD} + VMT_C + VMT_{SC} + VMT_{ANG} + VMT_{AFRC}$

VMT_{Total}: Total Vehicle Miles Travel (miles)
VMT_{AD}: Active Duty Personnel Vehicle Miles Travel (miles)
VMT_C: Civilian Personnel Vehicle Miles Travel (miles)
VMT_{SC}: Support Contractor Personnel Vehicle Miles Travel (miles)
VMT_{ANG}: Air National Guard Personnel Vehicle Miles Travel (miles)
VMT_{AFRC}: Reserve Personnel Vehicle Miles Travel (miles)

- Vehicle Emissions per Year
$V_{POL} = (VMT_{Total} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{Total}: Total Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Personnel On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

9. Personnel

9.1 General Information & Timeline Assumptions

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: Vendor-Contractor Vehicles

- Activity Description:
Vendor-Contractor Vehicles

- Activity Start Date
Start Month: 1
Start Year: 2025

- Activity End Date
Indefinite: Yes

DETAIL AIR CONFORMITY APPLICABILITY MODEL REPORT

End Month: N/A
End Year: N/A

- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	0.108206
SO_x	0.001193
NO_x	0.052925
CO	0.663533

Pollutant	Emissions Per Year (TONs)
PM 10	0.006705
PM 2.5	0.002405
Pb	0.000000
NH_3	0.013577

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)
CH_4	0.007435
N_2O	0.004740

Pollutant	Emissions Per Year (TONs)
CO_2	120.732637
CO_2e	122.331294

9.2 Personnel Assumptions

- Number of Personnel
Active Duty Personnel: 0
Civilian Personnel: 0
Support Contractor Personnel: 67
Air National Guard (ANG) Personnel: 0
Reserve Personnel: 0

- Default Settings Used: Yes

- Average Personnel Round Trip Commute (mile): 20 (default)

- Personnel Work Schedule
Active Duty Personnel: 5 Days Per Week (default)
Civilian Personnel: 5 Days Per Week (default)
Support Contractor Personnel: 5 Days Per Week (default)
Air National Guard (ANG) Personnel: 4 Days Per Week (default)
Reserve Personnel: 4 Days Per Month (default)

9.3 Personnel On Road Vehicle Mixture

- On Road Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	37.55	60.32	0	0.03	0.2	0	1.9
GOVs	54.49	37.73	4.67	0	0	3.11	0

9.4 Personnel Emission Factor(s)

- On Road Vehicle Criteria Pollutant Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	NH_3
LDGV	0.15014	0.00272	0.08183	1.15414	0.01648	0.00579	0.03482
LDGT	0.19850	0.00338	0.15423	1.58574	0.01798	0.00647	0.03664
HDGV	0.25262	0.00518	0.25160	1.83327	0.02830	0.01002	0.03696
LDDV	0.02453	0.00212	0.21377	0.31526	0.03028	0.01896	0.00310
LDDT	0.01608	0.00283	0.07126	0.15320	0.02417	0.01248	0.00310
HDDV	0.10482	0.01080	2.21934	0.52071	0.11665	0.05708	0.18048
MC	5.55535	0.00206	0.72741	17.74481	0.01913	0.00815	0.00862

- On Road Vehicle Greenhouse Gasses Emission Factors (grams/mile)

	CH_4	N_2O	CO_2	CO_2e
LDGV	0.01196	0.00928	275.34289	278.40759
LDGT	0.01652	0.01302	342.02606	346.32025
HDGV	0.02149	0.01816	523.58650	529.53564
LDDV	0.00114	0.03522	223.57891	234.10442
LDDT	0.00075	0.04708	298.82532	312.87385
HDDV	0.00487	0.17970	1140.57202	1194.24362
MC	0.25786	0.04719	207.94492	228.45331

9.5 Personnel Formula(s)

- Personnel Vehicle Miles Travel for Work Days per Year

$VMT_P = NP * WD * AC$

VMT_P: Personnel Vehicle Miles Travel (miles/year)
NP: Number of Personnel
WD: Work Days per Year
AC: Average Commute (miles)

- Total Vehicle Miles Travel per Year

$VMT_{Total} = VMT_{AD} + VMT_C + VMT_{SC} + VMT_{ANG} + VMT_{AFRC}$

VMT_{Total}: Total Vehicle Miles Travel (miles)
VMT_{AD}: Active Duty Personnel Vehicle Miles Travel (miles)
VMT_C: Civilian Personnel Vehicle Miles Travel (miles)
VMT_{SC}: Support Contractor Personnel Vehicle Miles Travel (miles)
VMT_{ANG}: Air National Guard Personnel Vehicle Miles Travel (miles)
VMT_{AFRC}: Reserve Personnel Vehicle Miles Travel (miles)

- Vehicle Emissions per Year

$V_{POL} = (VMT_{Total} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{Total}: Total Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Personnel On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

10. Construction / Demolition

10.1 General Information & Timeline Assumptions

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: Operational Equipment Use

- Activity Description:
Operational Equipment Use

DETAIL AIR CONFORMITY APPLICABILITY MODEL REPORT

- Activity Start Date
Start Month: 1
Start Month: 2025

- Activity End Date
Indefinite: False
End Month: 0
End Month: 2055

- Activity Emissions:

Pollutant	Total Emissions (TONs)
VOC	1.485932
SO_x	0.042469
NO_x	13.329465
CO	17.975869

Pollutant	Total Emissions (TONs)
PM 10	0.409454
PM 2.5	0.376695
Pb	0.000000
NH_3	0.000000

- Activity Emissions of GHG:

Pollutant	Total Emissions (TONs)
CH_4	0.186498
N_2O	0.037312

Pollutant	Total Emissions (TONs)
CO_2	4597.670495
CO_2e	4613.448542

- Global Scale Activity Emissions for SCGHG:

Pollutant	Total Emissions (TONs)
CH_4	0.186498
N_2O	0.037312

Pollutant	Total Emissions (TONs)
CO_2	4597.670495
CO_2e	4613.448542

10.1 Site Grading Phase

10.1.1 Site Grading Phase Timeline Assumptions

- Phase Start Date
Start Month: 1
Start Quarter: 1
Start Year: 2025

- Phase Duration
Number of Month: 360
Number of Days: 0

10.1.2 Site Grading Phase Assumptions

- General Site Grading Information
Area of Site to be Graded (ft^2): 0
Amount of Material to be Hauled On-Site (yd^3): 0
Amount of Material to be Hauled Off-Site (yd^3): 0

- Site Grading Default Settings
Default Settings Used: No
Average Day(s) worked per week: 5

- Construction Exhaust

Equipment Name	Number Of Equipment	Hours Per Day
Aerial Lifts Composite	6	1

Forklifts Composite	7	1
Off-Highway Trucks Composite	4	1
Rough Terrain Forklifts Composite	6	1

- Vehicle Exhaust

Average Hauling Truck Capacity (yd^3): 20

Average Hauling Truck Round Trip Commute (mile): 0

- Vehicle Exhaust Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	0	0	0	0	0	100.00	0

- Worker Trips

Average Worker Round Trip Commute (mile): 0

- Worker Trips Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	50.00	50.00	0	0	0	0	0

10.1.3 Site Grading Phase Emission Factor(s)

- Construction Exhaust Criteria Pollutant Emission Factors (g/hp-hour)

Aerial Lifts Composite [HP: 46] [LF: 0.31]						
	VOC	SO_x	NO_x	CO	PM 10	PM 2.5
Emission Factors	0.15354	0.00542	2.87672	3.08611	0.02068	0.01903
Forklifts Composite [HP: 82] [LF: 0.2]						
	VOC	SO_x	NO_x	CO	PM 10	PM 2.5
Emission Factors	0.26944	0.00487	2.55142	3.59881	0.13498	0.12418
Off-Highway Trucks Composite [HP: 376] [LF: 0.38]						
	VOC	SO_x	NO_x	CO	PM 10	PM 2.5
Emission Factors	0.17748	0.00488	1.08595	1.17415	0.03850	0.03542
Rough Terrain Forklifts Composite [HP: 96] [LF: 0.4]						
	VOC	SO_x	NO_x	CO	PM 10	PM 2.5
Emission Factors	0.11845	0.00489	1.69423	3.22091	0.03622	0.03332

- Construction Exhaust Greenhouse Gasses Pollutant Emission Factors (g/hp-hour)

Aerial Lifts Composite [HP: 46] [LF: 0.31]				
	CH_4	N_2O	CO_2	CO_2e
Emission Factors	0.02381	0.00476	586.90005	588.91415
Forklifts Composite [HP: 82] [LF: 0.2]				
	CH_4	N_2O	CO_2	CO_2e
Emission Factors	0.02138	0.00428	527.10822	528.91712
Off-Highway Trucks Composite [HP: 376] [LF: 0.38]				
	CH_4	N_2O	CO_2	CO_2e
Emission Factors	0.02144	0.00429	528.58735	530.40133
Rough Terrain Forklifts Composite [HP: 96] [LF: 0.4]				
	CH_4	N_2O	CO_2	CO_2e
Emission Factors	0.02145	0.00429	528.72612	530.54057

- Vehicle Exhaust & Worker Trips Criteria Pollutant Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	NH_3
LDGV	0.15014	0.00272	0.08183	1.15414	0.01648	0.00579	0.03482
LDGT	0.19850	0.00338	0.15423	1.58574	0.01798	0.00647	0.03664
HDGV	0.25262	0.00518	0.25160	1.83327	0.02830	0.01002	0.03696

LDDV	0.02453	0.00212	0.21377	0.31526	0.03028	0.01896	0.00310
LDDT	0.01608	0.00283	0.07126	0.15320	0.02417	0.01248	0.00310
HDDV	0.10482	0.01080	2.21934	0.52071	0.11665	0.05708	0.18048
MC	5.55535	0.00206	0.72741	17.74481	0.01913	0.00815	0.00862

- Vehicle Exhaust & Worker Trips Greenhouse Gasses Emission Factors (grams/mile)

	CH_4	N_2O	CO_2	CO_2e
LDGV	0.01196	0.00928	275.34289	278.40759
LDGT	0.01652	0.01302	342.02606	346.32025
HDGV	0.02149	0.01816	523.58650	529.53564
LDDV	0.00114	0.03522	223.57891	234.10442
LDDT	0.00075	0.04708	298.82532	312.87385
HDDV	0.00487	0.17970	1140.57202	1194.24362
MC	0.25786	0.04719	207.94492	228.45331

10.1.4 Site Grading Phase Formula(s)

- Fugitive Dust Emissions per Phase

$PM10_{FD} = (20 * ACRE * WD) / 2000$

$PM10_{FD}$: Fugitive Dust PM 10 Emissions (TONs)
20: Conversion Factor Acre Day to pounds (20 lb / 1 Acre Day)
ACRE: Total acres (acres)
WD: Number of Total Work Days (days)
2000: Conversion Factor pounds to tons

- Construction Exhaust Emissions per Phase

$CEE_{POL} = (NE * WD * H * HP * LF * EF_{POL} * 0.002205) / 2000$

CEE_{POL}: Construction Exhaust Emissions (TONs)
NE: Number of Equipment
WD: Number of Total Work Days (days)
H: Hours Worked per Day (hours)
HP: Equipment Horsepower
LF: Equipment Load Factor
EF_{POL}: Emission Factor for Pollutant (g/hp-hour)
0.002205: Conversion Factor grams to pounds
2000: Conversion Factor pounds to tons

- Vehicle Exhaust Emissions per Phase

$VMT_{VE} = (HA_{OnSite} + HA_{OffSite}) * (1 / HC) * HT$

VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
HA_{OnSite}: Amount of Material to be Hauled On-Site (yd^3)
$HA_{OffSite}$: Amount of Material to be Hauled Off-Site (yd^3)
HC: Average Hauling Truck Capacity (yd^3)
(1 / HC): Conversion Factor cubic yards to trips (1 trip / HC yd^3)
HT: Average Hauling Truck Round Trip Commute (mile/trip)

$V_{POL} = (VMT_{VE} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)

VM: Vehicle Exhaust On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

- Worker Trips Emissions per Phase
$VMT_{WT} = WD * WT * 1.25 * NE$

VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
WD: Number of Total Work Days (days)
WT: Average Worker Round Trip Commute (mile)
1.25: Conversion Factor Number of Construction Equipment to Number of Works
NE: Number of Construction Equipment

$V_{POL} = (VMT_{WT} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

AIR CONFORMITY APPLICABILITY MODEL REPORT
RECORD OF AIR ANALYSIS (ROAA)

1. General Information: The Air Force's Air Conformity Applicability Model (ACAM) was used to perform a net change in emissions analysis to assess the potential air quality impact/s associated with the action. The analysis was performed in accordance with the Air Force Manual 32-7002, *Environmental Compliance and Pollution Prevention*; the *Environmental Impact Analysis Process* (EIAP, 32 CFR 989); the *General Conformity Rule* (GCR, 40 CFR 93 Subpart B); and the *USAF Air Quality Environmental Impact Analysis Process (EIAP) Guide*. This report provides a summary of the ACAM analysis.

a. Action Location:
Base: VANDENBERG AFB
State: California
County(s): Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

b. Action Title: Falcon Program at Vandenberg Space Force Base

c. Project Number/s (if applicable):

d. Projected Action Start Date: 1 / 2025

e. Action Description:

The Proposed Action is to increase the annual Falcon launch cadence at VSFB through launches at SLC-4 to support future commercial and U.S. government launch service needs. SpaceX would launch Falcon 9 from SLC-4. Falcon 9 is approximately 229 feet tall and produces approximately 1.7 million pounds of thrust at liftoff. A discussion of Falcon 9 can be found in the 2016 EA and associated supplemental environmental documents. The number of launches would increase from 36 to 50 per year under the Proposed Action.

f. Point of Contact:
Name: Adam Poll
Title: Civilian/Senior Air Quality Specialist
Organization: Dudek
Email: apoll@dudek.com
Phone Number: 8053088516

2. Air Impact Analysis: Based on the attainment status at the action location, the requirements of the GCR are:

____ applicable
__X__ not applicable

Total reasonably foreseeable net direct and indirect emissions associated with the action were estimated through ACAM on a calendar-year basis for the start of the action through achieving "steady state" (hsba.e., no net gain/loss in emission stabilized and the action is fully implemented) emissions. The ACAM analysis uses the latest and most accurate emission estimation techniques available; all algorithms, emission factors, and methodologies used are described in detail in the *USAF Air Emissions Guide for Air Force Stationary Sources*, the *USAF Air Emissions Guide for Air Force Mobile Sources*, and the *USAF Air Emissions Guide for Air Force Transitory Sources*.

"Insignificance Indicators" were used in the analysis to provide an indication of the significance of the proposed Action's potential impacts to local air quality. The insignificance indicators are trivial (de minimis) rate thresholds that have been demonstrated to have little to no impact to air quality. These insignificance indicators are the 250 ton/yr Prevention of Significant Deterioration (PSD) major source threshold and 25 ton/yr for lead for actions occurring in areas that are "Attainment" (hsba.e., not exceeding any National Ambient Air Quality Standard (NAAQS)). These indicators do not define a significant impact; however, they do provide a threshold to identify actions that are insignificant. Any action with net emissions below the insignificance indicators for all criteria pollutants is considered so insignificant that the action will not cause or contribute to an exceedance on one or more NAAQS. For further detail on insignificance indicators, refer to *Level II, Air Quality Quantitative Assessment, Insignificance Indicators*.

The action's net emissions for every year through achieving steady state were compared against the Insignificance Indicators and are summarized below.

Analysis Summary:

2025

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2026

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2027

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2028

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			

VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2029

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2030

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2031

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2032

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No

NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2033

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2034

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2035

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2036

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No

CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2037

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2038

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2039

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2040

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No

SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2041

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2042

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2043

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2044

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No

PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2045

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2046

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2047

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2048

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No

PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2049

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2050

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2051

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2052

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No

Pb	0.000	25	No
NH3	0.166	250	No

2053

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2054

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2055

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.328	250	No
NOx	6.669	250	No
CO	11.404	250	No
SOx	0.886	250	No
PM 10	1.066	250	No
PM 2.5	1.014	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2056 - (Steady State)

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.328	250	No
NOx	6.669	250	No
CO	11.404	250	No
SOx	0.886	250	No
PM 10	1.066	250	No
PM 2.5	1.014	250	No
Pb	0.000	25	No

AIR CONFORMITY APPLICABILITY MODEL REPORT
RECORD OF AIR ANALYSIS (ROAA)

NH3	0.166	250	No

None of the estimated annual net emissions associated with this action are above the insignificance indicators; therefore, the action will not cause or contribute to an exceedance of one or more NAAQSs and will have an insignificant impact on air quality. No further air assessment is needed.

Adam Poll, Civilian/Senior Air Quality Specialist Jun 26 2024

Name, Title **Date**

AIR CONFORMITY APPLICABILITY MODEL REPORT
GREENHOUSE GAS (GHG) EMISSIONS

1. General Information: The Air Force's Air Conformity Applicability Model (ACAM) was used to perform an analysis to estimate GHG emissions and assess the theoretical Social Cost of Greenhouse Gases (SC GHG) associated with the action. The analysis was performed in accordance with the Air Force Manual 32-7002, Environmental Compliance and Pollution Prevention; the Environmental Impact Analysis Process (EIAP, 32 CFR 989); and the USAF Air Quality Environmental Impact Analysis Process (EIAP) Guide. This report provides a summary of GHG emissions and SC GHG analysis.

a. Action Location:
Base: VANDENBERG AFB
State: California
County(s): Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

b. Action Title: Falcon Program at Vandenberg Space Force Base

c. Project Number/s (if applicable):

d. Projected Action Start Date: 1 / 2025

e. Action Description:

The Proposed Action is to increase the annual Falcon launch cadence at VSFB through launches at SLC-4 to support future commercial and U.S. government launch service needs. SpaceX would launch Falcon 9 from SLC-4. Falcon 9 is approximately 229 feet tall and produces approximately 1.7 million pounds of thrust at liftoff. A discussion of Falcon 9 can be found in the 2016 EA and associated supplemental environmental documents. The number of launches would increase from 36 to 50 per year under the Proposed Action.

f. Point of Contact:
Name: Adam Poll
Title: Civilian/Senior Air Quality Specialist
Organization: Dudek
Email: apoll@dudek.com
Phone Number: 8053088516

2. Analysis: Total combined direct and indirect GHG emissions associated with the action were estimated through ACAM on a calendar-year basis from the action start through the expected life cycle of the action. The life cycle for Air Force actions with "steady state" emissions (SS, net gain/loss in emission stabilized and the action is fully implemented) is assumed to be 10 years beyond the SS emissions year or 20 years beyond SS emissions year for aircraft operations related actions.

GHG Emissions Analysis Summary:

GHGs produced by fossil-fuel combustion are primarily carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (NO_2). These three GHGs represent more than 97 percent of all U.S. GHG emissions. Emissions of GHGs are typically quantified and regulated in units of CO_2 equivalents (CO_2e). The CO_2e takes into account the global warming potential (GWP) of each GHG. The GWP is the measure of a particular GHG's ability to absorb solar radiation as well as its residence time within the atmosphere. The GWP allows comparison of global warming impacts between different gases; the higher the GWP, the more that gas contributes to climate change in comparison to CO_2. All GHG emissions estimates were derived from various emission sources using the methods, algorithms, emission factors, and GWPs from the most current Air Emissions Guide for Air Force Stationary Sources, Air Emissions Guide for Air Force Mobile Sources, and/or Air Emissions Guide for Air Force Transitory Sources.

AIR CONFORMITY APPLICABILITY MODEL REPORT
GREENHOUSE GAS (GHG) EMISSIONS

The Air Force has adopted the Prevention of Significant Deterioration (PSD) threshold for GHG of 75,000 ton per year (ton/yr) of CO2e (or 68,039 metric ton per year, mton/yr) as an indicator or "threshold of insignificance" for NEPA air quality impacts in all areas. This indicator does not define a significant impact; however, it provides a threshold to identify actions that are insignificant (de minimis, too trivial or minor to merit consideration). Actions with a net change in GHG (CO2e) emissions below the insignificance indicator (threshold) are considered too insignificant on a global scale to warrant any further analysis. Note that actions with a net change in GHG (CO2e) emissions above the insignificance indicator (threshold) are only considered potentially significant and require further assessment to determine if the action poses a significant impact. For further detail on insignificance indicators see Level II, Air Quality Quantitative Assessment, Insignificance Indicators (April 2023).

The following table summarizes the action-related GHG emissions on a calendar-year basis through the projected life cycle of the action.

Action-Related Annual GHG Emissions (mton/yr)						
YEAR	CO2	CH4	N2O	CO2e	Threshold	Exceedance
2025	1,932	0.10630615	0.05724406	2,022	68,039	No
2026	1,932	0.10630615	0.05724406	2,022	68,039	No
2027	1,932	0.10630615	0.05724406	2,022	68,039	No
2028	1,932	0.10630615	0.05724406	2,022	68,039	No
2029	1,932	0.10630615	0.05724406	2,022	68,039	No
2030	1,932	0.10630615	0.05724406	2,022	68,039	No
2031	1,932	0.10630615	0.05724406	2,022	68,039	No
2032	1,932	0.10630615	0.05724406	2,022	68,039	No
2033	1,932	0.10630615	0.05724406	2,022	68,039	No
2034	1,932	0.10630615	0.05724406	2,022	68,039	No
2035	1,932	0.10630615	0.05724406	2,022	68,039	No
2036	1,932	0.10630615	0.05724406	2,022	68,039	No
2037	1,932	0.10630615	0.05724406	2,022	68,039	No
2038	1,932	0.10630615	0.05724406	2,022	68,039	No
2039	1,932	0.10630615	0.05724406	2,022	68,039	No
2040	1,932	0.10630615	0.05724406	2,022	68,039	No
2041	1,932	0.10630615	0.05724406	2,022	68,039	No
2042	1,932	0.10630615	0.05724406	2,022	68,039	No
2043	1,932	0.10630615	0.05724406	2,022	68,039	No
2044	1,932	0.10630615	0.05724406	2,022	68,039	No
2045	1,932	0.10630615	0.05724406	2,022	68,039	No
2046	1,932	0.10630615	0.05724406	2,022	68,039	No
2047	1,932	0.10630615	0.05724406	2,022	68,039	No
2048	1,932	0.10630615	0.05724406	2,022	68,039	No
2049	1,932	0.10630615	0.05724406	2,022	68,039	No
2050	1,932	0.10630615	0.05724406	2,022	68,039	No
2051	1,932	0.10630615	0.05724406	2,022	68,039	No
2052	1,932	0.10630615	0.05724406	2,022	68,039	No
2053	1,932	0.10630615	0.05724406	2,022	68,039	No
2054	1,932	0.10630615	0.05724406	2,022	68,039	No
2055	1,793	0.10066654	0.05611577	1,882	68,039	No
2056 [SS Year]	1,793	0.10066654	0.05611577	1,882	68,039	No
2057	1,793	0.10066654	0.05611577	1,882	68,039	No
2058	1,793	0.10066654	0.05611577	1,882	68,039	No
2059	1,793	0.10066654	0.05611577	1,882	68,039	No
2060	1,793	0.10066654	0.05611577	1,882	68,039	No
2061	1,793	0.10066654	0.05611577	1,882	68,039	No
2062	1,793	0.10066654	0.05611577	1,882	68,039	No
2063	1,793	0.10066654	0.05611577	1,882	68,039	No

2064	1,793	0.10066654	0.05611577	1,882	68,039	No
2065	1,793	0.10066654	0.05611577	1,882	68,039	No
2066	1,793	0.10066654	0.05611577	1,882	68,039	No

The following U.S. and State's GHG emissions estimates (next two tables) are based on a five-year average (2016 through 2020) of individual state-reported GHG emissions (Reference: State Climate Summaries 2022, NOAA National Centers for Environmental Information, National Oceanic and Atmospheric Administration. https://statesummaries.ncics.org/downloads/).

State's Annual GHG Emissions (mton/yr)				
YEAR	CO2	CH4	N2O	CO2e
2025	336,950,322	1,567,526	55,459	338,573,307
2026	336,950,322	1,567,526	55,459	338,573,307
2027	336,950,322	1,567,526	55,459	338,573,307
2028	336,950,322	1,567,526	55,459	338,573,307
2029	336,950,322	1,567,526	55,459	338,573,307
2030	336,950,322	1,567,526	55,459	338,573,307
2031	336,950,322	1,567,526	55,459	338,573,307
2032	336,950,322	1,567,526	55,459	338,573,307
2033	336,950,322	1,567,526	55,459	338,573,307
2034	336,950,322	1,567,526	55,459	338,573,307
2035	336,950,322	1,567,526	55,459	338,573,307
2036	336,950,322	1,567,526	55,459	338,573,307
2037	336,950,322	1,567,526	55,459	338,573,307
2038	336,950,322	1,567,526	55,459	338,573,307
2039	336,950,322	1,567,526	55,459	338,573,307
2040	336,950,322	1,567,526	55,459	338,573,307
2041	336,950,322	1,567,526	55,459	338,573,307
2042	336,950,322	1,567,526	55,459	338,573,307
2043	336,950,322	1,567,526	55,459	338,573,307
2044	336,950,322	1,567,526	55,459	338,573,307
2045	336,950,322	1,567,526	55,459	338,573,307
2046	336,950,322	1,567,526	55,459	338,573,307
2047	336,950,322	1,567,526	55,459	338,573,307
2048	336,950,322	1,567,526	55,459	338,573,307
2049	336,950,322	1,567,526	55,459	338,573,307
2050	336,950,322	1,567,526	55,459	338,573,307
2051	336,950,322	1,567,526	55,459	338,573,307
2052	336,950,322	1,567,526	55,459	338,573,307
2053	336,950,322	1,567,526	55,459	338,573,307
2054	336,950,322	1,567,526	55,459	338,573,307
2055	336,950,322	1,567,526	55,459	338,573,307
2056 [SS Year]	336,950,322	1,567,526	55,459	338,573,307
2057	336,950,322	1,567,526	55,459	338,573,307
2058	336,950,322	1,567,526	55,459	338,573,307
2059	336,950,322	1,567,526	55,459	338,573,307
2060	336,950,322	1,567,526	55,459	338,573,307
2061	336,950,322	1,567,526	55,459	338,573,307
2062	336,950,322	1,567,526	55,459	338,573,307
2063	336,950,322	1,567,526	55,459	338,573,307
2064	336,950,322	1,567,526	55,459	338,573,307
2065	336,950,322	1,567,526	55,459	338,573,307
2066	336,950,322	1,567,526	55,459	338,573,307

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U.S. Annual GHG Emissions (mton/yr)				
YEAR	CO2	CH4	N2O	CO2e
2025	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2026	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2027	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2028	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2029	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2030	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2031	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2032	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2033	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2034	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2035	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2036	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2037	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2038	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2039	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2040	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2041	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2042	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2043	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2044	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2045	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2046	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2047	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2048	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2049	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2050	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2051	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2052	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2053	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2054	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2055	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2056 [SS Year]	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2057	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2058	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2059	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2060	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2061	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2062	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2063	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2064	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2065	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2066	5,136,454,179	25,626,912	1,500,708	5,163,581,798

GHG Relative Significance Assessment:

A Relative Significance Assessment uses the rule of reason and the concept of proportionality along with the consideration of the affected area (yGba.e., global, national, and regional) and the degree (intensity) of the proposed action's effects. The Relative Significance Assessment provides real-world context and allows for a reasoned choice against alternatives through a relative comparison analysis. The analysis weighs each alternative's annual net change in GHG emissions proportionally against (or relative to) global, national, and regional emissions.

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The action's surroundings, circumstances, environment, and background (context associated with an action) provide the setting for evaluating the GHG intensity (impact significance). From an air quality perspective, context of an action is the local area's ambient air quality relative to meeting the NAAQSs, expressed as attainment, nonattainment, or maintenance areas (this designation is considered the attainment status). GHGs are non-hazardous to health at normal ambient concentrations and, at a cumulative global scale, action-related GHG emissions can only potentially cause warming of the climatic system. Therefore, the action-related GHGs generally have an insignificant impact to local air quality.

However, the affected area (context) of GHG/climate change is global. Therefore, the intensity or degree of the proposed action's GHG/climate change effects are gauged through the quantity of GHG associated with the action as compared to a baseline of the state, U.S., and global GHG inventories. Each action (or alternative) has significance, based on their annual net change in GHG emissions, in relation to or proportionally to the global, national, and regional annual GHG emissions.

To provide real-world context to the GHG and climate change effects on a global scale, an action's net change in GHG emissions is compared relative to the state (where action will occur) and U.S. annual emissions. The following table provides a relative comparison of an action's net change in GHG emissions vs. state and U.S. projected GHG emissions for the same time period.

Total GHG Relative Significance (mton)					
		CO2	CH4	N2O	CO2e
2025-2066	State Total	14,151,913,505	65,836,095	2,329,292	14,220,078,892
2025-2066	U.S. Total	215,731,075,518	1,076,330,291	63,029,721	216,870,435,529
2025-2066	Action	79,478	4.397183	2.390711	83,242
Percent of State Totals		0.00056160%	0.00000668%	0.00010264%	0.00058538%
Percent of U.S. Totals		0.00003684%	0.00000041%	0.00000379%	0.00003838%

Climate Change Assessment (as SC GHG):

On a global scale, the potential climate change effects of an action are indirectly addressed and put into context through providing the theoretical SC GHG associated with an action. The SC GHG is an administrative and theoretical tool intended to provide additional context to a GHG's potential impacts through approximating the long-term monetary damage that may result from GHG emissions affect on climate change. It is important to note that the SC GHG is a monetary quantification, in 2020 U.S. dollars, of the theoretical economic damages that could result from emitting GHGs into the atmosphere.

The SC GHG estimates are derived using the methodology and discount factors in the "Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990," released by the Interagency Working Group on Social Cost of Greenhouse Gases (IWG SC GHGs) in February 2021.

The speciated IWG Annual SC GHG Emission associated with an action (or alternative) are first estimated as annual unit cost (cost per metric ton, $/mton). Results of the annual IWG Annual SC GHG Emission Assessments are tabulated in the IWG Annual SC GHG Cost per Metric Ton Table below:

IWG SC GHG Discount Factor: 2.5%

IWG Annual SC GHG Cost per Metric Ton ($/mton [In 2020 $])			
YEAR	CO2	CH4	N2O
2025	$83.00	$2,200.00	$30,000.00
2026	$84.00	$2,300.00	$30,000.00
2027	$86.00	$2,300.00	$31,000.00

2028	$87.00	$2,400.00	$32,000.00
2029	$88.00	$2,500.00	$32,000.00
2030	$89.00	$2,500.00	$33,000.00
2031	$91.00	$2,600.00	$33,000.00
2032	$92.00	$2,600.00	$34,000.00
2033	$94.00	$2,700.00	$35,000.00
2034	$95.00	$2,800.00	$35,000.00
2035	$96.00	$2,800.00	$36,000.00
2036	$98.00	$2,900.00	$36,000.00
2037	$99.00	$3,000.00	$37,000.00
2038	$100.00	$3,000.00	$38,000.00
2039	$102.00	$3,100.00	$38,000.00
2040	$103.00	$3,100.00	$39,000.00
2041	$104.00	$3,200.00	$39,000.00
2042	$106.00	$3,300.00	$40,000.00
2043	$107.00	$3,300.00	$41,000.00
2044	$108.00	$3,400.00	$41,000.00
2045	$110.00	$3,500.00	$42,000.00
2046	$111.00	$3,500.00	$43,000.00
2047	$112.00	$3,600.00	$43,000.00
2048	$114.00	$3,700.00	$44,000.00
2049	$115.00	$3,700.00	$45,000.00
2050	$116.00	$3,800.00	$45,000.00
2051	$118.00	$3,827.00	$45,817.00
2052	$119.00	$3,888.00	$46,423.00
2053	$120.00	$3,950.00	$47,028.00
2054	$122.00	$4,011.00	$47,634.00
2055	$123.00	$4,072.00	$48,240.00
2056 [SS Year]	$124.00	$4,134.00	$48,845.00
2057	$126.00	$4,195.00	$49,451.00
2058	$127.00	$4,257.00	$50,057.00
2059	$128.00	$4,318.00	$50,662.00
2060	$130.00	$4,379.00	$51,268.00
2061	$131.00	$4,441.00	$51,874.00
2062	$132.00	$4,502.00	$52,479.00
2063	$134.00	$4,563.00	$53,085.00
2064	$135.00	$4,625.00	$53,691.00
2065	$136.00	$4,686.00	$54,296.00
2066	$138.00	$4,747.00	$54,902.00

Action-related SC GHG were estimated by calendar-year for the projected action's lifecycle. Annual estimates were found by multiplying the annual emission for a given year by the corresponding IWG Annual SC GHG Emission value (see table above).

Action-Related Annual SC GHG ($K/yr [In 2020 $])				
YEAR	**CO2**	**CH4**	**N2O**	**GHG**
2025	$160.36	$0.23	$1.72	$162.31
2026	$162.29	$0.24	$1.72	$164.25
2027	$166.16	$0.24	$1.77	$168.18
2028	$168.09	$0.26	$1.83	$170.18
2029	$170.02	$0.27	$1.83	$172.12
2030	$171.95	$0.27	$1.89	$174.11
2031	$175.82	$0.28	$1.89	$177.98
2032	$177.75	$0.28	$1.95	$179.97

2033	$181.61	$0.29	$2.00	$183.90
2034	$183.54	$0.30	$2.00	$185.85
2035	$185.48	$0.30	$2.06	$187.84
2036	$189.34	$0.31	$2.06	$191.71
2037	$191.27	$0.32	$2.12	$193.71
2038	$193.21	$0.32	$2.18	$195.70
2039	$197.07	$0.33	$2.18	$199.57
2040	$199.00	$0.33	$2.23	$201.56
2041	$200.93	$0.34	$2.23	$203.51
2042	$204.80	$0.35	$2.29	$207.44
2043	$206.73	$0.35	$2.35	$209.43
2044	$208.66	$0.36	$2.35	$211.37
2045	$212.53	$0.37	$2.40	$215.30
2046	$214.46	$0.37	$2.46	$217.29
2047	$216.39	$0.38	$2.46	$219.23
2048	$220.25	$0.39	$2.52	$223.17
2049	$222.19	$0.39	$2.58	$225.16
2050	$224.12	$0.40	$2.58	$227.10
2051	$227.98	$0.41	$2.62	$231.01
2052	$229.91	$0.41	$2.66	$232.99
2053	$231.85	$0.42	$2.69	$234.96
2054	$235.71	$0.43	$2.73	$238.86
2055	$220.54	$0.41	$2.71	$223.66
2056 [SS Year]	$222.33	$0.42	$2.74	$225.49
2057	$225.92	$0.42	$2.77	$229.12
2058	$227.71	$0.43	$2.81	$230.95
2059	$229.51	$0.43	$2.84	$232.78
2060	$233.09	$0.44	$2.88	$236.41
2061	$234.89	$0.45	$2.91	$238.24
2062	$236.68	$0.45	$2.94	$240.08
2063	$240.26	$0.46	$2.98	$243.70
2064	$242.06	$0.47	$3.01	$245.54
2065	$243.85	$0.47	$3.05	$247.37
2066	$247.44	$0.48	$3.08	$251.00

The following two tables summarize the U.S. and State's Annual SC GHG by calendar-year. The U.S. and State's Annual SC GHG are in 2020 dollars and were estimated by each year for the projected action lifecycle. Annual SC GHG estimates were found by multiplying the U.S. and State's annual five-year average GHG emissions for a given year by the corresponding IWG Annual SC GHG Cost per Metric Ton value.

State's Annual SC GHG ($K/yr [In 2020 $])				
YEAR	**CO2**	**CH4**	**N2O**	**GHG**
2025	$27,966,876.69	$3,448,557.38	$1,663,780.19	$33,079,214.26
2026	$28,303,827.01	$3,605,309.99	$1,663,780.19	$33,572,917.19
2027	$28,977,727.65	$3,605,309.99	$1,719,239.53	$34,302,277.18
2028	$29,314,677.97	$3,762,062.60	$1,774,698.87	$34,851,439.44
2029	$29,651,628.30	$3,918,815.21	$1,774,698.87	$35,345,142.37
2030	$29,988,578.62	$3,918,815.21	$1,830,158.21	$35,737,552.04
2031	$30,662,479.26	$4,075,567.81	$1,830,158.21	$36,568,205.29
2032	$30,999,429.58	$4,075,567.81	$1,885,617.55	$36,960,614.95
2033	$31,673,330.22	$4,232,320.42	$1,941,076.89	$37,846,727.54
2034	$32,010,280.55	$4,389,073.03	$1,941,076.89	$38,340,430.47
2035	$32,347,230.87	$4,389,073.03	$1,996,536.23	$38,732,840.13
2036	$33,021,131.51	$4,545,825.64	$1,996,536.23	$39,563,493.38

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2037	$33,358,081.83	$4,702,578.25	$2,051,995.57	$40,112,655.65
2038	$33,695,032.15	$4,702,578.25	$2,107,454.91	$40,505,065.31
2039	$34,368,932.80	$4,859,330.86	$2,107,454.91	$41,335,718.56
2040	$34,705,883.12	$4,859,330.86	$2,162,914.25	$41,728,128.23
2041	$35,042,833.44	$5,016,083.46	$2,162,914.25	$42,221,831.16
2042	$35,716,734.08	$5,172,836.07	$2,218,373.59	$43,107,943.75
2043	$36,053,684.40	$5,172,836.07	$2,273,832.93	$43,500,353.41
2044	$36,390,634.73	$5,329,588.68	$2,273,832.93	$43,994,056.34
2045	$37,064,535.37	$5,486,341.29	$2,329,292.27	$44,880,168.93
2046	$37,401,485.69	$5,486,341.29	$2,384,751.61	$45,272,578.59
2047	$37,738,436.01	$5,643,093.90	$2,384,751.61	$45,766,281.52
2048	$38,412,336.66	$5,799,846.51	$2,440,210.95	$46,652,394.11
2049	$38,749,286.98	$5,799,846.51	$2,495,670.29	$47,044,803.77
2050	$39,086,237.30	$5,956,599.11	$2,495,670.29	$47,538,506.70
2051	$39,760,137.94	$5,998,922.32	$2,540,980.57	$48,300,040.83
2052	$40,097,088.26	$6,094,541.41	$2,574,588.93	$48,766,218.60
2053	$40,434,038.58	$6,191,728.03	$2,608,141.83	$49,233,908.44
2054	$41,107,939.23	$6,287,347.12	$2,641,750.19	$50,037,036.54
2055	$41,444,889.55	$6,382,966.21	$2,675,358.55	$50,503,214.31
2056 [SS Year]	$41,781,839.87	$6,480,152.83	$2,708,911.45	$50,970,904.15
2057	$42,455,740.51	$6,575,771.92	$2,742,519.81	$51,774,032.24
2058	$42,792,690.84	$6,672,958.53	$2,776,128.17	$52,241,777.54
2059	$43,129,641.16	$6,768,577.62	$2,809,681.07	$52,707,899.85
2060	$43,803,541.80	$6,864,196.72	$2,843,289.43	$53,511,027.95
2061	$44,140,492.12	$6,961,383.33	$2,876,897.79	$53,978,773.25
2062	$44,477,442.44	$7,057,002.42	$2,910,450.69	$54,444,895.56
2063	$45,151,343.09	$7,152,621.51	$2,944,059.05	$55,248,023.65
2064	$45,488,293.41	$7,249,808.13	$2,977,667.41	$55,715,768.95
2065	$45,825,243.73	$7,345,427.22	$3,011,220.31	$56,181,891.26
2066	$46,499,144.37	$7,441,046.31	$3,044,828.67	$56,985,019.36

U.S. Annual SC GHG ($K/yr [In 2020 $])				
YEAR	CO2	CH4	N2O	GHG
2025	$426,325,696.86	$56,379,205.70	$45,021,229.08	$527,726,131.63
2026	$431,462,151.04	$58,941,896.86	$45,021,229.08	$535,425,276.98
2027	$441,735,059.39	$58,941,896.86	$46,521,936.72	$547,198,892.97
2028	$446,871,513.57	$61,504,588.03	$48,022,644.35	$556,398,745.96
2029	$452,007,967.75	$64,067,279.20	$48,022,644.35	$564,097,891.30
2030	$457,144,421.93	$64,067,279.20	$49,523,351.99	$570,735,053.12
2031	$467,417,330.29	$66,629,970.37	$49,523,351.99	$583,570,652.65
2032	$472,553,784.47	$66,629,970.37	$51,024,059.62	$590,207,814.46
2033	$482,826,692.83	$69,192,661.54	$52,524,767.26	$604,544,121.62
2034	$487,963,147.01	$71,755,352.70	$52,524,767.26	$612,243,266.97
2035	$493,099,601.18	$71,755,352.70	$54,025,474.90	$618,880,428.78
2036	$503,372,509.54	$74,318,043.87	$54,025,474.90	$631,716,028.31
2037	$508,508,963.72	$76,880,735.04	$55,526,182.53	$640,915,881.29
2038	$513,645,417.90	$76,880,735.04	$57,026,890.17	$647,553,043.11
2039	$523,918,326.26	$79,443,426.21	$57,026,890.17	$660,388,642.63
2040	$529,054,780.44	$79,443,426.21	$58,527,597.80	$667,025,804.45
2041	$534,191,234.62	$82,006,117.38	$58,527,597.80	$674,724,949.80
2042	$544,464,142.97	$84,568,808.54	$60,028,305.44	$689,061,256.96
2043	$549,600,597.15	$84,568,808.54	$61,529,013.08	$695,698,418.77
2044	$554,737,051.33	$87,131,499.71	$61,529,013.08	$703,397,564.12
2045	$565,009,959.69	$89,694,190.88	$63,029,720.71	$717,733,871.28

2046	$570,146,413.87	$89,694,190.88	$64,530,428.35	$724,371,033.10
2047	$575,282,868.05	$92,256,882.05	$64,530,428.35	$732,070,178.44
2048	$585,555,776.41	$94,819,573.22	$66,031,135.98	$746,406,485.61
2049	$590,692,230.59	$94,819,573.22	$67,531,843.62	$753,043,647.42
2050	$595,828,684.76	$97,382,264.38	$67,531,843.62	$760,742,792.77
2051	$606,101,593.12	$98,074,191.00	$68,757,921.76	$772,933,705.88
2052	$611,238,047.30	$99,637,432.61	$69,667,350.59	$780,542,830.50
2053	$616,374,501.48	$101,226,301.14	$70,575,278.71	$788,176,081.32
2054	$626,647,409.84	$102,789,542.75	$71,484,707.53	$800,921,660.12
2055	$631,783,864.02	$104,352,784.36	$72,394,136.36	$808,530,784.74
2056 [SS Year]	$636,920,318.20	$105,941,652.89	$73,302,064.48	$816,164,035.56
2057	$647,193,226.55	$107,504,894.50	$74,211,493.31	$828,909,614.36
2058	$652,329,680.73	$109,093,763.02	$75,120,922.14	$836,544,365.89
2059	$657,466,134.91	$110,657,004.63	$76,028,850.26	$844,151,989.80
2060	$667,739,043.27	$112,220,246.25	$76,938,279.08	$856,897,568.60
2061	$672,875,497.45	$113,809,114.77	$77,847,707.91	$864,532,320.13
2062	$678,011,951.63	$115,372,356.38	$78,755,636.03	$872,139,944.04
2063	$688,284,859.99	$116,935,598.00	$79,665,064.86	$884,885,522.84
2064	$693,421,314.17	$118,524,466.52	$80,574,493.68	$892,520,274.37
2065	$698,557,768.34	$120,087,708.13	$81,482,421.80	$900,127,898.28
2066	$708,830,676.70	$121,650,949.74	$82,391,850.63	$912,873,477.08

Relative Comparison of SC GHG:

To provide additional real-world context to the potential climate change impact associate with an action, a Relative Comparison of SC GHG Assessment is also performed. While the SC GHG estimates capture an indirect approximation of global climate damages, the Relative Comparison of SC GHG Assessment provides a better perspective from a regional and global scale.

The Relative Comparison of SC GHG Assessment uses the rule of reason and the concept of proportionality along with the consideration of the affected area (yGba.e., global, national, and regional) and the SC GHG as the degree (intensity) of the proposed action's effects. The Relative Comparison Assessment provides real-world context and allows for a reasoned choice among alternatives through a relative contrast analysis which weighs each alternative's SC GHG proportionally against (or relative to) existing global, national, and regional SC GHG. The below table provides a relative comparison between an action's SC GHG vs. state and U.S. projected SC GHG for the same time period:

Total SC-GHG ($K [In 2020 $])					
		CO2	**CH4**	**N2O**	**GHG**
2025-2066	State Total	$1,561,090,839.68	$229,477,980.85	$98,592,952.22	$1,889,161,772.76
2025-2066	U.S. Total	$23,797,192,211.31	$3,751,651,735.39	$2,667,886,001.31	$30,216,729,948.01
2025-2066	Action	$8,733.75	$15.26	$101.07	$8,850.09
Percent of State Totals		0.00055946%	0.00000665%	0.00010251%	0.00046847%
Percent of U.S. Totals		0.00003670%	0.00000041%	0.00000379%	0.00002929%

From a global context, the action alternative's total SC GHG percentage of total global SC GHG for the same time period is: 0.00000392%.*

* Global value based on the U.S. emits 13.4% of all global GHG annual emissions (2018 Emissions Data, Center for Climate and Energy Solutions, accessed 7-6-2023, https://www.c2es.org/content/international-emissions).

AIR CONFORMITY APPLICABILITY MODEL REPORT
GREENHOUSE GAS (GHG) EMISSIONS

Adam Poll, Civilian/Senior Air Quality Specialist	Jun 26 2024
Name, Title	**Date**

Launch, Landing, and Static Fire

						Emission Factors						Emissions							Emissions						
			<3,000ft			Pounds per burn second						Tons emitted per launch						Metric tons per Activity	Tons per year						Metric tons per year
Type	Stage	Fuel	Burn time (seconds)	Number of Engines	Annual Activities	VOC	NOx	CO	SOx	PM10	PM2.5	VOC	NOx	CO	SOx	PM10	PM2.5	CO2e	VOC	NOx	CO	SOx	PM10	PM2.5	CO2e
Launch Falcon 9	1	RP1/LOX	23	9	50	0.00	9.42	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	273.96	0.00	5.42	0.00	0.00	0.00	0.00	13,697.79
Landing (Offshore) Falcon 9	1	RP1/LOX	18	3	43	0.00	3.14	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	90.41	0.00	1.22	0.00	0.00	0.00	0.00	3,887.43
Landing (VSFB) Falcon 9	1	RP1/LOX	18	3	7	0.00	3.14	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	90.41	0.00	0.20	0.00	0.00	0.00	0.00	632.84
Static Fire Falcon 9	1	RP1/LOX	7	9	30	0.00	9.42	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	18.26	0.00	0.99	0.00	0.00	0.00	0.00	547.91
																		Total	**0.00**	**7.82**	**0.00**	**0.00**	**0.00**	**0.00**	**18,765.97**

Emission Factors Per Engine

	Emission Factors (pounds per second per engine)						
Propellant	VOC	NOx	CO	SOx	PM10	PM2.5	CO2
RP-1/LOX	0.00	1.05	0.00	0.00	0.00	0.00	639.12

Source: Exhaust Plume Calculations for SpaceX Merlin5 Booster Engine, Sierra Engineering & Software, Inc. (June 14, 2019)

Notes:

Launch emissions include fuel spent up to 3,000 ft AGL.

Landing emissions include all intermittent burns below 3,000 ft AGL.

Static fire assumes all 9 engines with a 7 second burn time.

Landing emissions assumed to be 33% of nominal power (only 3 engines used).

Launch GHG emissions include fuel spent up to 100,000ft MSL (approximately 105 seconds).

Landing GHG emissions include all intermittent burns below 100,000 ft MSL.

Booster Recovery Operations

																Emissions (<3 nm)											Emissions (3-12 nm)										
Vessel	Operations Per Year	Total Ship time on Range	Engines and Generators		Horsepower	Emission Factors (g/kWh)										Tons							Metric Tons				Tons							Metric Tons			
		Hours	No.	Load		VOCs	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O	VOCs	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O	CO2e	VOCs	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O	CO2e
Tugboat	43	68	2	0.5	850	0.53	2.60	1.10	0.41	0.19	0.19	0.00	656.12	0.01	0.03	0.01	0.04	0.02	0.01	0.00	0.00	0.00	8.46	0.00	0.00	8.58	0.02	0.11	0.05	0.02	0.01	0.01	0.00	25.39	0.00	0.00	25.74
	43	68	2	0.31	133	0.53	2.60	1.10	0.41	0.19	0.19	0.00	656.12	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.82	0.00	0.00	0.83	0.00	0.01	0.00	0.00	0.00	0.00	0.00	2.46	0.00	0.00	2.50
Support Boat	43	68	1	0.5	3,900	0.53	2.60	1.10	0.41	0.19	0.19	0.00	656.12	0.01	0.03	0.02	0.08	0.04	0.01	0.01	0.01	0.00	19.42	0.00	0.00	19.68	0.05	0.25	0.11	0.04	0.02	0.02	0.00	58.25	0.00	0.00	59.04
	43	68	2	0.31	114	0.53	2.60	1.10	0.41	0.19	0.19	0.00	656.12	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.71	0.00	0.01	0.00	0.00	0.00	0.00	0.00	2.11	0.00	0.00	2.14
Barge	43	12	1	0.6	2,600	0.53	2.60	1.10	0.41	0.19	0.19	0.00	656.12	0.01	0.03	0.00	0.01	0.01	0.00	0.00	0.00	0.00	2.74	0.00	0.00	2.78	0.01	0.04	0.02	0.01	0.00	0.00	0.00	8.22	0.00	0.00	8.34
	43	68	1	0.6	268	0.18	2.50	0.90	0.16	0.22	0.22	0.00	568.30	0.03	0.03	0.00	0.01	0.00	0.00	0.00	0.00	0.00	1.39	0.00	0.00	1.41	0.00	0.02	0.01	0.00	0.00	0.00	0.00	4.16	0.00	0.00	4.23
															Total	**0.03**	**0.15**	**0.06**	**0.02**	**0.01**	**0.01**	**0.00**	**33.53**	**0.00**	**0.00**	**33.99**	**0.09**	**0.44**	**0.19**	**0.07**	**0.03**	**0.03**	**0.00**	**100.60**	**0.00**	**0.00**	**101.98**

Notes:

Total ship time, engine specifics, and emission factors consistent with the 2023 SEA.

Fairing Recovery Operations

Vessel	Operations Per Year	Total Ship time on Range	Engines and Generators		Horsepower	Emission Factors (g/kWh)									
		Hours	No.	Load		VOCs	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
Support Boat	43	68	2	0.6	820	0.53	2.60	1.10	0.41	0.19	0.19	0.00	656.12	0.01	0.03

Vessel	Emissions (<3 nm)										
	Tons							Metric Tons			
	VOCs	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O	CO2e
Support Boat	0.01	0.04	0.02	0.01	0.00	0.00	0.00	9.80	0.00	0.00	9.93

Vessel	Emissions (3-12 nm)										
	Tons							Metric Tons			
	VOCs	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O	CO2e
Support Boat	0.03	0.13	0.05	0.02	0.01	0.01	0.00	29.39	0.00	0.00	29.79

Notes:

Total ship time, engine specifics, and emission factors consistent with the 2023 SEA.

Equipment	NO_x	ROC	CO	SO_x	PM	PM_{10}	$PM_{2.5}$
Falcon 9 RP-1							
lb/day		0.68					
TPY		0.01					
RSV Loading							
lb/day		95.81					
TPY		0.05					
Payload Fueling							
lb/day	14.84	0.15					
TPY	0.11	0.00					
Solvent Use							
lb/day		45.54					
TPY		5.93					
Total Emissions							
lb/day	**14.84**	**142.19**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
TPY	**0.11**	**5.99**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Falcon 9 Potential to Emit Calculations

Attachment: A-1
Permit Number: PTO 15069
Facility: SpaceX

RP-1 and System Input Data

Information	*Value*	*Units*	*Reference*
Specific Gravity at System Temp................	0.840	--	Material Specifications
Vapor Pressure @ 20 °F..............................	0.00088	psi	Material Specifications
Vapor Molecular Weight.............................	148.00	lb/lb-mol	Material Specifications
Gas Constant...	10.73	scf-psi/°R-lb-mol	Ideal Gas Laws
System and RP-1 Temperature.................	474.67	°R	Permit Application
RP-1 Emission Factor..........................	0.00003	lb/ft^3	Calculated Value

Maximum Process Event Summary

Event Name	*Value*	*Units*	*Reference*
Events..	50	events/year	Permit Application
Static Launch and Abort Events.....................	30	events/year	Permit Application
Events per day	2	events/day	Permit Application
Event Vehicle RP-1 Throughput Volume..........	48,500	gals/event	Permit Application
Event Fill Line Throughput Volume................	1,543	gals/event	Permit Application
Daily Launch Volume.................................	50,043	gals/day	Calculated Value
Daily Static Launch and Abort Volume..........	50,043	gals/day	Calculated Value
Daily Launch Volume.................................	6,690	ft^3/day	Calculated Value
Daily Static Launch and Abort Volume..........	13,380	ft^3/day	Calculated Value
Annual Launch Volume...............................	2,502,150	gals/year	Calculated Value
Annual Static Launch and Abort Volume..........	2,502,150	gals/year	Calculated Value
Annual Launch Volume...............................	334,490	ft^3/yr	Calculated Value
Annual Static Launch and Abort Volume.........	334,490	ft^3/yr	Calculated Value

ROC Potential to Emit

Process	lb/day	TPY
Launches	0.34	0.00
Static Launches/Abort	0.68	0.00
Total PTE	**0.68**	**0.01**

Notes:
1. One Falcon 9 launch or static launch/abort permitted per day. PTE reflects the worst case scenario.

Processed By: KMB   Date: 2/11/2020

RSV Loading Potential to Emit Calculations

Attachment: A-3
Permit Number: PTO 15069
Facility: SpaceX

RP-1 and System Input Data

Information	*Value*	*Units*	*Reference*
Specific Gravity at System Temp…………….	0.809	--	Material Specifications
Vapor Pressure @ 70 °F………………………..	0.011	psi	Material Specifications
Vapor Molecular Weight………………………	148.00	lb/lb-mol	Material Specifications
Gas Constant……………………………………	10.73	scf-psi/°R-lb-mol	Ideal Gas Laws
System and RP-1 Temperature……..……..	529.67	°R	Permit Application
RP-1 Emission Factor………………………	0.00029	lb/ft^3	Calculated Value

RP-1 Fuel Consumption

Consumption Operations	*Value*	*Units*	*Reference*
Worst Case Daily RP-1 Consumption…………	378,000	gals/day	Equal to Total RP-1 Tank Calcs
Worst Case Annual RP-1 Consumption…….	2,502,150	gals	Falcon 9 Annual Launch Volume
Falcon 9 RP-1 Consumption…………………….	334,490	ft^3	Calculated Values

ROC Potential to Emit

lb/day	TPY
95.81	0.05

Processed By: KMB

Date: 2/11/2020

Payload Fueling Potential to Emit Calculations

Attachment: A-4
Permit Number: PTO 15069
Facility: SpaceX

Payload/Unloading Input Data

Information	*Value*	*Units*	*Reference*
Flow Rate (loading/unloading).............	5.00	scf/min	Permit Application
MMH Molecular Weight.....................	60.10	lb/lb-mol	Permit Application
N_2O_4 Molecular Weight..................	92.01	lb/lb-mol	Permit Application
Molar Denisty..........................	0.00264	lb-mole/scf	Permit Application
Processing Time........................	4	hours	Permit Application
Loading Annual Operations................	10	events/year	Permit Application
Unloading Annual Operations.............	5	events/year	Permit Application
Loading Control Efficiency...........	99.95	%	Permit Application
Unloading Control Efficiency..........	95.70	%	Permit Application
NO_x Fugitives Per Event.................	2.31	lb/event	Permit Application
ROC Fugitives Per Event.................	0.058	lb/event	Permit Application

Payload Loading Controlled Potential to Emit

Propellant	Pollutant	lb/day	TPY
N_2O_4	NO_x	12.53	0.06
MMH	ROC	0.10	0.00
N_2O_4	NO_x (Fugitives)	2.31	0.01
MMH	ROC (Fugitives)	0.06	0.00

Payload Unloading Controlled Potential to Emit

Propellant	Pollutant	lb/day	TPY
N_2O_4	NO_x	12.53	0.03
MMH	ROC	0.10	0.00
N_2O_4	NO_x (Fugitives)	2.31	0.01
MMH	ROC (Fugitives)	0.06	0.00

Total Potential to Emit

Propellant	Pollutant	lb/day	TPY
N_2O_4	NO_x	14.84	0.11
MMH	ROC	0.15	0.00

Notes:
1. One payload loading or unloading event permitted per day.
   PTE reflects the worst case scenario.

Processed By: KMB   Date: 2/11/2020

Roll-On Roll-Off Emissions - Los Angeles County Elizabeth C

Source Category	VOC	NO_x	CO	SO_x	PM_{10}	$PM_{2.5}$	Pb	CO2	CH4	N2O	CO2e
	ton/yr							MT/yr			
Marine Vessel	1.57	17.65	31.64	0.43	0.38	0.38	0.00	4102.10	0.06	0.17	4152.93
Off-Road	0.10	1.77	2.34	0.00	0.06	0.06	0.00	396.28	0.12	0.05	414.69
Total	**1.66**	**19.41**	**33.98**	**0.43**	**0.44**	**0.44**	**0.00**	**4,498.38**	**0.17**	**0.22**	**4,567.62**

Roll-On Roll-Off Emissions - Los Angeles County Elizabeth C

Marine Emission Estimates - Elizabeth C

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (hours/yr)
Tugboat	Transit	Propulsion	4	0.1%S	2	1,300	969	1.00	24.00	2088
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	2088
Generator-Barge	Transit	Generator Sets	4	0.1%S	1	49	37	0.74	24.00	2088
Emission Subtotals										

Boat Classification	Emission Factors VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
	(g/kW-hr)									
Tugboat	0.19	1.80	5.00	0.07	0.04	0.04	0.00	715.76	0.01	0.03
Tugboat	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03
	(g/hp-hr)									
Generator-Barge	0.12	2.75	4.10	0.01	0.01	0.01	-	568.30	0.02	0.01
Emission Subtotals										

Boat Classification	Maximum Daily Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
	(lb/day)									
Tugboat	19.49	184.65	512.92	6.98	4.10	4.10	0.06	73,426.05	2.97	1.03
Tugboat	0.46	6.10	6.07	0.08	0.15	0.15	0.00	796.22	0.04	0.01
Generator-Barge	0.23	5.28	7.87	0.01	0.02	0.02	-	1,090.29	0.02	0.03
Emission Subtotals	**20.18**	**196.02**	**526.86**	**7.07**	**4.26**	**4.26**	**0.06**	**75,312.57**	**3.03**	**1.07**

Boat Classification	Annual Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
	(ton/yr)							(MT/yr)			
Tugboat	0.85	8.03	22.31	0.30	0.18	0.18	0.00	2,897.58	0.04	0.12	2,933.58
Tugboat	0.02	0.27	0.26	0.00	0.01	0.01	0.00	31.42	0.00	0.00	31.85
Generator-Barge	0.01	0.15	0.22	0.00	0.00	0.00	-	27.22	0.00	0.00	27.36
Emission Subtotals	**0.87**	**8.44**	**22.79**	**0.31**	**0.19**	**0.19**	**0.00**	**2,956.22**	**0.04**	**0.12**	**2,992.78**

Note:

Marine Emission Estimates - Bernardine C

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (hours/yr)
Tugboat	Transit	Propulsion	3	0.1%S	2	500	373	1.00	24.00	2088
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	2088
Emission Subtotals										

Boat Classification	Emission Factors VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
	(g/kW-hr)									
Tugboat	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03
Tugboat	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03
Emission Subtotals										

Boat Classification	Maximum Daily Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
	(lb/day)									
Tugboat	15.47	205.49	197.28	2.68	4.34	4.34	0.02	28,240.79	1.14	0.39
Tugboat	0.46	6.10	6.07	0.08	0.15	0.15	0.00	796.22	0.04	0.01
Emission Subtotals	**15.93**	**211.58**	**203.35**	**2.77**	**4.49**	**4.49**	**0.02**	**29,037.01**	**1.18**	**0.41**

Boat Classification	Annual Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
	(ton/yr)							(MT/yr)			
Tugboat	0.67	8.94	8.58	0.12	0.19	0.19	0.00	1,114.45	0.02	0.05	1,128.30
Tugboat	0.02	0.27	0.26	0.00	0.01	0.01	0.00	31.42	0.00	0.00	31.85
Emission Subtotals	**0.69**	**9.20**	**8.85**	**0.12**	**0.20**	**0.20**	**0.00**	**1,145.88**	**0.02**	**0.05**	**1,160.15**

Note:

Emission Factors

Marine Propulsion

Engine Type	Engine Family	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
					(g/kW-hr)									
Slow Speed Diesel		<=1999	Tier 0	0.1%S	0.600	17.01	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		<=1999	Tier 0	0.1%S	0.500	13.16	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2000-2010	Tier 1	0.1%S	0.600	15.98	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2000-2010	Tier 1	0.1%S	0.500	12.22	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2011-2015	Tier 2	0.1%S	0.600	14.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2011-2015	Tier 2	0.1%S	0.500	10.53	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2016+	Tier 3	0.1%S	0.600	3.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2016+	Tier 3	0.1%S	0.500	2.63	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
EPA Certification	HCEXN19.0AAA		Tier 3	0.1%S	0.392	5.21	5.0	0.07	0.11	0.11	0.0006067	716		
EPA Certification	D233051MX03		Tier 4	0.1%S	0.190	1.80	5.0	0.07	0.04	0.04	0.0006067	716		

Notes:
Emission factors from Table 2.3 and 2.4 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 1 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.

Marine Auxiliary

Engine Type	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
				(g/kW-hr)									
Aux High Speed Diesel	<=1999	Tier 0	0.1%S	0.600	10.9	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	<=1999	Tier 0	0.1%S	0.600	13.82	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	9.78	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	12.22	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	7.71	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	10.53	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	1.97	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	2.63	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux Med Speed Diesel Tier 3 Standard	2011-2015	Tier 3	0.1%S	0.378	5.022	5	0.068	0.12	0.12	0.0006067			
				(g/hp-hr)									
Generator Sets		Tier 4 Final	0.1%S	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	-	568.2990	0.0180	0.0081

Notes:
Emission factors from Table 2.9 and 2.10 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
Load factors for auxiliary engines based on Table 3.1 of the of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 5 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.
Emission factors for generator sets are default emission factors from CalEEMod 2016.3.2, which relies on OFFROAD 2011.
See Table D-12 of the Carl Moyer Program Guidelines. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/msprog/moyer/guidelines/2011/2011cmp_guidelinesVER4.pdf?_ga=2.218661721.1589730523.1723135078-1780396104.1706050686

Marine exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\, EF_i \times Eng_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF	=	*Emission factor in grams per horse-power hour*
Eng	=	*Number of engines*
AvgHP	=	*Maximum rated average horsepower*
Load	=	*Load factor*
Activity	=	*Hours of operation*
i	=	*Equipment type*

Roll-On Roll-Off Emissions - Los Angeles County Elizabeth C

Off-Road Emission Estimates

Construction Equipment	OFFROAD Model Category	Engine Tier	Quantity	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (day/yr)
Crane-LR 1300	Crane	3	1	603	450	0.29	16	200
Crane-Tadano ATF 220G	Crane	4	1	197	147	0.29	8	200
KMAG	Off-Highway Truck	3	1	453	338	0.3	4.0	200
Generator-Barge	Generator Sets	4	1	49	37	0.74	1.5	200
Emission Subtotals								

Construction Equipment	Emission Factors (g/BHP-hr) VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
Crane-LR 1300	0.12	2.32	2.6	0.005	0.088	0.088	510.334	0.152	0.068138
Crane-Tadano ATF 220G	0.0600	0.2600	3.7000	0.0050	0.0080	0.0080	514.2600	0.1540	0.0690
KMAG	0.1200	2.3200	2.6000	0.0050	0.0088	0.0088	528.8080	0.1540	0.0690
Generator-Barge	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081
Emission Subtotals									

Construction Equipment	Daily Emissions (lb/day) VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20
Crane-LR 1300	0.74	14.31	16.04	0.03	0.54	0.54	3,147.87	0.94	0.42
Crane-Tadano ATF 220G	0.06	0.26	3.73	0.01	0.01	0.01	518.16	0.16	0.07
KMAG	0.14	2.78	3.12	0.01	0.01	0.01	634	0.18	0.08
Generator-Barge	0.01	0.33	0.49	0.00	0.00	0.00	68	0.00	0.00
Emission Subtotals	**0.96**	**17.68**	**23.37**	**0.04**	**0.56**	**0.56**	**4,368.26**	**1.28**	**0.57**

Construction Equipment	Annual Emissions (MT/yr) CO2	CH4	N2O	CO2E
Crane-LR 1300	285.57	0.09	0.04	299.06
Crane-Tadano ATF 220G	47.01	0.01	0.01	49.24
KMAG	57.52	0.02	0.01	60.18
Generator-Barge	6.18	0.00	0.00	6.21
Emission Subtotals	**396.28**	**0.12**	**0.05**	**414.69**

Notes:

Emission factors are default emission factors from CalEEMod 2016.3.2, which relies on OFFROAD 2011.

Load factor for generator and cranes are defaults from CalEEMod 2016.3.2.

Load factor for KMAG based on average speed over route compared to rated maximum travel speed.

See Table D-12 of the Carl Moyer Program Guidelines. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/msprog/moyer/guidelines/2011/2011cmp_guidelinesVER4.pdf?_ga=2.218661721.1589730523.1723135078-1780396104.1706050686

Emission Factors

Equipment Type	Year	Low HP	High HP	VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
				(g/BHP-hr)								
KMAG	Tier 3	300	599	0.1200	2.3200	2.6000	0.0050	0.0088	0.0088	528.8080	0.1540	0.0690
Generator Sets	Tier 4 Final	25	49	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081
Crane-LR 1300	Tier 3	600	750	0.1200	2.3200	2.6000	0.0050	0.0880	0.0880	510.3340	0.1520	0.0681
Crane-Tadano ATF 220G	Tier 4 Final	120	174	0.0600	0.2600	3.7000	0.0050	0.0080	0.0080	514.2600	0.1540	0.0690

Off-road mobile equipment exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\, EF_i \times Pop_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF = *Emission factor in grams per horse-power hour*

Pop = *Population, or the number of pieces of equipment*

AvgHP = *Maximum rated average horsepower*

Load = *Load factor*

Activity = *Hours of operation*

i = *Equipment type*

Roll-On Roll-Off Emissions Kelly C - Los Angeles County

Source Category	**VOC**	**NO_x**	**CO**	**SO_x**	**PM_{10}**	**$PM_{2.5}$**	**Pb**	**CO2**	**CH4**	**N2O**	**CO2e**
	ton/yr							**MT/yr**			
Marine Vessel	0.78	10.44	10.06	0.14	0.22	0.22	0.00	1305.59	0.02	0.05	1321.74
Off-Road	0.10	1.77	2.34	0.00	0.06	0.06	0.00	396.28	0.12	0.05	414.69
Total	**0.88**	**12.21**	**12.40**	**0.14**	**0.28**	**0.28**	**0.00**	**1,701.88**	**0.13**	**0.10**	**1,736.43**

Roll-On Roll-Off Emissions Kelly C - Los Angeles County

Marine Emission Estimates - Kelly C

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (hours/yr)
Tugboat	Transit	Propulsion	3	0.1%S	2	1,000	746	1.00	24.00	792
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	792
Generator-Barge	Transit	Generator Sets	4	0.1%S	1	49	37	0.74	24.00	792
Emission Subtotals										

Boat Classification	Engine	Emission Factors VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
		(g/kW-hr)									
Tugboat	Propulsion	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03
Tugboat	Auxiliary	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03
		(g/hp-hr)									
Generator-Barge	Generator Sets	0.12	2.75	4.10	0.01	0.01	0.01	-	568.30	0.02	0.01

Boat Classification	Engine	Maximum Daily Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
		(lb/day)									
Tugboat	Propulsion	30.93	410.97	394.56	5.37	8.68	8.68	0.05	56,481.58	2.29	0.79
Tugboat	Auxiliary	0.46	6.10	6.07	0.08	0.15	0.15	0.00	796.22	0.04	0.01
Generator-Barge	Generator Sets	0.23	5.28	7.87	0.01	0.02	0.02	-	1,090.29	0.02	0.03
Emission Subtotals		**31.62**	**422.34**	**408.49**	**5.46**	**8.84**	**8.84**	**0.05**	**58,368.10**	**2.34**	**0.84**

Boat Classification	Engine	Annual Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
		(ton/yr)							(MT/yr)			
Tugboat	Propulsion	0.51	6.78	6.51	0.09	0.14	0.14	0.00	845.45	0.01	0.03	855.95
Tugboat	Auxiliary	0.01	0.10	0.10	0.00	0.00	0.00	0.00	11.92	0.00	0.00	12.08
Generator-Barge	Generator Sets	0.00	0.07	0.10	0.00	0.00	0.00	-	13.58	0.00	0.00	13.65
Emission Subtotals		**0.52**	**6.95**	**6.71**	**0.09**	**0.15**	**0.15**	**0.00**	**870.95**	**0.01**	**0.03**	**881.68**

Note:

Marine Emission Estimates - Bernardine C

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (hours/yr)
Tugboat	Transit	Propulsion	3	0.1%S	2	500	373	1.00	24.00	792
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	792
Emission Subtotals										

Boat Classification	Engine	Emission Factors VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
		(g/kW-hr)									
Tugboat	Propulsion	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03
Tugboat	Auxiliary	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03

Boat Classification	Engine	Maximum Daily Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
		(lb/day)									
Tugboat	Propulsion	15.47	205.49	197.28	2.68	4.34	4.34	0.02	28,240.79	1.14	0.39
Tugboat	Auxiliary	0.46	6.10	6.07	0.08	0.15	0.15	0.00	796.22	0.04	0.01
Emission Subtotals		**15.93**	**211.58**	**203.35**	**2.77**	**4.49**	**4.49**	**0.02**	**29,037.01**	**1.18**	**0.41**

Boat Classification	Engine	Annual Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
		(ton/yr)							(MT/yr)			
Tugboat	Propulsion	0.26	3.39	3.26	0.04	0.07	0.07	0.00	422.72	0.01	0.02	427.98
Tugboat	Auxiliary	0.01	0.10	0.10	0.00	0.00	0.00	0.00	11.92	0.00	0.00	12.08
Emission Subtotals		**0.26**	**3.49**	**3.36**	**0.05**	**0.07**	**0.07**	**0.00**	**434.64**	**0.01**	**0.02**	**440.06**

Note:

Emission Factors

Marine Propulsion

Engine Type	Engine Family	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
					(g/kW-hr)									
Slow Speed Diesel		<=1999	Tier 0	0.1%S	0.600	17.01	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		<=1999	Tier 0	0.1%S	0.500	13.16	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2000-2010	Tier 1	0.1%S	0.600	15.98	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2000-2010	Tier 1	0.1%S	0.500	12.22	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2011-2015	Tier 2	0.1%S	0.600	14.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2011-2015	Tier 2	0.1%S	0.500	10.53	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2016+	Tier 3	0.1%S	0.600	3.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2016+	Tier 3	0.1%S	0.500	2.63	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
EPA Certification	HCEXN19.0AAA		Tier 3	0.1%S	0.392	5.21	5.0	0.07	0.11	0.11	0.0006067	716		
EPA Certification	D233051MX03		Tier 4	0.1%S	0.190	1.80	5.0	0.07	0.04	0.04	0.0006067	716		

Notes:
Emission factors from Table 2.3 and 2.4 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 1 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.

Marine Auxiliary

Engine Type	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
				(g/kW-hr)									
Aux High Speed Diesel	<=1999	Tier 0	0.1%S	0.600	10.9	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	<=1999	Tier 0	0.1%S	0.600	13.82	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	9.78	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	12.22	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	7.71	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	10.53	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	1.97	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	2.63	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux Med Speed Diesel Tier 3 Standard	2011-2015	Tier 3	0.1%S	0.378	5.022	5	0.068	0.12	0.12	0.0006067			
				(g/hp-hr)									
Generator Sets		Tier 4 Final	0.1%S	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	-	568.2990	0.0180	0.0081

Notes:
Emission factors from Table 2.9 and 2.10 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
Load factors for auxiliary engines based on Table 3.1 of the of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 5 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.
Emission factors for generator sets are default emission factors from CalEEMod 2016.3.2, which relies on OFFROAD 2011 and the Carl Moyer Progam Guidelines.
See Table D-12 of the Carl Moyer Program Guidelines. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/msprog/moyer/guidelines/2011/2011cmp_guidelinesVER4.pdf?_ga=2.218661721.1589730523.1723135078-1780396104.1706050686

Marine exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\ EF_i \times Eng_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF	=	*Emission factor in grams per horse-power hour*
Eng	=	*Number of engines*
AvgHP	=	*Maximum rated average horsepower*
Load	=	*Load factor*
Activity	=	*Hours of operation*
i	=	*Equipment type*

Roll-On Roll-Off Emissions Kelly C - Los Angeles County

Off-Road Emission Estimates

Construction Equipment	OFFROAD Model Category	Engine Tier	Quantity	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (day/yr)
Crane-LR 1300	Crane	3	1	603	450	0.29	16	200
Crane-Tadano ATF 220G	Crane	4	1	197	147	0.29	8	200
KMAG	Off-Highway Truck	3	1	453	338	0.3	4.0	200
Generator-Barge	Generator Sets	4	1	49	37	0.74	1.5	200
Emission Subtotals								

Construction Equipment	Emission Factors (g/BHP-hr) VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
Crane-LR 1300	0.12	2.32	2.6	0.005	0.088	0.088	510.334	0.152	0.068138
Crane-Tadano ATF 220G	0.0600	0.2600	3.7000	0.0050	0.0080	0.0080	514.2600	0.1540	0.0690
KMAG	0.1200	2.3200	2.6000	0.0050	0.0088	0.0088	528.8080	0.1540	0.0690
Generator-Barge	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081
Emission Subtotals									

Construction Equipment	Daily Emissions (lb/day) VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	Annual Emissions (MT/yr) CO2	CH4	N2O	CO2E
Crane-LR 1300	0.74	14.31	16.04	0.03	0.54	0.54	3,147.87	0.94	0.42	285.57	0.09	0.04	299.06
Crane-Tadano ATF 220G	0.06	0.26	3.73	0.01	0.01	0.01	518.16	0.16	0.07	47.01	0.01	0.01	49.24
KMAG	0.14	2.78	3.12	0.01	0.01	0.01	634	0.18	0.08	57.52	0.02	0.01	60.18
Generator-Barge	0.01	0.33	0.49	0.00	0.00	0.00	68	0.00	0.00	6.18	0.00	0.00	6.21
Emission Subtotals	**0.96**	**17.68**	**23.37**	**0.04**	**0.56**	**0.56**	**4,368.26**	**1.28**	**0.57**	**396.28**	**0.12**	**0.05**	**414.69**

Notes:

Emission factors are default emission factors from CalEEMod 2016.3.2, which relies on OFFROAD 2011.
Load factor for generator and cranes are defaults from CalEEMod 2016.3.2.
Load factor for KMAG based on average speed over route compared to rated maximum travel speed.
See Table D-12 of the Carl Moyer Program Guidelines. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/msprog/moyer/guidelines/2011/2011cmp_guidelinesVER4.pdf?_ga=2.218661721.1589730523.1723135078-1780396104.1706050686

Emission Factors

Equipment Type	Year	Low HP	High HP	VOC (g/BHP-hr)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
KMAG	Tier 3	300	599	0.1200	2.3200	2.6000	0.0050	0.0088	0.0088	528.8080	0.1540	0.0690
Generator Sets	Tier 4 Final	25	49	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081
Crane-LR 1300	Tier 3	600	750	0.1200	2.3200	2.6000	0.0050	0.0880	0.0880	510.3340	0.1520	0.0681
Crane-Tadano ATF 220G	Tier 4 Final	120	174	0.0600	0.2600	3.7000	0.0050	0.0080	0.0080	514.2600	0.1540	0.0690

Off-road mobile equipment exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\, EF_i \times Pop_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF = *Emission factor in grams per horse-power hour*
Pop = *Population, or the number of pieces of equipment*
AvgHP = *Maximum rated average horsepower*
Load = *Load factor*
Activity = *Hours of operation*
i = *Equipment type*

Roll-On Roll-Off Emissions Elizabeth C - Santa Barbara County

Source Category	VOC	NO_x	CO	SO_x	PM_{10}	$PM_{2.5}$	Pb	CO2	CH4	N20	CO2e
	ton/yr							MT/yr			
Marine Vessel	1.56	17.50	31.42	0.43	0.38	0.38	0.00	4,074.88	0.06	0.17	4125.57
Off-Road	0.04	0.80	1.10	0.00	0.00	0.00	0.00	169.50	0.03	0.01	174.36
Total	**1.60**	**18.30**	**32.52**	**0.43**	**0.38**	**0.38**	**0.00**	**4,244.38**	**0.09**	**0.18**	**4,299.93**

Roll-On Roll-Off Emissions Elizabeth C - Santa Barbara County

Marine Emission Estimates - Elizabeth C

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (hours/yr)
Tugboat	Transit	Propulsion	4	0.1%S	2	1,300	969	1.00	24.00	2088
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	2088
Emission Subtotals										

Boat Classification	Engine	Emission Factors (g/kW-hr) VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
Tugboat	Propulsion	0.19	1.80	5.00	0.07	0.04	0.04	0.00	715.76	0.01	0.03
Tugboat	Auxiliary	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03

Boat Classification	Engine	Maximum Daily Emissions (lb/day) VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
Tugboat	Propulsion	19.49	184.65	512.92	6.98	4.10	4.10	0.06	73,426.05	2.97	1.03
Tugboat	Auxiliary	0.46	6.10	6.07	0.08	0.15	0.15	0.00	796.22	0.04	0.01
Emission Subtotals		**19.95**	**190.75**	**518.99**	**7.06**	**4.25**	**4.25**	**0.06**	**74,222.28**	**3.01**	**1.04**

Boat Classification	Engine	Annual Emissions (ton/year) VOC	NOx	CO	SOx	PM10	PM2.5	Pb	(MT/yr) CO2	CH4	N20	CO2E
Tugboat	Propulsion	0.85	8.03	22.31	0.30	0.18	0.18	0.00	2,897.58	0.04	0.12	2,933.58
Tugboat	Auxiliary	0.02	0.27	0.26	0.00	0.01	0.01	0.00	31.42	0.00	0.00	31.85
Emission Subtotals		**0.87**	**8.30**	**22.58**	**0.31**	**0.18**	**0.18**	**0.00**	**2,929.00**	**0.04**	**0.12**	**2,965.43**

Note:

Marine Emission Estimates - Bernardine C

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (hours/yr)
Tugboat	Transit	Propulsion	3	0.1%S	2	500	373	1.00	24.00	2088
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	2088
Emission Subtotals										

Boat Classification	Engine	Emission Factors (g/kW-hr) VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
Tugboat	Propulsion	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03
Tugboat	Auxiliary	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03

Boat Classification	Engine	Maximum Daily Emissions (lb/day) VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
Tugboat	Propulsion	15.47	205.49	197.28	2.68	4.34	4.34	0.02	28,240.79	1.14	0.39
Tugboat	Auxiliary	0.46	6.10	6.07	0.08	0.15	0.15	0.00	796.22	0.04	0.01
Emission Subtotals		**15.93**	**211.58**	**203.35**	**2.77**	**4.49**	**4.49**	**0.02**	**29,037.01**	**1.18**	**0.41**

Boat Classification	Engine	Annual Emissions (ton/yr) VOC	NOx	CO	SOx	PM10	PM2.5	Pb	(MT/yr) CO2	CH4	N20	CO2E
Tugboat	Propulsion	0.67	8.94	8.58	0.12	0.19	0.19	0.00	1,114.45	0.02	0.05	1,128.30
Tugboat	Auxiliary	0.02	0.27	0.26	0.00	0.01	0.01	0.00	31.42	0.00	0.00	31.85
Emission Subtotals		**0.69**	**9.20**	**8.85**	**0.12**	**0.20**	**0.20**	**0.00**	**1,145.88**	**0.02**	**0.05**	**1,160.15**

Note:

Marine Propulsion

Engine Type	Engine Family	Model	Tier	Fuel	VOC (g/kW-hr)	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
Slow Speed Diesel		<=1999	Tier 0	0.1%S	0.600	17.01	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		<=1999	Tier 0	0.1%S	0.500	13.16	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2000-2010	Tier 1	0.1%S	0.600	15.98	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2000-2010	Tier 1	0.1%S	0.500	12.22	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2011-2015	Tier 2	0.1%S	0.600	14.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2011-2015	Tier 2	0.1%S	0.500	10.53	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2016+	Tier 3	0.1%S	0.600	3.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2016+	Tier 3	0.1%S	0.500	2.63	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
EPA Certification	HCEXN19.0AAA		Tier 3	0.1%S	0.392	5.21	5.0	0.07	0.11	0.11	0.0006067	716		
EPA Certification	D233051MX03		Tier 4	0.1%S	0.190	1.80	5.0	0.07	0.04	0.04	0.0006067	716		

Notes:
Emission factors from Table 2.3 and 2.4 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 1 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.

Marine Auxiliary

Engine Type	Model	Tier	Fuel	VOC (g/kW-hr)	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
Aux High Speed Diesel	<=1999	Tier 0	0.1%S	0.600	10.9	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	<=1999	Tier 0	0.1%S	0.600	13.82	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	9.78	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	12.22	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	7.71	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	10.53	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	1.97	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	2.63	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux Med Speed Diesel Tier 3 Standard	2011-2015	Tier 3	0.1%S	0.378	5.022	5	0.068	0.12	0.12	0.0006067			

Notes:
Emission factors from Table 2.9 and 2.10 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
Load factors for auxiliary engines based on Table 3.1 of the of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 5 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.

Marine exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\, EF_i \times Eng_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF	=	*Emission factor in grams per horse-power hour*
Eng	=	*Number of engines*
AvgHP	=	*Maximum rated average horsepower*
Load	=	*Load factor*
Activity	=	*Hours of operation*
i	=	*Equipment type*

Roll-On Roll-Off Emissions Elizabeth C - Santa Barbara County

Off-Road Emission Estimates

Construction Equipment	OFFROAD Model Category	Engine Tier	Quantity	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (hours/yr)
Crane-HTC-3140LB J8	Crane-transport	4	1	550	410	0.29	0.5	75
Crane-HTC-3140LB J8	Crane-lift	4	1	215	160	0.29	2	300
KMAG	Off-Highway Truck	3	1	453	338	0.30	8	1125
Generator-Barge	Generator Sets	4	1	49	37	0.74	24.0	3600
Emission Subtotals								

Construction Equipment	Emission Factors VOC (g/BHP-hr)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
Crane-HTC-3140LB J8	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	470.5495	0.1522	0.0682
Crane-HTC-3140LB J8	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	472.9057	0.1529	0.0690
KMAG	0.1200	2.3200	2.6000	0.0050	0.0088	0.0088	528.8080	0.1540	0.0690
Generator-Barge	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081
Emission Subtotals									

Construction Equipment	Daily Emissions VOC (lb/day)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20
Crane-HTC-3140LB J8	0.01	0.05	0.39	0.00	0.00	0.00	82.73	0.03	0.01
Crane-HTC-3140LB J8	0.02	0.07	0.60	0.00	0.00	0.00	130.01	0.04	0.02
KMAG	0.27	5.21	5.84	0.01	0.02	0.02	1,188.24	0.35	0.16
Generator-Barge	0.23	5.28	7.87	0.01	0.02	0.02	1,090	0.03	0.02
Emission Subtotals	**0.53**	**10.61**	**14.70**	**0.02**	**0.04**	**0.04**	**2,491.27**	**0.45**	**0.20**

Construction Equipment	Annual Emissions VOC (ton/year)	NOx	CO	SOx	PM10	PM2.5	CO2 (MT/yr)	CH4	N2O	CO2E
Crane-HTC-3140LB J8	0.00	0.00	0.03	0.00	0.00	0.00	5.63	0.00	0.00	5.92
Crane-HTC-3140LB J8	0.00	0.01	0.05	0.00	0.00	0.00	8.85	0.00	0.00	9.30
KMAG	0.02	0.39	0.44	0.00	0.00	0.00	80.85	0.02	0.01	84.58
Generator-Barge	0.02	0.40	0.59	0.00	0.00	0.00	74.18	0.00	0.00	74.55
Emission Subtotals	**0.04**	**0.80**	**1.10**	**0.00**	**0.00**	**0.00**	**169.50**	**0.03**	**0.01**	**174.36**

Notes:

Emission factors are default emission factors from CalEEMod 2016.3.2, which relies on OFFROAD 2011.

Load factor for generator are defaults from CalEEMod 2016.3.2.

Load factor for KMAG based on average speed over route compared to rated maximum travel speed.

Fugitive dust emissions from paved roads assumes the KMAG is loaded.

See Table D-12 of the Carl Moyer Program Guidelines. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/msprog/moyer/guidelines/2011/2011cmp_guidelinesVER4.pdf?_ga=2.218661721.1589730523.1723135078-1780396104.1706050686

Emission Factors

Equipment Type	Year	Low HP	High HP	VOC (g/BHP-hr)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
KMAG	Tier 3	300	599	0.1200	2.3200	2.6000	0.0050	0.0088	0.0088	528.8080	0.1540	0.0690
Crane-HTC-3140LB J8	Tier 4 Final	175	299	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	472.9057	0.1529	0.0690
Crane-HTC-3140LB J8	Tier 4 Final	300	599	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	470.5495	0.1522	0.0682
Generator Sets	Tier 4 Final	25	49	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081

Off-road mobile equipment exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\, EF_i \times Pop_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF	=	*Emission factor in grams per horse-power hour*
Pop	=	*Population, or the number of pieces of equipment*
AvgHP	=	*Maximum rated average horsepower*
Load	=	*Load factor*
Activity	=	*Hours of operation*
i	=	*Equipment type*

Roll-On Roll-Off Emissions Kelly C - Santa Barbara County

Source Category	VOC	NO_x	CO	SO_x	PM_{10}	$PM_{2.5}$	Pb	CO2	CH4	N20	CO2e
	ton/yr							MT/yr			
Marine Vessel	0.78	10.37	9.97	0.14	0.22	0.22	0.00	1,292.01	0.02	0.05	1308.09
Off-Road	0.00	0.05	0.07	0.00	0.00	0.00	0.00	11.30	0.00	0.00	11.62
Total	**0.78**	**10.43**	**10.04**	**0.14**	**0.22**	**0.22**	**0.00**	**1,303.31**	**0.02**	**0.05**	**1,319.71**

Roll-On Roll-Off Emissions Kelly C - Santa Barbara County

Marine Emission Estimates - Kelly C

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (hours/yr)
Tugboat	Transit	Propulsion	3	0.1%S	2	1,000	746	1.00	24.00	792
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	792

Boat Classification	Engine	Emission Factors (g/kW-hr) VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
Tugboat	Propulsion	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03
Tugboat	Auxiliary	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03

Boat Classification	Engine	Maximum Daily Emissions (lb/day) VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
Tugboat	Propulsion	30.93	410.97	394.56	5.37	8.68	8.68	0.05	56,481.58	2.29	0.79
Tugboat	Auxiliary	0.46	6.10	6.07	0.08	0.15	0.15	0.00	796.22	0.04	0.01
Emission Subtotals		**31.39**	**417.07**	**400.63**	**5.45**	**8.83**	**8.83**	**0.05**	**57,277.80**	**2.32**	**0.80**

Boat Classification	Engine	Annual Emissions (ton/year) VOC	NOx	CO	SOx	PM10	PM2.5	Pb	(MT/yr) CO2	CH4	N20	CO2E
Tugboat	Propulsion	0.51	6.78	6.51	0.09	0.14	0.14	0.00	845.45	0.01	0.03	855.95
Tugboat	Auxiliary	0.01	0.10	0.10	0.00	0.00	0.00	0.00	11.92	0.00	0.00	12.08
Emission Subtotals		**0.52**	**6.88**	**6.61**	**0.09**	**0.15**	**0.15**	**0.00**	**857.37**	**0.01**	**0.03**	**868.03**

Note:

Marine Emission Estimates - Bernardine C

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (hours/yr)
Tugboat	Transit	Propulsion	3	0.1%S	2	500	373	1.00	24.00	792
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	792

Boat Classification	Engine	Emission Factors (g/kW-hr) VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
Tugboat	Propulsion	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03
Tugboat	Auxiliary	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03

Boat Classification	Engine	Maximum Daily Emissions (lb/day) VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
Tugboat	Propulsion	15.47	205.49	197.28	2.68	4.34	4.34	0.02	28,240.79	1.14	0.39
Tugboat	Auxiliary	0.46	6.10	6.07	0.08	0.15	0.15	0.00	796.22	0.04	0.01
Emission Subtotals		**15.93**	**211.58**	**203.35**	**2.77**	**4.49**	**4.49**	**0.02**	**29,037.01**	**1.18**	**0.41**

Boat Classification	Engine	Annual Emissions (ton/yr) VOC	NOx	CO	SOx	PM10	PM2.5	Pb	(MT/yr) CO2	CH4	N20	CO2E
Tugboat	Propulsion	0.26	3.39	3.26	0.04	0.07	0.07	0.00	422.72	0.01	0.02	427.98
Tugboat	Auxiliary	0.01	0.10	0.10	0.00	0.00	0.00	0.00	11.92	0.00	0.00	12.08
Emission Subtotals		**0.26**	**3.49**	**3.36**	**0.05**	**0.07**	**0.07**	**0.00**	**434.64**	**0.01**	**0.02**	**440.06**

Note:

Marine Propulsion

Engine Type	Engine Family	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
					(g/kW-hr)									
Slow Speed Diesel		<=1999	Tier 0	0.1%S	0.600	17.01	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		<=1999	Tier 0	0.1%S	0.500	13.16	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2000-2010	Tier 1	0.1%S	0.600	15.98	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2000-2010	Tier 1	0.1%S	0.500	12.22	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2011-2015	Tier 2	0.1%S	0.600	14.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2011-2015	Tier 2	0.1%S	0.500	10.53	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2016+	Tier 3	0.1%S	0.600	3.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2016+	Tier 3	0.1%S	0.500	2.63	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
EPA Certification	HCEXN19.0AAA		Tier 3	0.1%S	0.392	5.21	5.0	0.07	0.11	0.11	0.0006067	716		
EPA Certification	D233051MX03		Tier 4	0.1%S	0.190	1.80	5.0	0.07	0.04	0.04	0.0006067	716		

Notes:
Emission factors from Table 2.3 and 2.4 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 1 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.

Marine Auxiliary

Engine Type	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
				(g/kW-hr)									
Aux High Speed Diesel	<=1999	Tier 0	0.1%S	0.600	10.9	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	<=1999	Tier 0	0.1%S	0.600	13.82	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	9.78	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	12.22	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	7.71	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	10.53	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	1.97	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	2.63	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux Med Speed Diesel Tier 3 Standard	2011-2015	Tier 3	0.1%S	0.378	5.022	5	0.068	0.12	0.12	0.0006067			
				(g/hp-hr)									
Generator Sets		Tier 4 Final	0.1%S	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	-	568.2990	0.0180	0.0081

Notes:
Emission factors from Table 2.9 and 2.10 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
Load factors for auxiliary engines based on Table 3.1 of the of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 5 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.

Marine exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\ EF_i \times Eng_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF = *Emission factor in grams per horse-power hour*
Eng = *Number of engines*
AvgHP = *Maximum rated average horsepower*
Load = *Load factor*
Activity = *Hours of operation*
i = *Equipment type*

Roll-On Roll-Off Emissions Kelly C - Santa Barbara County

Off-Road Emission Estimates

Construction Equipment	OFFROAD Model Category	Engine Tier	Quantity	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (hours/yr)	Emission Factors VOC (g/BHP-hr)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
Crane-HTC-3140LB J8	Crane-transport	4	1	550	410	0.29	0.5	5	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	470.5495	0.1522	0.0682
Crane-HTC-3140LB J8	Crane-lift	4	1	215	160	0.29	2	20	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	472.9057	0.1529	0.0690
KMAG	Off-Highway Truck	3	1	453	338	0.30	8	75	0.1200	2.3200	2.6000	0.0050	0.0088	0.0088	528.8080	0.1540	0.0690
Generator-Barge	Generator Sets	4	1	49	37	0.74	24.0	240	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081
Emission Subtotals																	

Construction Equipment	Daily Emissions VOC (lb/day)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20
Crane-HTC-3140LB J8	0.01	0.05	0.39	0.00	0.00	0.00	82.73	0.03	0.01
Crane-HTC-3140LB J8	0.02	0.07	0.60	0.00	0.00	0.00	130.01	0.04	0.02
KMAG	0.27	5.21	5.84	0.01	0.02	0.02	1,188.24	0.35	0.16
Generator-Barge	0.23	5.28	7.87	0.01	0.02	0.02	1,090	0.03	0.02
Emission Subtotals	**0.53**	**10.61**	**14.70**	**0.02**	**0.04**	**0.04**	**2,491.27**	**0.45**	**0.20**

Construction Equipment	Annual Emissions VOC (ton/year)	NOx	CO	SOx	PM10	PM2.5	CO2 (MT/yr)	CH4	N2O	CO2E
Crane-HTC-3140LB J8	0.00	0.00	0.00	0.00	0.00	0.00	0.38	0.00	0.00	0.39
Crane-HTC-3140LB J8	0.00	0.00	0.00	0.00	0.00	0.00	0.59	0.00	0.00	0.62
KMAG	0.00	0.03	0.03	0.00	0.00	0.00	5.39	0.00	0.00	5.64
Generator-Barge	0.00	0.03	0.04	0.00	0.00	0.00	4.95	0.00	0.00	4.97
Emission Subtotals	**0.00**	**0.05**	**0.07**	**0.00**	**0.00**	**0.00**	**11.30**	**0.00**	**0.00**	**11.62**

Notes:

Emission factors are default emission factors from CalEEMod 2016.3.2, which relies on OFFROAD 2011.
Load factor for generator are defaults from CalEEMod 2016.3.2.
Load factor for KMAG based on average speed over route compared to rated maximum travel speed.
Fugitive dust emissions from paved roads assumes the KMAG is loaded.
See Table D-12 of the Carl Moyer Program Guidelines. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/msprog/moyer/guidelines/2011/2011cmp_guidelinesVER4.pdf?_ga=2.218661721.1589730523.1723135078-1780396104.1706050686

Emission Factors

Equipment Type	Year	Low HP	High HP	VOC (g/BHP-hr)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
KMAG	Tier 3	300	599	0.1200	2.3200	2.6000	0.0050	0.0088	0.0088	528.8080	0.1540	0.0690
Crane-HTC-3140LB J8	Tier 4 Final	175	299	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	472.9057	0.1529	0.0690
Crane-HTC-3140LB J8	Tier 4 Final	300	599	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	470.5495	0.1522	0.0682
Generator Sets	Tier 4 Final	25	49	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081

Off-road mobile equipment exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\, EF_i \times Pop_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF = *Emission factor in grams per horse-power hour*
Pop = *Population, or the number of pieces of equipment*
AvgHP = *Maximum rated average horsepower*
Load = *Load factor*
Activity = *Hours of operation*
i = *Equipment type*

SpaceX Roll-On Roll-Off Proposed Action Elizabeth C Ventura County

Marine Emission Estimates - Elizabeth C

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (hours/yr)
Tugboat	Transit	Propulsion	4	0.1%S	2	1,300	969	1.00	24.00	1872
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	1872
Generator-Barge	Transit	Generator Sets	4	0.1%S	1	49	37	0.74	24.00	1872
Emission Subtotals										

Boat Classification	Emission Factors VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
	(g/kW-hr)									
Tugboat (Propulsion)	0.19	1.80	5.00	0.07	0.04	0.04	0.00	715.76	0.01	0.03
Tugboat (Auxiliary)	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03
	(g/hp-hr)									
Generator-Barge	0.12	2.75	4.10	0.01	0.01	0.01	-	568.30	0.02	0.01

Boat Classification	Maximum Daily Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
	(lb/day)									
Tugboat (Propulsion)	19.49	184.65	512.92	6.98	4.10	4.10	0.06	73,426.05	2.97	1.03
Tugboat (Auxiliary)	0.46	6.10	6.07	0.08	0.15	0.15	0.00	796.22	0.04	0.01
Generator-Barge	0.23	5.28	7.87	0.01	0.02	0.02	-	1,090.29	0.02	0.03
Emission Subtotals	**20.18**	**196.02**	**526.86**	**7.07**	**4.26**	**4.26**	**0.06**	**75,312.57**	**3.03**	**1.07**

Boat Classification	Annual Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
	(ton/yr)							(MT/yr)			
Tugboat (Propulsion)	0.76	7.20	20.00	0.27	0.16	0.16	0.00	2,597.83	0.04	0.11	2,630.11
Tugboat (Auxiliary)	0.02	0.24	0.24	0.00	0.01	0.01	0.00	28.17	0.00	0.00	28.55
Generator-Barge	0.01	0.16	0.23	0.00	0.00	0.00	-	29.13	0.00	0.00	29.27
Emission Subtotals	**0.78**	**7.59**	**20.47**	**0.28**	**0.17**	**0.17**	**0.00**	**2,655.13**	**0.04**	**0.11**	**2,687.93**

Note:

Marine Emission Estimates - Bernardine C

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (hours/yr)
Tugboat	Transit	Propulsion	3	0.1%S	2	500	373	1.00	24.00	1872
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	1872
Emission Subtotals										

Boat Classification	Emission Factors VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
	(g/kW-hr)									
Tugboat (Propulsion)	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03
Tugboat (Auxiliary)	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03

Boat Classification	Maximum Daily Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
	(lb/day)									
Tugboat (Propulsion)	15.47	205.49	197.28	2.68	4.34	4.34	0.02	28,240.79	1.14	0.39
Tugboat (Auxiliary)	0.46	6.10	6.07	0.08	0.15	0.15	0.00	796.22	0.04	0.01
Emission Subtotals	**15.93**	**211.58**	**203.35**	**2.77**	**4.49**	**4.49**	**0.02**	**29,037.01**	**1.18**	**0.41**

Boat Classification	Annual Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
	(ton/yr)							(MT/yr)			
Tugboat (Propulsion)	0.60	8.01	7.69	0.10	0.17	0.17	0.00	999.17	0.01	0.04	1,011.58
Tugboat (Auxiliary)	0.02	0.24	0.24	0.00	0.01	0.01	0.00	28.17	0.00	0.00	28.55
Emission Subtotals	**0.62**	**8.25**	**7.93**	**0.11**	**0.17**	**0.17**	**0.00**	**1,027.34**	**0.01**	**0.04**	**1,040.13**

Note:

Emission Factors

Marine Propulsion

Engine Type	Engine Family	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
					(g/kW-hr)									
Slow Speed Diesel		<=1999	Tier 0	0.1%S	0.600	17.01	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		<=1999	Tier 0	0.1%S	0.500	13.16	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2000-2010	Tier 1	0.1%S	0.600	15.98	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2000-2010	Tier 1	0.1%S	0.500	12.22	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2011-2015	Tier 2	0.1%S	0.600	14.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2011-2015	Tier 2	0.1%S	0.500	10.53	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2016+	Tier 3	0.1%S	0.600	3.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2016+	Tier 3	0.1%S	0.500	2.63	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
EPA Certification	HCEXN19.0AAA		Tier 3	0.1%S	0.392	5.21	5.0	0.07	0.11	0.11	0.0006067	716		
EPA Certification	D233051MX03		Tier 4	0.1%S	0.190	1.80	5.0	0.07	0.04	0.04	0.0006067	716		

Notes:
Emission factors from Table 2.3 and 2.4 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 1 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.

Marine Auxiliary

Engine Type	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
				(g/kW-hr)									
Aux High Speed Diesel	<=1999	Tier 0	0.1%S	0.600	10.9	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	<=1999	Tier 0	0.1%S	0.600	13.82	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	9.78	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	12.22	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	7.71	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	10.53	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	1.97	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	2.63	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux Med Speed Diesel Tier 3 Standard	2011-2015	Tier 3	0.1%S	0.378	5.022	5	0.068	0.12	0.12	0.0006067			
				(g/hp-hr)									
Generator Sets		Tier 4 Final	0.1%S	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	-	568.2990	0.0180	0.0081

Notes:
Emission factors from Table 2.9 and 2.10 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
Load factors for auxiliary engines based on Table 3.1 of the of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 5 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.
Emission factors for generator sets are default emission factors from CalEEMod 2016.3.2, which relies on OFFROAD 2011 and the Carl Moyer Progam Guidelines.
See Table D-12 of the Carl Moyer Program Guidelines. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/msprog/moyer/guidelines/2011/2011cmp_guidelinesVER4.pdf?_ga=2.218661721.1589730523.1723135078-1780396104.1706050686

Marine exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\ EF_i \times Eng_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF	=	*Emission factor in grams per horse-power hour*
Eng	=	*Number of engines*
AvgHP	=	*Maximum rated average horsepower*
Load	=	*Load factor*
Activity	=	*Hours of operation*
i	=	*Equipment type*

SpaceX Roll-On Roll-Off Emissions Proposed Action Kelly C Ventura County

Marine Emission Estimates - Kelly C

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (hours/yr)
Tugboat	Transit	Propulsion	3	0.1%S	2	1,000	746	1.00	24.00	708
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	708
Generator-Barge	Transit	Generator Sets	4	0.1%S	1	49	37	0.74	24.00	708
Emission Subtotals										

Boat Classification	Emission Factors VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
	(g/kW-hr)									
Tugboat	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03
Tugboat	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03
	(g/hp-hr)									
Generator-Barge	0.12	2.75	4.10	0.01	0.01	0.01	-	568.30	0.02	0.01
Emission Subtotals										

Boat Classification	Maximum Daily Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
	(lb/day)									
Tugboat	30.93	410.97	394.56	5.37	8.68	8.68	0.05	56,481.58	2.29	0.79
Tugboat	0.46	6.10	6.07	0.08	0.15	0.15	0.00	796.22	0.04	0.01
Generator-Barge	0.23	5.28	7.87	0.01	0.02	0.02	0	1,090.29	0.02	0.03
Emission Subtotals	**31.62**	**422.34**	**408.49**	**5.46**	**8.84**	**8.84**	**0.05**	**58,368.10**	**2.34**	**0.84**

Boat Classification	Annual Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
	(ton/yr)							(MT/yr)			
Tugboat	0.46	6.06	5.82	0.08	0.13	0.13	0.00	755.78	0.01	0.03	765.17
Tugboat	0.01	0.09	0.09	0.00	0.00	0.00	0.00	10.65	0.00	0.00	10.80
Generator-Barge	0.00	0.06	0.09	0.00	0.00	0.00	-	11.02	0.00	0.00	11.07
Emission Subtotals	**0.47**	**6.21**	**6.00**	**0.08**	**0.13**	**0.13**	**0.00**	**777.45**	**0.01**	**0.03**	**787.04**

Note:

Marine Emission Estimates - Bernardine C

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (hours/yr)
Tugboat	Transit	Propulsion	3	0.1%S	2	500	373	1.00	24.00	708
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	708
Emission Subtotals										

Boat Classification	Emission Factors VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
	(g/kW-hr)									
Tugboat	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03
Tugboat	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03
Emission Subtotals										

Boat Classification	Maximum Daily Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
	(lb/day)									
Tugboat	15.47	205.49	197.28	2.68	4.34	4.34	0.02	28,240.79	1.14	0.39
Tugboat	0.46	6.10	6.07	0.08	0.15	0.15	0.00	796.22	0.04	0.01
Emission Subtotals	**15.93**	**211.58**	**203.35**	**2.77**	**4.49**	**4.49**	**0.02**	**29,037.01**	**1.18**	**0.41**

Boat Classification	Annual Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
	(ton/yr)							(MT/yr)			
Tugboat	0.23	3.03	2.91	0.04	0.06	0.06	0.00	377.89	0.01	0.02	382.58
Tugboat	0.01	0.09	0.09	0.00	0.00	0.00	0.00	10.65	0.00	0.00	10.80
Emission Subtotals	**0.23**	**3.12**	**3.00**	**0.04**	**0.07**	**0.07**	**0.00**	**388.54**	**0.01**	**0.02**	**393.38**

Note:

Emission Factors

Marine Propulsion

Engine Type	Engine Family	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
					(g/kW-hr)									
Slow Speed Diesel		<=1999	Tier 0	0.1%S	0.600	17.01	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		<=1999	Tier 0	0.1%S	0.500	13.16	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2000-2010	Tier 1	0.1%S	0.600	15.98	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2000-2010	Tier 1	0.1%S	0.500	12.22	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2011-2015	Tier 2	0.1%S	0.600	14.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2011-2015	Tier 2	0.1%S	0.500	10.53	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2016+	Tier 3	0.1%S	0.600	3.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2016+	Tier 3	0.1%S	0.500	2.63	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
EPA Certification	HCEXN19.0AAA		Tier 3	0.1%S	0.392	5.21	5.0	0.07	0.11	0.11	0.0006067	716		
EPA Certification	D233051MX03		Tier 4	0.1%S	0.190	1.80	5.0	0.07	0.04	0.04	0.0006067	716		

Notes:
Emission factors from Table 2.3 and 2.4 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 1 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.

Marine Auxiliary

Engine Type	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
				(g/kW-hr)									
Aux High Speed Diesel	<=1999	Tier 0	0.1%S	0.600	10.9	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	<=1999	Tier 0	0.1%S	0.600	13.82	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	9.78	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	12.22	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	7.71	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	10.53	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	1.97	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	2.63	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux Med Speed Diesel Tier 3 Standard	2011-2015	Tier 3	0.1%S	0.378	5.022	5	0.068	0.12	0.12	0.0006067			
				(g/hp-hr)									
Generator Sets		Tier 4 Final	0.1%S	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	-	568.2990	0.0180	0.0081

Notes:
Emission factors from Table 2.9 and 2.10 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
Load factors for auxiliary engines based on Table 3.1 of the of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 5 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.
Emission factors for generator sets are default emission factors from CalEEMod 2016.3.2, which relies on OFFROAD 2011 and the Carl Moyer Progam Guidelines.
See Table D-12 of the Carl Moyer Program Guidelines. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/msprog/moyer/guidelines/2011/2011cmp_guidelinesVER4.pdf?_ga=2.218661721.1589730523.1723135078-1780396104.1706050686

Marine exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\, EF_i \times Eng_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF	=	*Emission factor in grams per horse-power hour*
Eng	=	*Number of engines*
AvgHP	=	*Maximum rated average horsepower*
Load	=	*Load factor*
Activity	=	*Hours of operation*
i	=	*Equipment type*

SpaceX SLC-4 Operations Detailed Report

Table of Contents

1. Basic Project Information

1.1. Basic Project Information

Data Field	Value
Project Name	SpaceX SLC-4 Operations
Construction Start Date	1/1/2024
Operational Year	2025
Lead Agency	—
Land Use Scale	Project/site
Analysis Level for Defaults	County
Windspeed (m/s)	3.10
Precipitation (days)	27.8
Location	34.58233161250706, -120.6276097945451
County	Santa Barbara
City	Unincorporated
Air District	Santa Barbara County APCD
Air Basin	South Central Coast
TAZ	3342
EDFZ	6
Electric Utility	Pacific Gas & Electric Company
Gas Utility	Southern California Gas
App Version	2022.1.1.24

1.2. Land Use Types

Land Use Subtype	Size	Unit	Lot Acreage	Building Area (sq ft)	Landscape Area (sq ft)	Special Landscape Area (sq ft)	Population	Description

General Heavy Industry	1.00	1000sqft	0.02	1,000	0.00	—	—	—

1.3. User-Selected Emission Reduction Measures by Emissions Sector

No measures selected

2. Emissions Summary

2.1. Construction Emissions Compared Against Thresholds

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Un/Mit.	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unmit.	4.80	4.32	11.1	52.9	0.03	0.12	6.56	6.68	0.11	1.56	1.67	—	9,929	9,929	0.54	0.62	34.8	10,161
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unmit.	4.86	4.35	11.7	53.4	0.03	0.12	6.56	6.68	0.11	1.56	1.67	—	9,804	9,804	0.57	0.62	0.90	10,003
Average Daily (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unmit.	4.74	4.27	10.6	52.2	0.02	0.11	6.29	6.40	0.10	1.49	1.59	—	9,146	9,146	0.53	0.52	14.3	9,328
Annual (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unmit.	0.87	0.78	1.93	9.52	< 0.005	0.02	1.15	1.17	0.02	0.27	0.29	—	1,514	1,514	0.09	0.09	2.37	1,544

2.2. Construction Emissions by Year, Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Year	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e

Daily - Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2024	4.80	4.32	11.1	52.9	0.03	0.12	6.56	6.68	0.11	1.56	1.67	—	9,929	9,929	0.54	0.62	34.8	10,161
Daily - Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2024	4.86	4.35	11.7	53.4	0.03	0.12	6.56	6.68	0.11	1.56	1.67	—	9,804	9,804	0.57	0.62	0.90	10,003
Average Daily	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2024	4.74	4.27	10.6	52.2	0.02	0.11	6.29	6.40	0.10	1.49	1.59	—	9,146	9,146	0.53	0.52	14.3	9,328
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2024	0.87	0.78	1.93	9.52	< 0.005	0.02	1.15	1.17	0.02	0.27	0.29	—	1,514	1,514	0.09	0.09	2.37	1,544

2.4. Operations Emissions Compared Against Thresholds

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Un/Mit.	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unmit.	33.6	30.6	103	77.9	0.15	4.49	0.00	4.49	4.49	0.00	4.49	693	31,354	32,047	67.8	0.54	0.26	33,902
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unmit.	33.6	30.6	103	77.9	0.15	4.49	0.00	4.49	4.49	0.00	4.49	693	31,354	32,047	67.8	0.54	0.26	33,902
Average Daily (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unmit.	1.77	1.61	5.02	4.05	0.01	0.23	0.00	0.23	0.23	0.00	0.23	693	16,540	17,233	67.2	0.42	0.26	19,039
Annual (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unmit.	0.32	0.29	0.92	0.74	< 0.005	0.04	0.00	0.04	0.04	0.00	0.04	115	2,738	2,853	11.1	0.07	0.04	3,152

2.5. Operations Emissions by Sector, Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Sector	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mobile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Area	0.04	0.03	< 0.005	0.04	< 0.005	< 0.005	—	< 0.005	< 0.005	—	< 0.005	—	0.18	0.18	< 0.005	< 0.005	—	0.18
Energy	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	—	0.00	—	15,625	15,625	2.53	0.31	—	15,780
Water	—	—	—	—	—	—	—	—	—	—	—	47.7	107	154	0.18	0.11	—	191
Waste	—	—	—	—	—	—	—	—	—	—	—	645	0.00	645	64.5	0.00	—	2,257
Refrig.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.26	0.26
Stationary	33.6	30.5	103	77.9	0.15	4.49	0.00	4.49	4.49	0.00	4.49	0.00	15,622	15,622	0.63	0.12	0.00	15,674
Total	33.6	30.6	103	77.9	0.15	4.49	0.00	4.49	4.49	0.00	4.49	693	31,354	32,047	67.8	0.54	0.26	33,902
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mobile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Area	0.03	0.03	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Energy	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	—	0.00	—	15,625	15,625	2.53	0.31	—	15,780
Water	—	—	—	—	—	—	—	—	—	—	—	47.7	107	154	0.18	0.11	—	191
Waste	—	—	—	—	—	—	—	—	—	—	—	645	0.00	645	64.5	0.00	—	2,257
Refrig.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.26	0.26
Stationary	33.6	30.5	103	77.9	0.15	4.49	0.00	4.49	4.49	0.00	4.49	0.00	15,622	15,622	0.63	0.12	0.00	15,674
Total	33.6	30.6	103	77.9	0.15	4.49	0.00	4.49	4.49	0.00	4.49	693	31,354	32,047	67.8	0.54	0.26	33,902
Average Daily	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Mobile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Area	0.03	0.03	< 0.005	0.02	< 0.005	< 0.005	—	< 0.005	< 0.005	—	< 0.005	—	0.09	0.09	< 0.005	< 0.005	—	0.09
Energy	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	—	0.00	—	15,625	15,625	2.53	0.31	—	15,780
Water	—	—	—	—	—	—	—	—	—	—	—	47.7	107	154	0.18	0.11	—	191
Waste	—	—	—	—	—	—	—	—	—	—	—	645	0.00	645	64.5	0.00	—	2,257
Refrig.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.26	0.26
Stationary	1.74	1.58	5.02	4.03	0.01	0.23	0.00	0.23	0.23	0.00	0.23	0.00	808	808	0.03	0.01	0.00	811
Total	1.77	1.61	5.02	4.05	0.01	0.23	0.00	0.23	0.23	0.00	0.23	693	16,540	17,233	67.2	0.42	0.26	19,039
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mobile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Area	0.01	0.01	< 0.005	< 0.005	< 0.005	< 0.005	—	< 0.005	< 0.005	—	< 0.005	—	0.01	0.01	< 0.005	< 0.005	—	0.01
Energy	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	—	0.00	—	2,587	2,587	0.42	0.05	—	2,613
Water	—	—	—	—	—	—	—	—	—	—	—	7.90	17.7	25.6	0.03	0.02	—	31.6
Waste	—	—	—	—	—	—	—	—	—	—	—	107	0.00	107	10.7	0.00	—	374
Refrig.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.04	0.04
Stationary	0.32	0.29	0.92	0.74	< 0.005	0.04	0.00	0.04	0.04	0.00	0.04	0.00	134	134	0.01	< 0.005	0.00	134
Total	0.32	0.29	0.92	0.74	< 0.005	0.04	0.00	0.04	0.04	0.00	0.04	115	2,738	2,853	11.1	0.07	0.04	3,152

3. Construction Emissions Details

3.1. Fleet Vehicle Use (2024) - Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Location	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Onsite	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—
Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—
Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Average Daily	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—
Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—
Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Offsite	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	0.50	0.47	0.34	4.01	0.00	0.00	0.62	0.62	0.00	0.15	0.15	—	641	641	0.04	0.03	3.00	654

Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	0.51	0.47	0.39	4.11	0.00	0.00	0.62	0.62	0.00	0.15	0.15	—	628	628	0.05	0.03	0.08	638
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Average Daily	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	0.50	0.47	0.39	4.01	0.00	0.00	0.61	0.61	0.00	0.14	0.14	—	630	630	0.05	0.03	1.30	641
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	0.09	0.09	0.07	0.73	0.00	0.00	0.11	0.11	0.00	0.03	0.03	—	104	104	0.01	< 0.005	0.22	106
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00

3.3. Vendor-Contractor Vehicles (2024) - Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Location	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Onsite	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—

Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—
Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Average Daily	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—
Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—
Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Offsite	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	0.24	0.12	3.92	1.91	0.02	0.03	0.60	0.63	0.03	0.16	0.20	—	2,421	2,421	0.11	0.35	6.09	2,534
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00

Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	0.24	0.11	4.03	1.95	0.02	0.03	0.60	0.63	0.03	0.16	0.20	—	2,422	2,422	0.11	0.35	0.16	2,529
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Average Daily	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	0.17	0.08	2.89	1.39	0.01	0.02	0.42	0.44	0.02	0.12	0.14	—	1,738	1,738	0.08	0.25	1.88	1,817
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	0.03	0.02	0.53	0.25	< 0.005	< 0.005	0.08	0.08	< 0.005	0.02	0.03	—	288	288	0.01	0.04	0.31	301
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00

3.5. Equipment (2024) - Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Location	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Onsite	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Off-Road Equipment	0.42	0.34	4.09	14.4	0.01	0.09	—	0.09	0.08	—	0.08	—	1,387	1,387	0.05	0.01	—	1,392
Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—
Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00

Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Off-Road Equipment	0.42	0.34	4.09	14.4	0.01	0.09	—	0.09	0.08	—	0.08	—	1,387	1,387	0.05	0.01	—	1,392
Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—
Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Average Daily	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Off-Road Equipment	0.43	0.34	4.10	14.4	0.01	0.09	—	0.09	0.08	—	0.08	—	1,391	1,391	0.05	0.01	—	1,395
Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—
Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Off-Road Equipment	0.08	0.06	0.75	2.63	< 0.005	0.02	—	0.02	0.01	—	0.01	—	230	230	0.01	< 0.005	—	231
Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—
Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Offsite	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00

Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Average Daily	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00

3.7. Worker Vehicles (2024) - Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Location	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Onsite	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—

Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—
Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Average Daily	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—
Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—
Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Offsite	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	3.63	3.39	2.78	32.7	0.00	0.00	5.34	5.34	0.00	1.25	1.25	—	5,480	5,480	0.34	0.23	25.7	5,582
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00

Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	3.69	3.42	3.21	33.0	0.00	0.00	5.34	5.34	0.00	1.25	1.25	—	5,366	5,366	0.37	0.23	0.67	5,444
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Average Daily	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	3.64	3.38	3.19	32.4	0.00	0.00	5.26	5.26	0.00	1.23	1.23	—	5,386	5,386	0.35	0.23	11.2	5,474
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	0.66	0.62	0.58	5.91	0.00	0.00	0.96	0.96	0.00	0.22	0.22	—	892	892	0.06	0.04	1.85	906
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00

4. Operations Emissions Details

4.1. Mobile Emissions by Land Use

4.1.1. Unmitigated

Mobile source emissions results are presented in Sections 2.6. No further detailed breakdown of emissions is available.

4.2. Energy

4.2.1. Electricity Emissions By Land Use - Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Land Use	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e

Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
General Heavy Industry	—	—	—	—	—	—	—	—	—	—	—	—	15,625	15,625	2.53	0.31	—	15,780
Total	—	—	—	—	—	—	—	—	—	—	—	—	15,625	15,625	2.53	0.31	—	15,780
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
General Heavy Industry	—	—	—	—	—	—	—	—	—	—	—	—	15,625	15,625	2.53	0.31	—	15,780
Total	—	—	—	—	—	—	—	—	—	—	—	—	15,625	15,625	2.53	0.31	—	15,780
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
General Heavy Industry	—	—	—	—	—	—	—	—	—	—	—	—	2,587	2,587	0.42	0.05	—	2,613
Total	—	—	—	—	—	—	—	—	—	—	—	—	2,587	2,587	0.42	0.05	—	2,613

4.2.3. Natural Gas Emissions By Land Use - Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Land Use	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
General Heavy Industry	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	—	0.00	—	0.00	0.00	0.00	0.00	—	0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	—	0.00	—	0.00	0.00	0.00	0.00	—	0.00
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

General Heavy Industry	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	—	0.00	—	0.00	0.00	0.00	0.00	—	0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	—	0.00	—	0.00	0.00	0.00	0.00	—	0.00
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
General Heavy Industry	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	—	0.00	—	0.00	0.00	0.00	0.00	—	0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	—	0.00	—	0.00	0.00	0.00	0.00	—	0.00

4.3. Area Emissions by Source

4.3.1. Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Source	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Consumer Products	0.02	0.02	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Architectural Coatings	0.01	0.01	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Landscape Equipment	0.01	0.01	< 0.005	0.04	< 0.005	< 0.005	—	< 0.005	< 0.005	—	< 0.005	—	0.18	0.18	< 0.005	< 0.005	—	0.18
Total	0.04	0.03	< 0.005	0.04	< 0.005	< 0.005	—	< 0.005	< 0.005	—	< 0.005	—	0.18	0.18	< 0.005	< 0.005	—	0.18
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Consumer	0.02	0.02	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Architectural Coatings	0.01	0.01	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	0.03	0.03	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Consumer Products	< 0.005	< 0.005	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Architectural Coatings	< 0.005	< 0.005	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Landscape Equipment	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	—	< 0.005	< 0.005	—	< 0.005	—	0.01	0.01	< 0.005	< 0.005	—	0.01
Total	0.01	0.01	< 0.005	< 0.005	< 0.005	< 0.005	—	< 0.005	< 0.005	—	< 0.005	—	0.01	0.01	< 0.005	< 0.005	—	0.01

4.4. Water Emissions by Land Use

4.4.1. Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Land Use	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
General Heavy Industry	—	—	—	—	—	—	—	—	—	—	—	47.7	107	154	0.18	0.11	—	191
Total	—	—	—	—	—	—	—	—	—	—	—	47.7	107	154	0.18	0.11	—	191

Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
General Heavy Industry	—	—	—	—	—	—	—	—	—	—	—	47.7	107	154	0.18	0.11	—	191
Total	—	—	—	—	—	—	—	—	—	—	—	47.7	107	154	0.18	0.11	—	191
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
General Heavy Industry	—	—	—	—	—	—	—	—	—	—	—	7.90	17.7	25.6	0.03	0.02	—	31.6
Total	—	—	—	—	—	—	—	—	—	—	—	7.90	17.7	25.6	0.03	0.02	—	31.6

4.5. Waste Emissions by Land Use

4.5.1. Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Land Use	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
General Heavy Industry	—	—	—	—	—	—	—	—	—	—	—	645	0.00	645	64.5	0.00	—	2,257
Total	—	—	—	—	—	—	—	—	—	—	—	645	0.00	645	64.5	0.00	—	2,257
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
General Heavy Industry	—	—	—	—	—	—	—	—	—	—	—	645	0.00	645	64.5	0.00	—	2,257
Total	—	—	—	—	—	—	—	—	—	—	—	645	0.00	645	64.5	0.00	—	2,257

Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
General Heavy Industry	—	—	—	—	—	—	—	—	—	—	—	107	0.00	107	10.7	0.00	—	374
Total	—	—	—	—	—	—	—	—	—	—	—	107	0.00	107	10.7	0.00	—	374

4.6. Refrigerant Emissions by Land Use

4.6.1. Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Land Use	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
General Heavy Industry	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.26	0.26
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.26	0.26
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
General Heavy Industry	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.26	0.26
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.26	0.26
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
General Heavy Industry	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.04	0.04
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.04	0.04

4.7. Offroad Emissions By Equipment Type

4.7.1. Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Equipment Type	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

4.8. Stationary Emissions By Equipment Type

4.8.1. Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Equipment Type	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Emergency Generator	33.6	30.5	103	77.9	0.15	4.49	0.00	4.49	4.49	0.00	4.49	0.00	15,622	15,622	0.63	0.12	0.00	15,674

Total	33.6	30.5	103	77.9	0.15	4.49	0.00	4.49	4.49	0.00	4.49	0.00	15,622	15,622	0.63	0.12	0.00	15,674
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Emergency Generator	33.6	30.5	103	77.9	0.15	4.49	0.00	4.49	4.49	0.00	4.49	0.00	15,622	15,622	0.63	0.12	0.00	15,674
Total	33.6	30.5	103	77.9	0.15	4.49	0.00	4.49	4.49	0.00	4.49	0.00	15,622	15,622	0.63	0.12	0.00	15,674
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Emergency Generator	0.32	0.29	0.92	0.74	< 0.005	0.04	0.00	0.04	0.04	0.00	0.04	0.00	134	134	0.01	< 0.005	0.00	134
Total	0.32	0.29	0.92	0.74	< 0.005	0.04	0.00	0.04	0.04	0.00	0.04	0.00	134	134	0.01	< 0.005	0.00	134

4.9. User Defined Emissions By Equipment Type

4.9.1. Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Equipment Type	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

4.10. Soil Carbon Accumulation By Vegetation Type

4.10.1. Soil Carbon Accumulation By Vegetation Type - Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Vegetation	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

4.10.2. Above and Belowground Carbon Accumulation by Land Use Type - Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Land Use	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

4.10.3. Avoided and Sequestered Emissions by Species - Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Species	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Avoided	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Subtotal	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sequestered	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Subtotal	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Removed	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Subtotal	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Avoided	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Subtotal	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sequestered	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Subtotal	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Removed	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Subtotal	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Avoided	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Subtotal	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Sequest	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Subtotal	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Removed	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Subtotal	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

5. Activity Data

5.1. Construction Schedule

Phase Name	Phase Type	Start Date	End Date	Days Per Week	Work Days per Phase	Phase Description
Fleet Vehicle Use	Site Preparation	1/1/2024	12/31/2024	7.00	366	—
Vendor-Contractor Vehicles	Site Preparation	1/1/2024	12/31/2024	5.00	262	—
Equipment	Grading	1/1/2024	12/31/2024	7.00	366	—
Worker Vehicles	Grading	1/1/2024	12/31/2024	7.00	366	—

5.2. Off-Road Equipment

5.2.1. Unmitigated

Phase Name	Equipment Type	Fuel Type	Engine Tier	Number per Day	Hours Per Day	Horsepower	Load Factor
Equipment	Aerial Lifts	Diesel	Average	6.00	1.00	84.0	0.37
Equipment	Forklifts	CNG	Average	7.00	1.00	70.0	0.30
Equipment	Off-Highway Trucks	Diesel	Average	4.00	1.00	367	0.40
Equipment	Rough Terrain Forklifts	Diesel	Average	6.00	1.00	96.0	0.40

5.3. Construction Vehicles

5.3.1. Unmitigated

Phase Name	Trip Type	One-Way Trips per Day	Miles per Trip	Vehicle Mix
Fleet Vehicle Use	—	—	—	—
Fleet Vehicle Use	Worker	100	8.80	LDA,LDT1,LDT2
Fleet Vehicle Use	Vendor	—	5.30	HHDT,MHDT
Fleet Vehicle Use	Hauling	0.00	20.0	HHDT
Fleet Vehicle Use	Onsite truck	—	—	HHDT
Vendor-Contractor Vehicles	—	—	—	—
Vendor-Contractor Vehicles	Worker	0.00	8.80	LDA,LDT1,LDT2
Vendor-Contractor Vehicles	Vendor	134	5.30	HHDT,MHDT
Vendor-Contractor Vehicles	Hauling	0.00	20.0	HHDT
Vendor-Contractor Vehicles	Onsite truck	—	—	HHDT
Equipment	—	—	—	—
Equipment	Worker	0.00	8.80	LDA,LDT1,LDT2
Equipment	Vendor	—	5.30	HHDT,MHDT
Equipment	Hauling	0.00	20.0	HHDT
Equipment	Onsite truck	—	—	HHDT
Worker Vehicles	—	—	—	—
Worker Vehicles	Worker	700	10.8	LDA,LDT1,LDT2
Worker Vehicles	Vendor	—	5.30	HHDT,MHDT
Worker Vehicles	Hauling	0.00	20.0	HHDT
Worker Vehicles	Onsite truck	—	—	HHDT

5.4. Vehicles

5.4.1. Construction Vehicle Control Strategies

Non-applicable. No control strategies activated by user.

5.5. Architectural Coatings

Phase Name	Residential Interior Area Coated (sq ft)	Residential Exterior Area Coated (sq ft)	Non-Residential Interior Area Coated (sq ft)	Non-Residential Exterior Area Coated (sq ft)	Parking Area Coated (sq ft)

5.6. Dust Mitigation

5.6.1. Construction Earthmoving Activities

Phase Name	Material Imported (cy)	Material Exported (cy)	Acres Graded (acres)	Material Demolished (sq. ft.)	Acres Paved (acres)
Fleet Vehicle Use	—	—	0.00	0.00	—
Vendor-Contractor Vehicles	—	—	0.00	0.00	—
Equipment	—	—	0.00	0.00	—
Worker Vehicles	—	—	0.00	0.00	—

5.6.2. Construction Earthmoving Control Strategies

Non-applicable. No control strategies activated by user.

5.7. Construction Paving

Land Use	Area Paved (acres)	% Asphalt
General Heavy Industry	0.00	0%

5.8. Construction Electricity Consumption and Emissions Factors

kWh per Year and Emission Factor (lb/MWh)

Year	kWh per Year	CO2	CH4	N2O
2024	0.00	204	0.03	< 0.005

5.9. Operational Mobile Sources

5.9.1. Unmitigated

Land Use Type	Trips/Weekday	Trips/Saturday	Trips/Sunday	Trips/Year	VMT/Weekday	VMT/Saturday	VMT/Sunday	VMT/Year
Total all Land Uses	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

5.10. Operational Area Sources

5.10.1. Hearths

5.10.1.1. Unmitigated

5.10.2. Architectural Coatings

Residential Interior Area Coated (sq ft)	Residential Exterior Area Coated (sq ft)	Non-Residential Interior Area Coated (sq ft)	Non-Residential Exterior Area Coated (sq ft)	Parking Area Coated (sq ft)
0	0.00	1,500	500	—

5.10.3. Landscape Equipment

Season	Unit	Value
Snow Days	day/yr	0.00
Summer Days	day/yr	180

5.11. Operational Energy Consumption

5.11.1. Unmitigated

Electricity (kWh/yr) and CO2 and CH4 and N2O and Natural Gas (kBTU/yr)

Land Use	Electricity (kWh/yr)	CO2	CH4	N2O	Natural Gas (kBTU/yr)
General Heavy Industry	27,959,568	204	0.0330	0.0040	0.00

5.12. Operational Water and Wastewater Consumption

5.12.1. Unmitigated

Land Use	Indoor Water (gal/year)	Outdoor Water (gal/year)
General Heavy Industry	22,330,980	18,110,000

5.13. Operational Waste Generation

5.13.1. Unmitigated

Land Use	Waste (ton/year)	Cogeneration (kWh/year)
General Heavy Industry	1,197	—

5.14. Operational Refrigeration and Air Conditioning Equipment

5.14.1. Unmitigated

Land Use Type	Equipment Type	Refrigerant	GWP	Quantity (kg)	Operations Leak Rate	Service Leak Rate	Times Serviced
General Heavy Industry	Other commercial A/C and heat pumps	R-410A	2,088	0.30	4.00	4.00	18.0

5.15. Operational Off-Road Equipment

5.15.1. Unmitigated

Equipment Type	Fuel Type	Engine Tier	Number per Day	Hours Per Day	Horsepower	Load Factor

5.16. Stationary Sources

5.16.1. Emergency Generators and Fire Pumps

Equipment Type	Fuel Type	Number per Day	Hours per Day	Hours per Year	Horsepower	Load Factor
Emergency Generator	Diesel	3.00	2.00	25.0	779	1.00
Emergency Generator	Diesel	1.00	2.00	25.0	367	1.00
Emergency Generator	Diesel	1.00	2.00	25.0	320	1.00
Emergency Generator	Diesel	1.00	24.0	576	314	1.00

5.16.2. Process Boilers

Equipment Type	Fuel Type	Number	Boiler Rating (MMBtu/hr)	Daily Heat Input (MMBtu/day)	Annual Heat Input (MMBtu/yr)

5.17. User Defined

Equipment Type	Fuel Type

5.18. Vegetation

5.18.1. Land Use Change

5.18.1.1. Unmitigated

Vegetation Land Use Type	Vegetation Soil Type	Initial Acres	Final Acres

5.18.1. Biomass Cover Type

5.18.1.1. Unmitigated

Biomass Cover Type	Initial Acres	Final Acres

5.18.2. Sequestration

5.18.2.1. Unmitigated

Tree Type	Number	Electricity Saved (kWh/year)	Natural Gas Saved (btu/year)

6. Climate Risk Detailed Report

6.1. Climate Risk Summary

Cal-Adapt midcentury 2040–2059 average projections for four hazards are reported below for your project location. These are under Representation Concentration Pathway (RCP) 8.5 which assumes GHG emissions will continue to rise strongly through 2050 and then plateau around 2100.

Climate Hazard	Result for Project Location	Unit
Temperature and Extreme Heat	6.60	annual days of extreme heat
Extreme Precipitation	4.10	annual days with precipitation above 20 mm
Sea Level Rise	0.00	meters of inundation depth
Wildfire	9.82	annual hectares burned

Temperature and Extreme Heat data are for grid cell in which your project are located. The projection is based on the 98th historical percentile of daily maximum/minimum temperatures from observed historical data (32 climate model ensemble from Cal-Adapt, 2040–2059 average under RCP 8.5). Each grid cell is 6 kilometers (km) by 6 km, or 3.7 miles (mi) by 3.7 mi.
Extreme Precipitation data are for the grid cell in which your project are located. The threshold of 20 mm is equivalent to about ¾ an inch of rain, which would be light to moderate rainfall if received over a full day or heavy rain if received over a period of 2 to 4 hours. Each grid cell is 6 kilometers (km) by 6 km, or 3.7 miles (mi) by 3.7 mi.
Sea Level Rise data are for the grid cell in which your project are located. The projections are from Radke et al. (2017), as reported in Cal-Adapt (Radke et al., 2017, CEC-500-2017-008), and consider inundation location and depth for the San Francisco Bay, the Sacramento-San Joaquin River Delta and California coast resulting different increments of sea level rise coupled with extreme storm events. Users may select from four scenarios to view the range in potential inundation depth for the grid cell. The four scenarios are: No rise, 0.5 meter, 1.0 meter, 1.41 meters
Wildfire data are for the grid cell in which your project are located. The projections are from UC Davis, as reported in Cal-Adapt (2040–2059 average under RCP 8.5), and consider historical data of climate, vegetation, population density, and large (> 400 ha) fire history. Users may select from four model simulations to view the range in potential wildfire probabilities for the grid cell. The four simulations make different assumptions about expected rainfall and temperature are: Warmer/drier (HadGEM2-ES), Cooler/wetter (CNRM-CM5), Average conditions (CanESM2), Range of different rainfall and temperature possibilities (MIROC5). Each grid cell is 6 kilometers (km) by 6 km, or 3.7 miles (mi) by 3.7 mi.

6.2. Initial Climate Risk Scores

Climate Hazard	Exposure Score	Sensitivity Score	Adaptive Capacity Score	Vulnerability Score
Temperature and Extreme Heat	N/A	N/A	N/A	N/A
Extreme Precipitation	N/A	N/A	N/A	N/A
Sea Level Rise	N/A	N/A	N/A	N/A
Wildfire	N/A	N/A	N/A	N/A
Flooding	N/A	N/A	N/A	N/A

Drought	N/A	N/A	N/A	N/A
Snowpack Reduction	N/A	N/A	N/A	N/A
Air Quality Degradation	N/A	N/A	N/A	N/A

The sensitivity score reflects the extent to which a project would be adversely affected by exposure to a climate hazard. Exposure is rated on a scale of 1 to 5, with a score of 5 representing the greatest exposure.
The adaptive capacity of a project refers to its ability to manage and reduce vulnerabilities from projected climate hazards. Adaptive capacity is rated on a scale of 1 to 5, with a score of 5 representing the greatest ability to adapt.
The overall vulnerability scores are calculated based on the potential impacts and adaptive capacity assessments for each hazard. Scores do not include implementation of climate risk reduction measures.

6.3. Adjusted Climate Risk Scores

Climate Hazard	Exposure Score	Sensitivity Score	Adaptive Capacity Score	Vulnerability Score
Temperature and Extreme Heat	N/A	N/A	N/A	N/A
Extreme Precipitation	N/A	N/A	N/A	N/A
Sea Level Rise	N/A	N/A	N/A	N/A
Wildfire	N/A	N/A	N/A	N/A
Flooding	N/A	N/A	N/A	N/A
Drought	N/A	N/A	N/A	N/A
Snowpack Reduction	N/A	N/A	N/A	N/A
Air Quality Degradation	N/A	N/A	N/A	N/A

The sensitivity score reflects the extent to which a project would be adversely affected by exposure to a climate hazard. Exposure is rated on a scale of 1 to 5, with a score of 5 representing the greatest exposure.
The adaptive capacity of a project refers to its ability to manage and reduce vulnerabilities from projected climate hazards. Adaptive capacity is rated on a scale of 1 to 5, with a score of 5 representing the greatest ability to adapt.
The overall vulnerability scores are calculated based on the potential impacts and adaptive capacity assessments for each hazard. Scores include implementation of climate risk reduction measures.

6.4. Climate Risk Reduction Measures

7. Health and Equity Details

7.1. CalEnviroScreen 4.0 Scores

The maximum CalEnviroScreen score is 100. A high score (i.e., greater than 50) reflects a higher pollution burden compared to other census tracts in the state.

Indicator	Result for Project Census Tract
Exposure Indicators	—
AQ-Ozone	6.40
AQ-PM	8.33
AQ-DPM	1.94
Drinking Water	69.5
Lead Risk Housing	39.5
Pesticides	69.9
Toxic Releases	4.78
Traffic	30.0
Effect Indicators	—
CleanUp Sites	87.5
Groundwater	99.1
Haz Waste Facilities/Generators	99.3
Impaired Water Bodies	51.2
Solid Waste	83.3
Sensitive Population	—
Asthma	22.0
Cardio-vascular	38.5
Low Birth Weights	7.06
Socioeconomic Factor Indicators	—
Education	7.40
Housing	81.9
Linguistic	0.00
Poverty	44.9
Unemployment	67.5

7.2. Healthy Places Index Scores

The maximum Health Places Index score is 100. A high score (i.e., greater than 50) reflects healthier community conditions compared to other census tracts in the state.

Indicator	Result for Project Census Tract
Economic	—
Above Poverty	51.63608366
Employed	0.230976517
Median HI	47.9019633
Education	—
Bachelor's or higher	52.66264596
High school enrollment	100
Preschool enrollment	20.94187091
Transportation	—
Auto Access	92.6344155
Active commuting	57.93660978
Social	—
2-parent households	92.39060695
Voting	25.18927242
Neighborhood	—
Alcohol availability	97.0101373
Park access	4.722186578
Retail density	7.404080585
Supermarket access	2.399589375
Tree canopy	53.80469652
Housing	—
Homeownership	0.436288977
Housing habitability	62.00436289
Low-inc homeowner severe housing cost burden	99.12742205

Low-inc renter severe housing cost burden	76.40189914
Uncrowded housing	77.4541255
Health Outcomes	—
Insured adults	99.2429103
Arthritis	0.0
Asthma ER Admissions	72.7
High Blood Pressure	0.0
Cancer (excluding skin)	0.0
Asthma	0.0
Coronary Heart Disease	0.0
Chronic Obstructive Pulmonary Disease	0.0
Diagnosed Diabetes	0.0
Life Expectancy at Birth	78.6
Cognitively Disabled	87.2
Physically Disabled	99.2
Heart Attack ER Admissions	56.4
Mental Health Not Good	0.0
Chronic Kidney Disease	0.0
Obesity	0.0
Pedestrian Injuries	19.6
Physical Health Not Good	0.0
Stroke	0.0
Health Risk Behaviors	—
Binge Drinking	0.0
Current Smoker	0.0
No Leisure Time for Physical Activity	0.0
Climate Change Exposures	—

Wildfire Risk	0.0
SLR Inundation Area	0.0
Children	0.1
Elderly	99.5
English Speaking	94.4
Foreign-born	2.8
Outdoor Workers	87.6
Climate Change Adaptive Capacity	—
Impervious Surface Cover	90.1
Traffic Density	15.0
Traffic Access	0.0
Other Indices	—
Hardship	41.2
Other Decision Support	—
2016 Voting	26.1

7.3. Overall Health & Equity Scores

Metric	Result for Project Census Tract
CalEnviroScreen 4.0 Score for Project Location (a)	35.0
Healthy Places Index Score for Project Location (b)	28.0
Project Located in a Designated Disadvantaged Community (Senate Bill 535)	No
Project Located in a Low-Income Community (Assembly Bill 1550)	Yes
Project Located in a Community Air Protection Program Community (Assembly Bill 617)	No

a: The maximum CalEnviroScreen score is 100. A high score (i.e., greater than 50) reflects a higher pollution burden compared to other census tracts in the state.
b: The maximum Health Places Index score is 100. A high score (i.e., greater than 50) reflects healthier community conditions compared to other census tracts in the state.

7.4. Health & Equity Measures

No Health & Equity Measures selected.

7.5. Evaluation Scorecard

Health & Equity Evaluation Scorecard not completed.

7.6. Health & Equity Custom Measures

No Health & Equity Custom Measures created.

8. User Changes to Default Data

Screen	Justification
Construction: Construction Phases	Operational vehicle and equipment use modeled here.
Construction: Off-Road Equipment	Based on applicant provided information.
Construction: Trips and VMT	Based on applicant provided information.
Operations: Energy Use	Based on applicant provided information. All electric.
Operations: Water and Waste Water	Based on applicant provided information. Outdoor water use for launch support.
Operations: Solid Waste	Based on applicant provided information.
Operations: Refrigerants	etwer
Operations: Emergency Generators and Fire Pumps	Existing permitted generators for GHG emissions.

SC-GHG-2021 Interim Costs Alternative 1

	2021 Interim Estimates												
	Metric Tons per year			SC-CO2 per Metric Ton			SC-CH4 per Metric Ton			SC-N2O per Metric Ton			
Year	CO_2	CH_4	N_2O	5.00%	3.00%	2.50%	5.00%	3.00%	2.50%	5.00%	3.00%	2.50%	
2025	17,935.02	0.73	0.122	17	56	83	800	1700	2200	6800	21000	30000	
2026	17,935.02	0.73	0.122	17.4	57.2	84.2	828	1760	2260	7000	21400	30600	
2027	17,935.02	0.73	0.122	17.8	58.4	85.4	856	1820	2320	7200	21800	31200	
2028	17,935.02	0.73	0.122	18.2	59.6	86.6	884	1880	2380	7400	22200	31800	
2029	17,935.02	0.73	0.122	18.6	60.8	87.8	912	1940	2440	7600	22600	32400	
2030	17,935.02	0.73	0.122	19	62	89	940	2000	2500	7800	23000	33000	
												Total	

	Cost of CO2			Cost of CH4			Cost of N2O			Total Cost of GHGs		
Year	5.00%	3.00%	2.50%	5.00%	3.00%	2.50%	5.00%	3.00%	2.50%	5.00%	3.00%	2.50%
2025	$304,895	$1,004,361	$1,488,607	$584	$1,241	$1,606	$827	$2,555	$3,649	$306,306	$1,008,156	$1,493,862
2026	$312,069	$1,025,883	$1,510,129	$604	$1,285	$1,650	$852	$2,603	$3,722	$313,525	$1,029,771	$1,515,501
2027	$319,243	$1,047,405	$1,531,651	$625	$1,328	$1,693	$876	$2,652	$3,795	$320,744	$1,051,385	$1,537,139
2028	$326,417	$1,068,927	$1,553,173	$645	$1,372	$1,737	$900	$2,701	$3,868	$327,963	$1,073,000	$1,558,778
2029	$333,591	$1,090,449	$1,574,695	$666	$1,416	$1,781	$925	$2,749	$3,941	$335,182	$1,094,614	$1,580,417
2030	$340,765	$1,111,971	$1,596,217	$686	$1,460	$1,825	$949	$2,798	$4,014	$342,400	$1,116,229	$1,602,056
	$1,936,982	**$6,348,997**	**$9,254,470**	**$3,810**	**$8,102**	**$10,291**	**$5,328**	**$16,057**	**$22,991**	**$1,946,120**	**$6,373,156**	**$9,287,753**

2022 Draft Costs

Year	Metric Tons per year			SC-CO2 per Metric Ton			SC-CH4 per Metric Ton			SC-N2O per Metric Ton		
	CO_2	CH_4	N_2O	2.50%	2.00%	1.50%	2.50%	2.00%	1.50%	2.50%	2.00%	1.50%
2025	17,935.02	0.73	0.122	130	212	360	1590	2025	2737	39972	60267	95210
2026	17,935.02	0.73	0.122	133	215	365	1657	2101	2823	40920	61492	96796
2027	17,935.02	0.73	0.122	136	219	370	1724	2176	2910	41868	62718	98381
2028	17,935.02	0.73	0.122	139	223	375	1791	2252	2996	42916	63944	99966
2029	17,935.02	0.73	0.122	141	226	380	1857	2327	3083	43764	65169	101552
2030	17,935.02	0.73	0.122	144	230	384	1924	2403	3169	44712	66395	103137

Year	Cost of CO2			Cost of CH4			Cost of N2O			Total Cost of GHGs		
	2.50%	2.00%	1.50%	2.50%	2.00%	1.50%	2.50%	2.00%	1.50%	2.50%	2.00%	1.50%
2025	$2,331,553	$3,802,224	$6,456,607	$1,161	$1,478	$1,998	$4,862	$7,331	$11,582	$2,337,576	$3,811,034	$6,470,187
2026	$2,385,358	$3,856,029	$6,546,282	$1,209	$1,533	$2,060	$4,978	$7,480	$11,775	$2,391,545	$3,865,043	$6,560,118
2027	$2,439,163	$3,927,769	$6,635,957	$1,258	$1,588	$2,124	$5,093	$7,629	$11,968	$2,445,514	$3,936,987	$6,650,049
2028	$2,492,968	$3,999,509	$6,725,633	$1,307	$1,644	$2,187	$5,221	$7,779	$12,161	$2,499,496	$4,008,932	$6,739,980
2029	$2,528,838	$4,053,315	$6,815,308	$1,355	$1,698	$2,250	$5,324	$7,928	$12,353	$2,535,517	$4,062,941	$6,829,911
2030	$2,582,643	$4,125,055	$6,887,048	$1,404	$1,754	$2,313	$5,439	$8,077	$12,546	$2,589,486	$4,134,885	$6,901,907
Total	**$14,760,521**	**$23,763,902**	**$40,066,835**	**$7,695**	**$9,696**	**$12,932**	**$30,917**	**$46,224**	**$72,385**	**$14,799,133**	**$23,819,821**	**$40,152,151**

Appendix B

Exhaust Plume Calculations for SpaceX Merlin5 Booster Engine

ANALYSIS REPORT	**NUMBER: 2019-002** **DATE: 14 June 2019**
SUBJECT: Exhaust Plume Calculations for SpaceX Merlin5 Booster Engine	**PAGE 1 OF 11** **NO. OF APPEN. 0**
PREPARED FOR: Matthew Thompson, SpaceX	**(W.O. 6012)**
DISTRIBUTION: Katy Smith, SpaceX	

1.0 SUMMARY

Calculations were performed to estimate the far-field exhaust constituents of the SpaceX Merlin 5 LOX-kerosene booster rocket engine firing under sea-level conditions. Although the exit-plane exhaust is fuel-rich and contains high concentrations of carbon monoxide (CO), subsequent entrainment of ambient air results in complete conversion of the CO into carbon dioxide (CO_2) and oxidation of the soot from the gas generator exhaust. A small amount of thermal nitrous oxides (NOx) is formed, all as NO. The NO emission is predicted to be 1.047 lb_m/s under nominal power (100%) operation.

2.0 ENGINE DESCRIPTION

The subject engine is the baseline booster engine for the SpaceX Falcon 9 launch vehicle family. This analysis address the latest version of the engine, the Merlin 5. The propellants are liquid oxygen (LOX) and the RP-1 grade of kerosene. The subject engine consists of a 16.27:1 regeneratively-cooled thrust chamber nozzle exhaust plus a fuel-rich gas exhaust from the turbopump drive system. As a simplification needed to address the problem with the existing axisymmetric analysis tools, the computational nozzle exit plane includes an outer annulus of low mixture ratio turbine exhaust gas generator surrounding the physical thrust chamber exhaust plume. Characteristic dimensions of the thrust chamber nozzle are included in Table 1.

The nominal operating condition for the Merlin 5 engine is an injector face stagnation pressure (Pc) of 1859 psia and an engine O/F mixture ratio (MR) of 2.356. The associated thrust chamber MR is 2.576 and the gas generator (GG) MR is 0.423. The GG mass fraction is about 4.28% of the total engine flow. The current analysis was performed for the 100% nominal engine operating pressure (Pc=1859 psia) and an engine MR of 2.58.

Table 1: Merlin 5 Nozzle Characteristics

Throat Radius (in)	4.429
Downstream radius of curvature (in)	1.250
Tangency angle (deg)	35.33
Nozzle lip exit angle (deg)	8.973
Nozzle exit diameter (in) [excluding GG exhaust duct]	35.733
Nozzle throat to exit length (in)	39.617

3.0 ANALYSIS APPROACH

A series of simulations were required to estimate the emissions from the Merlin 5 engine. The PERCORP analysis model[1] was used to estimate the O/F mixture ratio variations that exist within the Merlin 5 thrust chamber. The fuel-rich combustion model in PERCORP was also used to estimate the gas generate exhaust constituents. The VIPER parabolized Navier-Stokes model[2] was used to kinetically expand the thrust chamber exhaust to the nozzle exit plane. The VIPER results were used to assess the validity of the PERCORP solution, correlating engine thrust, mass flow rate and specific impulse (ISP) to test results. PERCORP input parameters were adjusted until there was good agreement between the VIPER performance predictions and the test results. The SPF code[3] was used to predict the flow structure of the free exhaust plume and the entrainment of ambient air. VIPER solution was used as the starting condition for the SPF. Though the SPF code can handle detailed chemical kinetics within the plume evolving flow field, the strong barrel shock downstream of the nozzle exit produces numerical convergence problems with the version of SPF used. The present SPF simulations were performed without chemical kinetics. The results were air entrainment and gas temperature profiles. The SPF and VIPER results were used as inputs for one-dimensional kinetic modelling of the plume flow field. The kinetic model in the TDK code[4] was used to model chemical reactions within the evolving plume flow field.

TDK modelling of the plume flow field included chemical mechanism that address a) the oxidation of CO to CO_2, b) the complex oxidation of hydrocarbons to H_2O and CO_2, c) the oxidation of soot to CO_2, and d) the thermal generation of NOx in a mixture of air and combustion products. Table 2 includes the chemical reactions and rates used in the TDK simulation.

Table 2: Kinetic Reactions Included in One Dimensional Chemistry Simulations*

	A	N	B
H + H + m = H2 + m†	6.4E17	1.0	0.0
H + OH + m = H2O + m	8.4E21	2.0	0.0
O + O + m = O2 + m	1.9E13	0.0	-1.79
CO + O + m = CO2 + m	1.0E14	0.0	0.0
O + H + m = OH + m	3.62E18	1.0	0.0
CH4 + m = CH3 + H + m	1.259E17	0	88.4
HCO + m = CO + H + m	5.012E14	0	19.0
C2H3 + m = C2H2 + H + m	7.943E14	0	31.5
N+NO = N2+O	2.700E13	0	0.355
N+O2 = NO+O	9.000E9	-1.0	6.5
N+OH = NO+H	3.360E13	0	0.385
HO2+NO = NO2+OH	2.110E12	0	-0.480
NO2+O = NO+O2	3.900E12	0	-0.240
NO2+H = NO+OH	1.320E14	0	0.360
O2 + H = O + OH	2.2E14	0.0	16.8
H2 + O = H + OH	1.8E10	-1.	8.9
H2 + OH = H2O + H	2.2E13	0.0	5.15
OH + OH = H2O + O	6.3E12	0.0	1.09
CO + OH = CO2 + H	1.5E7	-1.3	-.765
CO + O = CO2	2.5E6	0.0	3.18
CO2 + O = CO + O2	1.7E13	0.0	52.7
CH4+ OH = CH3 + H2O	3.162E13	0	6.0
H + CH4 = CH3 + H2	6.310E14	0	15.1
O + CH4 = CH3 + OH	3.981E14	0	14.0
CH3 + O = CH2O + H	1.259E14	0	2.0
CH3 + OH = CH2O + H2	3.981E12	0	0
C2H2 + OH = C2H + H2O	6.310E12	0	7.0
H + CH2O = HCO + H2	3.162E14	0	10.5
O + CH2O = HCO + OH	1.995E13	0	3.1

* TDK reaction format is k=AT**(-N)*EXP(-1000B/RT) [cc-Kcal-K-mole-s]

† m is any molecule for a third body reaction

Table 2: Kinetic Reactions Included in One Dimensional Chemistry Simulations (ctd)

	A	N	B
OH + CH2O = HCO + H2O	7.943E12	0	0.2
H + HCO = CO + H2	1.995E14	0	0
OH + HCO = CO + H2O	1.000E14	0	0
H + C2H2 = C2H + H2	1.995E14	0	19.0
O + C2H2 = CH2 + CO	5.012E13	0	3.7
C2H + O2 = HCO + CO	1.000E13	0	7.0
CH2 + O2 = HCO + OH	1.000E14	0	3.7
H + C2H4 = C2H3 + H2	1.000E14	0	8.5
C2H2 + H = C2H3	5.500E12	0	2.39
H + C3H6 = C2H4 + CH3	3.981E12	0	0
C(GR)[‡] + OH = CO + H	6.02E8	-0.5	0

4.0 ANALYSIS RESULTS

The PERCORP modelling of the Merlin 5 thrust chamber included 11.1% fuel film cooling injected at two locations down the chamber wall. The SpaceX supplied chamber wall temperature profile agreed well with the PERCORP results. The PERCORP solution for the nominal 319.36 lbf-s/lb_m thrust chamber specific impulse includes a 2.0% core mixing loss, yielding a characteristic velocity (C*) efficiency of 96.4%. The C* efficiency agrees well with SpaceX test data. The fuel-rich combustion model was used to predict the GG exhaust species mass fractions (Table 3). The PERCORP results included initial boundary conditions for the VIPER nozzle flow field simulation. The predicted thrust chamber nozzle exit species mass fractions from VIPER are listed in Table 4.

The GG exhaust species from PERCORP and the nozzle exhaust species, temperature and velocity fields from VIPER were used as initial conditions for the SPF exhaust plume flow field modelling. Three heavy hydrocarbon species ($C_{12}H_{23}$, C_7H_{14} and C_3H_6) predicted to exist in the GG exhaust were thermally cracked into smaller constituents (C_2H_2, C_2H_4, CH_4, H_2) using relationships suggested by Reference 5.

The SPF modelling stepped to 100 nozzle exit radii (Rexit = 18.3214 inches, 1.527 ft). Predicted plume contours for temperature and mass fractions of N_2, CO and soot are presented in Figure 1 through Figure 4. Since there plume entrainment and mixing field is simulated for chemically frozen flow, the N_2 contours are representative of the air entrainment, while the CO and soot contours indicate key products of incomplete combustion.

‡ C(GR) is the carbon representative of soot

Table 3: Gas Generator Exhaust Species Mass Fraction from PERCORP

Species	Mass Fraction
CO	0.3035
CO2	0.0625
H2	0.0030
H2O	0.0918
CH4	0.0476
C2H2	0.0114
C2H4	0.2098
C(GR)	0.0030
C2H6	0.0471
C3H6	0.0662
C7H14	0.0397
C12H23	0.1144

Table 4: Thrust Chamber Nozzle Exit Species Mass Fraction from VIPER Simulation

Species	Mass Fraction
CO2	0.4230
H2O	0.2538
CO	0.2536
O2	0.0367
H2	0.0086
C(GR)	0.0066
OH	0.0064
C2H2	0.0062
CH4	0.0027
O	0.0013
C2H4	7.79E-04
H	1.31E-04
HCO	1.49E-05

Figure 1: Plume Temperature Contours (degrees K)
R is radius normalized by Rexit, X is axial distance from nozzle exit normailzied by Rexit

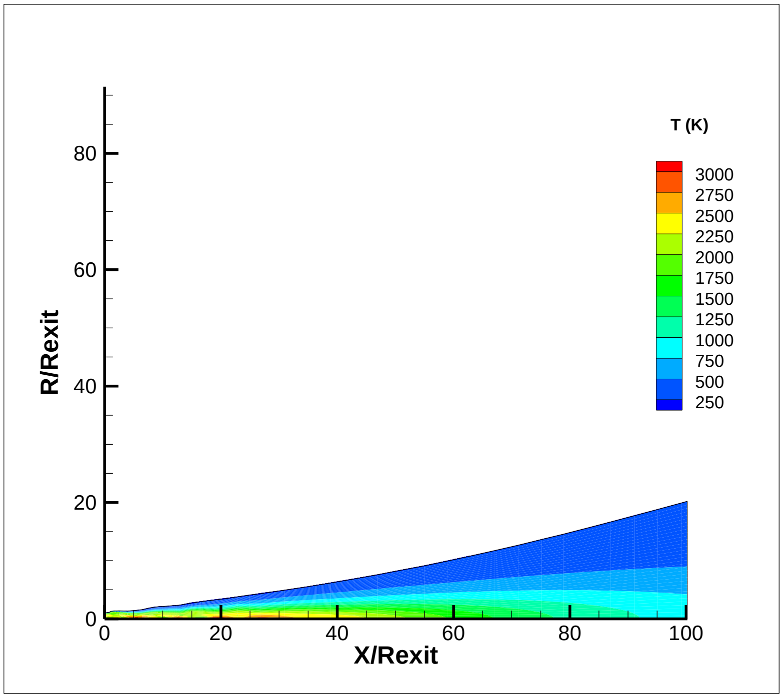


Figure 2: Plume N_2 Mass Fraction Contours (degrees K)
R is radius normalized by Rexit, X is axial distance from nozzle exit normailzied by Rexit

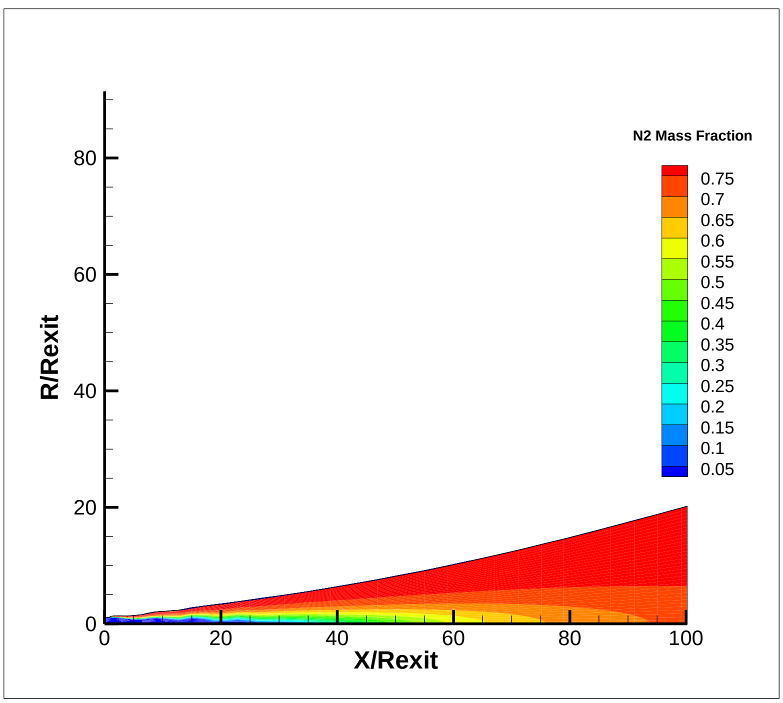


Figure 3: Plume CO Mass Fraction
R is radius normalized by Rexit, X is axial distance from nozzle exit normailzied by Rexit

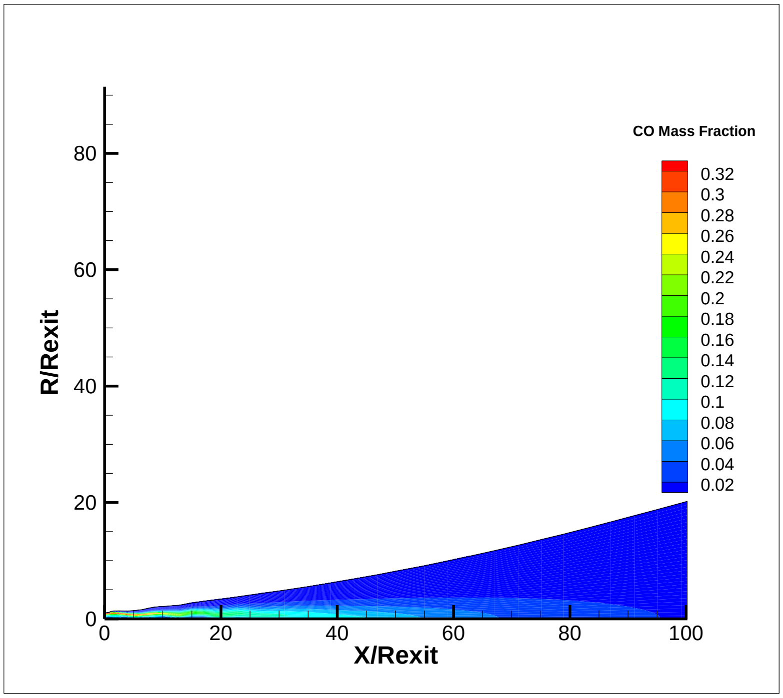
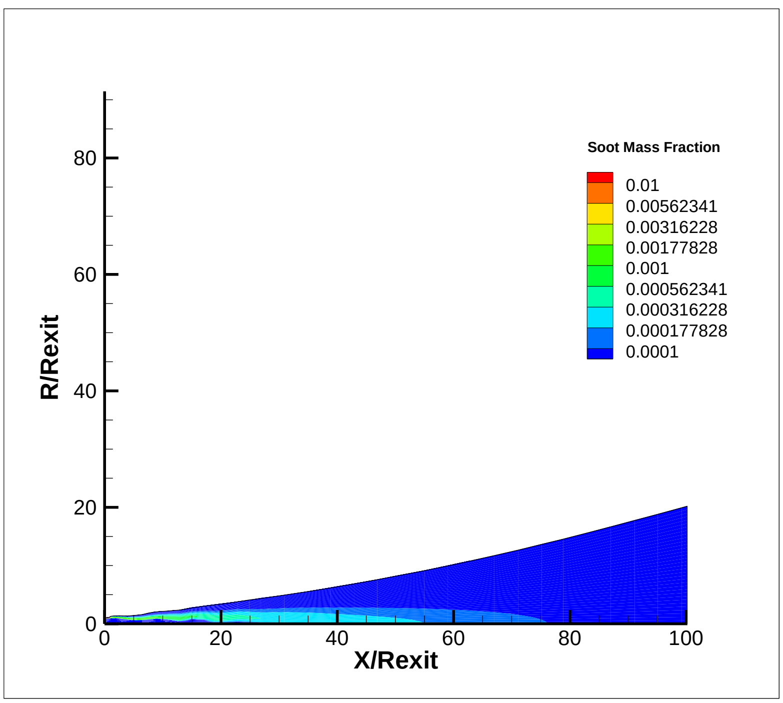


Figure 4: Plume Soot Mass Fraction Contours
R is radius normalized by Rexit, X is axial distance from nozzle exit normailzied by Rexit



The reactive plume was defined to include all flow that had a CO concentration greater than 1,000 ppm. Integration of the SPF data indicates that 18,390 lb/s air is entrained by the end of the simulation (Figure 5). It is estimated that the 153 meter entrainment end point is reached 294 msec after the plume flow exits the nozzle.

Figure 5: Axial Air Entrainment Estimates from SPF.

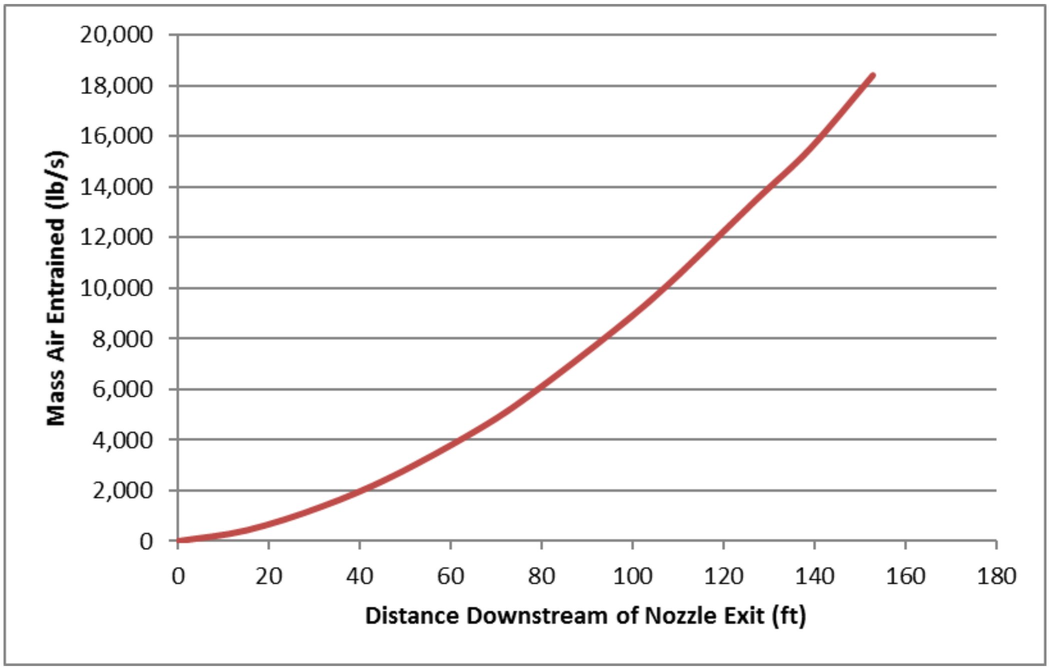
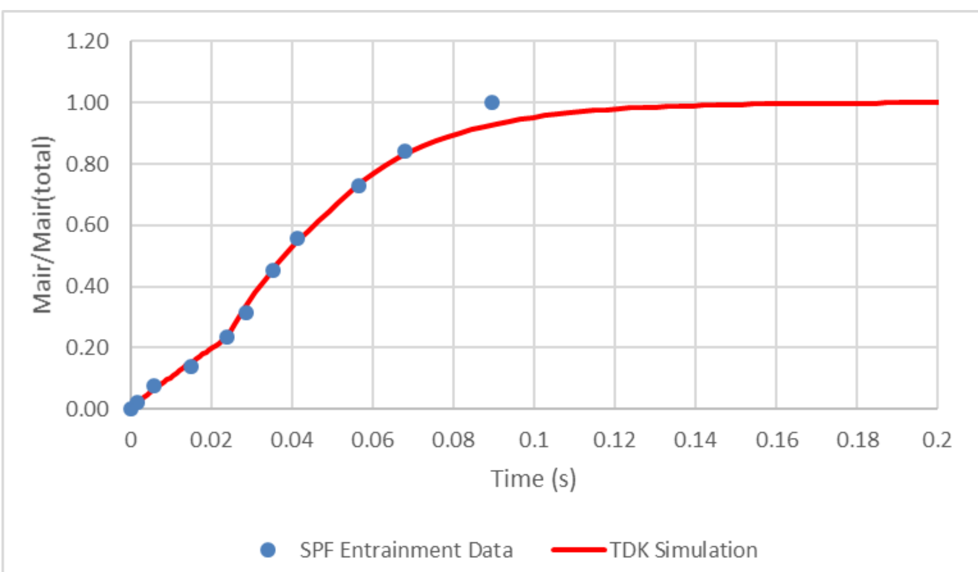


Figure 6: Approximate Air Entrainment Profile used in TDK Simulations



The subsequent TDK simulation of the plume chemistry required an approximate fit of the air entrainment rate. The SPF air entrainment profile was fit to an "availability profile" for the TDK simulations, whereby ambient air is mixed into the plume flow. Figure 6 shows that the approximate TDK air addition agrees well with the entrainment rate predicted by SPF.

The one-dimensional kinetics modeling of the after-burning characteristics of the exhaust plume was performed assuming a piecemeal constant pressure (13.6-14.7 psia) and entrainment of ambient temperature air. The model predicted that all the soot quickly (<5 msec) burns out (i.e. converts to CO). Complete CO oxidation occurs within 35 msec, with concentrations reduced to 2 ppm. The small concentration of unburnt hydrocarbons (CH_4, C_2H_2, C_2H_4, CH_3) are rapidly oxidized, surviving less than 1 msec. The limited thermal NO formation occurs during the early part of the entrainment process, with NO mass fraction constant after about 10 msec. The NO mass fraction at the end of the 157 ft long plume entrainment is 0.000055. Given the total mixed plume mass flow rate of 19041 lb/s, this corresponds to a NO mass flow of 1.047 lb/s. Figure 7 and Figure 8 show the predicted temperature and pollutant species mass fraction profiles. The pollutant flow rates were calculated in terms of lb_m generated per second of steady engine operation.

Figure 7: Predicted Profile of Bulk Plume Temperature and Species Concentration

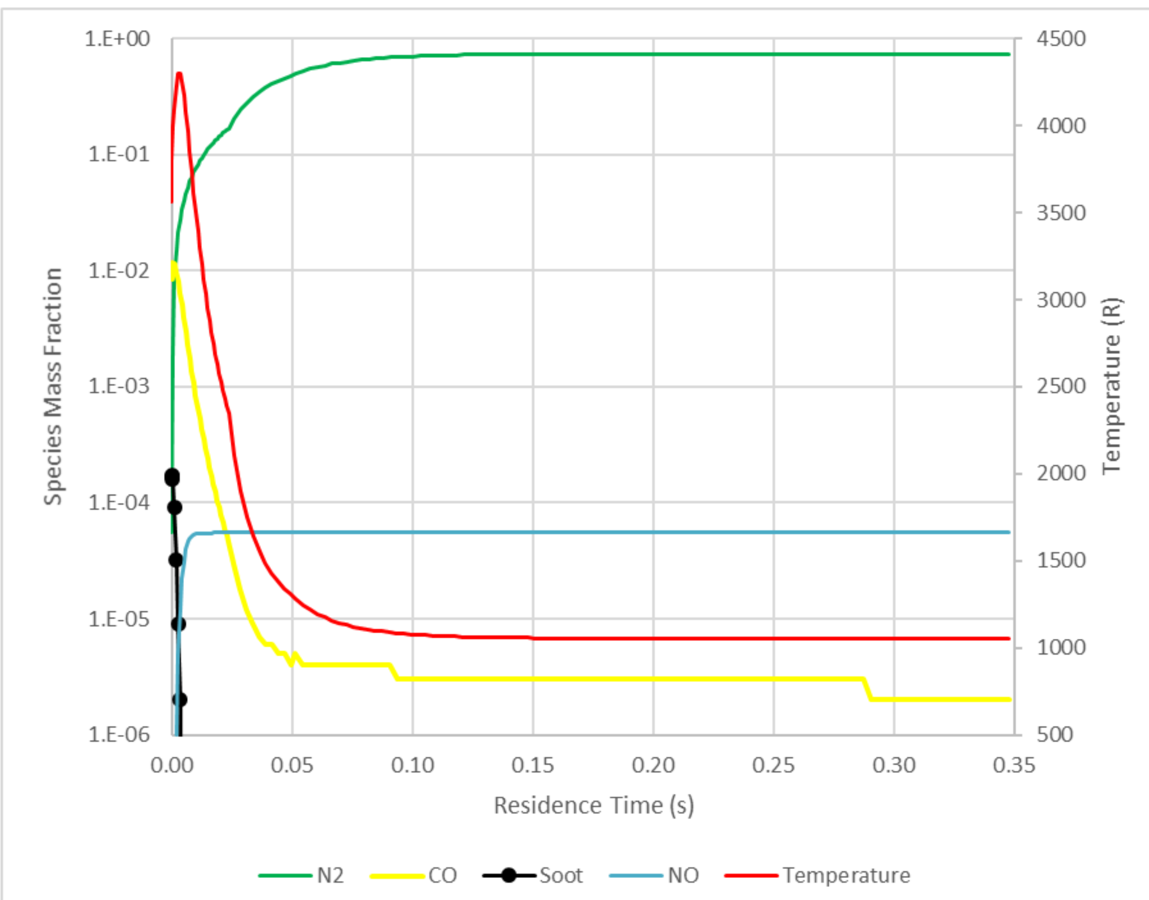
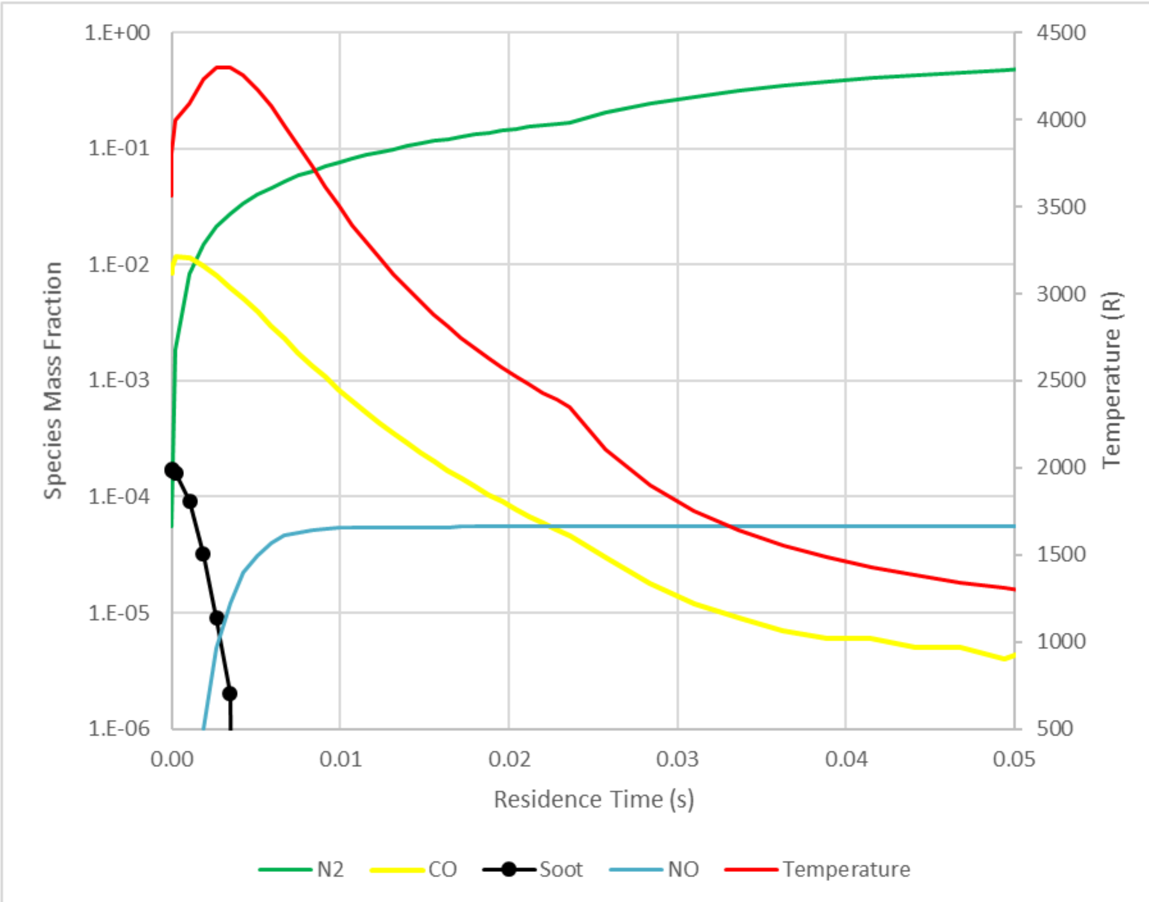


Figure 8: Predicted Profile of Bulk Plume Temperature and Species Concentration for Initial Residence Times



5.0 REFERENCES

[1] *Performance Correlation Program (PERCORP 2006) Reference and User's Manual, Version 2.0*, Sierra Engineering Inc., Carson City, NV, June 2009

[2] *Viscous Interaction Performance Evaluation Routine For Two-Phase Nozzle Flows With Finite Rate Chemistry, VIPER 4.5*, Software and Engineering Associates, Carson City, NV, 2018

[3] Taylor, M.W. and Pergament, H.S.; *Standardized Plume Flowfield Model SPF-III, Version 4.2 Program User's Manual*, PST TR-51, Propulsion Science and Technology, Inc. East Windsor, NJ, June 2000

[4] Nickerson, G. R., Dunn, S.S., Coats, D.E. and Berker, D.R.; *Two-Dimensional Kinetics (TDK) Nozzle Performance Computer Program User's Manual*, Software and Engineering Associates, Carson City, NV, Jan 1999

[5] Nickerson, G.R. and Johnson, C.W.; "A Sooting Model for Fuel Rich LOX/Hydrocarbon Combustion", 28th JANNAF Combustion Meetings, San Antonio, TX, 28 Oct-1 Nov, 1991

Appendix C

SCAQMD General Conformity Determination

Air Quality and Greenhouse Gas Emissions Technical Report

Falcon Program Expansion Alternative 2 at Vandenberg Space Force Base, California

OCTOBER 2024

Prepared for:

SPACE LAUNCH DELTA 30, INSTALLATION MANAGEMENT FLIGHT ENVIRONMENTAL ASSETS
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Table of Contents

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TABLES

APPENDIX

Acronyms and Abbreviations

Acronym/Abbreviation	Definition
CAA	Clean Air Act
CO	carbon monoxide
EPA	U.S. Environmental Protection Agency
HAP	hazardous air pollutant
NAAQS	National Ambient Air Quality Standards
NO_2	nitrogen dioxide
NO_x	oxides of nitrogen
O_3	ozone
PM_{10}	particulate matter with an aerodynamic diameter less than or equal to 10 microns
$PM_{2.5}$	particulate matter with an aerodynamic diameter less than or equal to 2.5 microns
Alternative 2	Falcon Program Expansion at Vandenberg Space Force Base
SO_2	sulfur dioxide
SO_x	sulfur oxides
VOC	volatile organic compound

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Executive Summary

The purpose of this technical report is to assess the potential air quality emissions impacts associated with implementation of the Falcon Program Expansion (Alternative 2) and alternatives at Vandenberg Space Force Base (VSFB), California.

Project and Approach Overview

Alternative 2 is to increase the annual Falcon launch cadence at VSFB through launches at Space Launch Complex (SLC)-4 to support future commercial and U.S. government launch service needs.

The project site is in Santa Barbara County, California but has components occurring within Ventura and Los Angeles Counties. The California Air Resources Board is responsible for maintaining air quality standards in California. The local air districts implement adopted air quality standards and regulations.

Operational criteria air pollutant emissions were estimated using the Air Conformity Applicability Model (ACAM), spreadsheet models, and the California Emissions Estimator Model (CalEEMod). Alternative 2 does not contain a construction component.

Air Quality

Criteria air pollutants are defined as pollutants for which the federal and state governments have established ambient air quality standards, or criteria, for outdoor concentrations to protect public health. Criteria air pollutants include ozone (O_3), nitrogen dioxide (NO_2), carbon monoxide (CO), sulfur dioxide (SO_2), particulate matter with an aerodynamic diameter less than or equal to 10 microns (PM_{10}), particulate matter with an aerodynamic diameter less than or equal to 2.5 microns ($PM_{2.5}$), and lead. Pollutants that were evaluated were reactive organic gases, oxides of nitrogen (NO_x), CO, sulfur oxides (SO_x), PM_{10}, and $PM_{2.5}$. Reactive organic gases and NO_x are important because they are precursors to O_3.

Insignificance Criteria

For air quality impact assessments, significance is defined by the degree to which the effects of Alternative 2 potentially could affect public health or safety. The U.S. Air Force (USAF) conducts National Environmental Policy Act (NEPA) and General Conformity Rule air quality impact assessments in tandem within the Environmental Impact Analysis Process (EIAP) (HQ AFCEC/CZTQ 2023a).

The USAF insignificance thresholds are EPA-established annual emission rates that, if exceeded, would trigger a regulatory requirement. Insignificance indicators are EPA-established rate thresholds that are partially applied or applied out of context to their intended use; however, can provide a direct gauge of potential impact. Although indicators do not trigger a regulatory requirement, they do provide an indication or a warning that the action is potentially approaching a threshold which would trigger a significant regulatory requirement.

The air quality impact evaluation for this action requires two separate analyses: the Clean Air Act (CAA) General Conformity Analysis and an analysis under NEPA. Impacts of air pollutants emitted by activities in the Pacific Ocean, bays, and inland locations in State waters (i.e., up to 3 nm from the coast) are assessed under the General

Conformity Rule. Impacts of air pollutants emitted by activities in the Pacific Ocean, bays, and inland locations in U.S. territorial seas (i.e., up to 12 nm from the coast) are assessed under NEPA. Each coastal state may claim the territorial sea that extends seaward up to 12 nm from its shores and exercise sovereignty over its territorial sea, the air space above it, and the seabed and subsoil beneath it (National Oceanic and Atmospheric Administration [NOAA] 2017). The state jurisdictions may extend the full distance of territorial seas or may retain historical limits.

The project's operational emissions are below the DAF insignificance thresholds within the SBCAPCD, VCAPCD, and SCAQMD jurisdictions. Therefore, the proposed project is not expected to result in any new or additional violations of the NAAQS or impede the projected attainment of the NAAQS.

Greenhouse Gas Emissions

Alternative 2 would generate greenhouse gas (GHG) emissions during operation. During operation, GHGs would be generated from launch and landings, boost-back, fairing recovery, roll-on-roll-off, personnel, energy use, solid waste generation, and water and wastewater.

The social cost of GHG (SC-GHG) is an economic concept used to quantify the monetary value of the long-term societal damages caused by the emission of GHGs into the atmosphere. This metric seeks to capture the various adverse impacts associated with GHG emissions, such as climate change, health problems, ecosystem damage, and economic losses. By assigning a dollar value to these damages, the SC-GHG provides a tool for policymakers, businesses, and governments to assess the true costs of emitting CO_2, CH_4, N_2O, and other GHGs. Under a 5% discount rate, Alternative 2 would have a SC-GHGs of over $1.5 million, under a 3% discount rate over $4.9 million, and at a 2.5% discount rate over $7.1 million.

Alternative 2 would not have an adverse effect on water, ecosystem and ecosystem services, the coast, indigenous peoples, energy, food, or human health. In terms of climate change impacts on Alternative 2, it may adapt to changing conditions of water supplies; keep employees safe by following all California Occupational Safety and Health Administration regulations; and prepare for major storm and flooding events and adjust operations accordingly.

1 Introduction

1.1 Report Purpose and Scope

The purpose of this technical report is to assess the potential air emissions associated with implementation of the Falcon Program Expansion (Alternative 2) and alternatives at Vandenberg Space Force Base (VSFB), California. This assessment uses the thresholds based on the Department of the Air Force (DAF) insignificance thresholds and indicators to determine if the project would result in an adverse effect.

This introductory section provides a description of the project and the project location. Chapter 2, Air Quality, describes the air quality–related environmental setting, regulatory setting, existing air quality conditions, and threshold and analysis methodology, and presents an air quality impact analysis. Chapter 3, Greenhouse Gases, describes the greenhouse gas (GHG)–related environmental setting, regulatory setting, existing conditions, and threshold and analysis methodology, and presents a GHG impact analysis. Chapter 4, References Cited, provides a list of the references used in this report.

1.2 Regional and Local Setting

Alternative 2 would be located at Space Launch Complex (SLC)-4 on VSFB. VSFB occupies 99,604 acres of central Santa Barbara County, California, and is approximately halfway between San Diego and San Francisco. VSFB occurs in a transitional ecological region that includes the northern and southern distributional limits for many plant and animal species. The Santa Ynez River and State Highway 246 divide VSFB into two distinct parts: North Base and South Base. SLC-4 is located on South Base. SLC-4E is the existing Falcon 9 program launch facility.

1.3 Project Description

Alternative 2 is to increase the annual Falcon launch cadence at VSFB through launches at SLC-4 to support future commercial and U.S. government launch service needs. A description of Alternative 2 is in the following sections.

1.3.1 Launch Vehicle

SpaceX would launch Falcon 9 from SLC-4. Falcon 9 is approximately 229 feet tall and produces approximately 1.7 million pounds of thrust at liftoff. A discussion of Falcon 9 can be found in the 2016 EA and associated supplemental environmental documents.

1.3.2 Launch

SpaceX would conduct launch operations in the same way as described in the 2023 SEA and previous environmental documents (Department of Air Force 2023). One to 3 days before each launch, an engine static fire test, which lasts a few seconds, may be performed. The need to conduct a static fire test depends on the mission, but there would be no more than 30 static fire events per year. Launch operations would occur day or night, at any time during the year. Following each launch, SpaceX would perform a boost-back and landing of the first stage, either downrange on a droneship or at landing zones at VSFB. Mission objectives may occasionally require expending the first stage booster in the Pacific Ocean, as the 2023 SEA described. If intentionally expending the first stage, it would break up upon atmospheric re-entry and there would be no residual propellant or explosion upon impact with the Pacific Ocean. The first stage remnants would sink to the bottom of the ocean.

SpaceX, the USSF, the FAA, and the USCG implement numerous protocols and procedures to assess, avoid, mitigate, and minimize potential risks to public safety and the environment during space launch, which are discussed throughout this EA. The Falcon 9 launch vehicle is proven as one of the most reliable space launch vehicles ever developed, with over a 99% launch success rate since June 2010. While unlikely, there is an extremely low risk of a launch failure. This represents an off-nominal, very low probability, and worst-case scenario, and is not assessed in detail for these reasons. SpaceX implements an Operations Safety Plan at SLC-4, and in the event of a launch failure, SpaceX would activate an Emergency Action Plan. Accordingly, the potential impacts on the environment resulting from a launch failure are not expected to be significant.

Alternative 2 does not include altering the dimensions (shape and altitude) of the airspace or shipping lanes. USCG District Eleven was granted specific regulatory authority to restrict vessel movement, implement safety and warning zones, and provide early warning advisement, but all responsibility to limit risk to navigation safety is solely on the acting space party. USCG District Eleven will advise SpaceX and SLD 30 when the risk exceeds acceptable levels and the primary applicant will be responsible for minimizing the risk with alternate strategies before formal publications. Federal government agencies, including the USCG, are responsible for ensuring maritime safety as required applicable statutes and regulations, such as the PWSA, 33 C.F.R. § 1 (*General Provisions*), 14 C.F.R. § 450 (*Launch and Reentry License Requirements*), and 40 C.F.R. § 229.3 (*Transportation and Disposal of Vessels*). To comply with the necessary notification requirements, SLD 30 would notify USCG of any upcoming launch operations to ensure safe launches over the high seas and navigable waters of the U.S., consistent with current procedures. The USCG would be responsible for issuing NOTMARs that provide hazard area locations before each mission event with ocean impacts. A NOTMAR provides notice of temporary changes in conditions or hazards in navigable waterways with maritime traffic to assist in mitigating risks for dangers associated with waterway users. This tool provides an established and reliable line of communication with the maritime public. The NOTMAR would include the operations dates and times and coordinates of the hazardous operation area.

All launch and reentry operations would comply with the necessary notification requirements, including issuing NOTAMs, as defined in agreements required for an FAA issued launch license. Advance notice via Notice to Air Missions (NOTAMs) and identifying Aircraft Hazard Areas assist general aviation pilots to schedule around any temporary disruption of flight activities in the area of operation. A NOTAM provides notice of unanticipated or temporary changes to components of, or hazards in, the National Airspace System (FAA Order JO 7930.2S, Notices to Air Missions). The FAA issues a NOTAM at least 72 hours before a launch or reentry activity in the airspace to notify pilots and other interested parties of temporary conditions. Launches and reentries would be infrequent and of short duration, and SpaceX regularly provides FAA with updates and schedule changes to their notional three-month launch schedule to minimize interruption to air traffic. FAA's licensing requirements, the process for closures of the National Air Space System, and VSFB's Range Safety actions during launch operations are the 2023 SEA.

1.3.3 Launch Frequency

SpaceX's proposes to increase its launch cadence at VSFB from 36 to 50 launches per year. SpaceX has continued to improve its turn-around time between launches which has provided more opportunity for launches at SLC-4.

1.3.4 Boost-back and Landing

SpaceX would land first stage boosters at VSFB or downrange on a droneship as described in the 2023 SEA. Launches from SLC-4 and those landing downrange on a droneship would occur as described in the 2023 SEA. SpaceX would land up to 12 boosters at SLC-4.

Fairing recovery and jettisoning of the Merlin Vacuum Engine skirt ring would occur as described in the 2023 SEA. The droneship would then transport the booster to the Port of Long Beach as described in the 2023 SEA.

1.3.5 Payloads

Payloads and their associated materials/fuels/volumes are mission dependent, but would be similar to current commercial and government payloads as described 2011 *Environmental Assessment for Launch of NASA Routine Payloads* (NASA 2011). As discussed in the 2023 SEA, Falcon launches from SLC-4 would have similar payloads.

1.3.6 Personnel and Ground Operations

Operations would be similar to those described in the 2023 SEA at SLC-4. To support a cadence increase, SpaceX anticipates adding up to 400 additional personnel to VSFB operations. The existing SpaceX facilities are adequate to support the staff increase. Ground transportation support during launch campaigns would continue to be minimal. SpaceX would continue to utilize up to four specialized trucks per launch to transport boosters between existing SpaceX facilities, including facilities in Hawthorne, California, Building 398, and the hangar at SLC-4 on VSFB. The first stage, second stage, interstage, and payload are each transported by 18-wheel trucks. Fuel and helium are also delivered by 18-wheel trucks on a weekly basis. Personal vehicles would be used by employees to commute locally on and off site. Payload integration and pre-launch protocols associated with Alternative 2 would remain unchanged. However, these operations would increase in frequency to support 50 launches per year.

1.3.7 Utilities

SpaceX would utilize approximately 70,000 gallons of water per launch at SLC-4, as described in the 2023 SEA. Landing operations at SLC-4 would continue to utilize approximately 40,000 gallons per landing.

1.3.8 Vehicle Refurbishment

SpaceX would continue to process vehicles at existing SpaceX facilities, including Building 398 and the SLC-4 hangar for launch operations. Operations include refurbishing the recovered first stage and fairing for reuse in future missions. With launches of up to 50 Falcon 9 from SLC-4, up to 50 boosters and 50 fairings would be refurbished each year. Solvents such as isopropyl alcohol, isopar, and Simple Green would be used during these operations, as well for launch pad operations, facility maintenance, and system flushing.

1.3.9 Booster Roll-On-Roll-Off

SpaceX proposes to transport first stages and fairings from the Port of Long Beach to the VSFB Harbor via a "roll-on-roll-off" (RORO) barge. The first stage would be transferred from the droneship to SpaceX's Self-

Propelled Modular Transport (SPMT) that is positioned on a small, low draft barge. The first stage would be pulled by a tug using a Tier 3 (or higher) engine from the Port of Long Beach into the VSFB Harbor. The first stage would then be driven off the barge by the SPMT and travel from VSFB Harbor to the hangar at SLC-4E, where it would be unloaded. A support tug would be launched from the Port of Hueneme and travel up the coast to assist the barge and primary tug in maneuvering into and out of the VSFB Harbor, the exact arrival time would depend on tide. On day two, the support tug would hotel (also known as berthing while producing in-port emissions while moored) at VSFB harbor for 24 hours. On day three, SpaceX would perform the RORO operation, requiring approximately 15 hours for the primary tug to execute the operation. The support tug would assist the operation, then hotel at the VSFB harbor for the remainder of the time. On day four, the support tug would remain hoteling at VSFB harbor for 24 hours. On day five, the support tug would travel back to the Port of Hueneme, with the exact departure time dependent on tide. Alternative 2 would include up to 50 events per year utilizing roll-on-roll-off operations.

1.3.10 No Action Alternative

Under the No Action Alternative, SpaceX would not increase the annual cadence for Falcon operations from VSFB. SpaceX's ability to fully meet the National Space Transportation Policy goals of providing low-cost reliable access to and from space would be negatively affected, as would the more short-term need to meet the increase in current and future manifest demands. Therefore, the No Action Alternative does not meet the Purpose and Need.

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2 Air Quality

2.1 Environmental Setting

The project site takes place within Santa Barbara County, Ventura County, and Los Angeles County, California.

2.1.1 Meteorological and Topographical Conditions

The primary factors that determine air quality are the locations of air pollutant sources and the amounts of pollutants emitted. Meteorological and topographical conditions, however, also are important. Factors such as wind speed and direction, air temperature gradients and sunlight, and precipitation and humidity interact with physical landscape features to determine the movement and dispersal of criteria air pollutants.

VSFB occupies 99,604 acres of central Santa Barbara County, California, and is approximately halfway between San Diego and San Francisco. VSFB is located within the South-Central Coastal Air Basin (SCCAB), which includes San Luis Obispo, Santa Barbara, and Ventura counties. The Santa Barbara County Air Pollution Control District (SBCAPCD) has jurisdiction over Santa Barbara County and the Ventura County Air Pollution Control District (VCAPCD) has jurisdiction over Ventura County. Alternative 2 would also take place within Los Angeles County for fairing recovery and ocean landings. Los Angeles County is located within the South Coast Air Basin (SCAB) and the South Coast Air Quality Management District (SCAQMD). As such, additional discussion is provided for that region.

Climate

Air quality in the SCCAB is influenced by its meteorological conditions. The Mediterranean climate is characterized by warm summers and mild winters with relatively dry weather. The annual precipitation is on average 17.7 inches per year and the average maximum temperature is 70.8ºF and the average minimum temperature is 50.2 ºF (WRCC 2016).

The climate of the SCCAB is strongly influenced by its proximity to the Pacific Ocean and the location of the high-pressure cell in the northeastern Pacific. With a Mediterranean-type climate, the project area is characterized by warm, dry summers and cool winters with occasional rainy periods. Cool, humid marine air causes frequent fog and low clouds along the coast, generally during the night and morning hours in the late spring and early summer months. The project area is subject to a diurnal cycle in which daily onshore winds from the west and northwest are replaced by mild offshore breezes flowing from warm inland valleys during night and early morning hours. This alternating cycle can create a situation where suspended pollutants are swept offshore at night, and then carried back onshore the following day. Dispersion of pollutants is further degraded when the wind velocity for both day and nighttime breezes is low. The region is also subject to seasonal “Santa Ana” winds. These are typically hot, dry northerly winds that blow offshore at 15 to 20 mph, but can reach speeds in excess of 60 mph.

Two types of temperature inversions (warmer air on top of cooler air) are created in the area: subsidence and radiational. The subsidence inversion is a regional effect created by the Pacific high in which air is heated as it is compressed when it flows from the high-pressure area to the low-pressure areas inland. This type of inversion generally forms at about 1,000 to 2,000 feet and can occur throughout the year, but it is most evident during the summer months. Radiational, or surface, inversions are formed by the more rapid cooling of air near the ground during the night, especially during winter. This type of inversion is typically lower (0 to 500 feet at VSFB, for example) and is generally accompanied by stable air. Both types of inversions limit the dispersal of air pollutants within the regional airshed, with the more stable the air (low wind speeds, uniform temperatures), the lower the amount of pollutant dispersion.

South Coast Air Basin

The metropolitan portions of the County are within the South Coast Air Basin (SCAB). The SCAB is a 6,745-square-mile area bounded by the Pacific Ocean to the west and the San Gabriel, San Bernardino, and San Jacinto Mountains to the north and east. Projects located within the SCAB are subject to the rules and regulations imposed by the SCAQMD, as well as the California Ambient Air Quality Standards (CAAQS) adopted by CARB and National Ambient Air Quality Standards (NAAQS) adopted by the EPA, as detailed below in Section 2.2, Regulatory Setting.

Climate and Topography

The SCAB's air pollution problems are a consequence of the combination of emissions from the nation's second-largest urban area, meteorological conditions that hinder dispersion of those emissions, and mountainous terrain surrounding the SCAB that traps pollutants as they are pushed inland with the sea breeze (SCAQMD 2017). Meteorological and topographical factors that affect air quality in the SCAB are described below.[1]

Climate

The SCAB is characterized as having a Mediterranean climate (typified as semiarid with mild winters, warm summers, and moderate rainfall). The general region lies in the semi-permanent high-pressure zone of the eastern Pacific; as a result, the climate is mild and tempered by cool sea breezes. The usually mild climatological pattern is interrupted infrequently by periods of extremely hot weather, winter storms, or Santa Ana winds.

Moderate temperatures, comfortable humidity, and limited precipitation characterize the climate in the SCAB. The average annual temperature varies little throughout the SCAB, averaging 75°F. However, with a less-pronounced oceanic influence, the eastern inland portions of the SCAB show greater variability in annual minimum and maximum temperatures. All portions of the SCAB have recorded temperatures over 100°F in recent years. Although the SCAB has a semiarid climate, the air near the surface is moist because of the presence of a shallow marine layer. Except for infrequent periods when dry air is brought into the SCAB by offshore winds, the ocean effect is dominant. Periods with heavy fog are frequent, and low stratus clouds, occasionally referred to as "high fog," are a characteristic climate feature. Annual average relative humidity is 70% at the coast and 57% in the eastern part of the SCAB (SCAQMD 1993). Precipitation in the SCAB is typically 9 to 14 inches annually and is rarely in the form of snow or hail because of typically warm weather. However, annual precipitation averages about 18.19 inches at the Project site, falling mostly from October through May (WRCC 2016).[2] Most of the rainfall in Southern California occurs between late fall and early spring, with most rain typically occurring in the months of January and February. Overall, Los Angeles's climate is characterized by relatively low rainfall, with warm summers and mild winters. Average temperatures range from a high of 92.2°F in July to a low of 40.0°F in December (WRCC 2016).

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1 The discussion of meteorological and topographical conditions of the SCAB is based on information provided in the Final 2016 Air Quality Management Plan (SCAQMD 2017).

2 Local climate data for the County is based on the most-representative station measured by the Western Regional Climate Center, which is the Newhall climatological station.

Sunlight

The presence and intensity of sunlight are necessary prerequisites for the formation of photochemical smog. Under the influence of the ultraviolet radiation of sunlight, certain primary pollutants (mainly reactive hydrocarbons and oxides of nitrogen [NO_x][3]) react to form secondary pollutants (primarily oxidants). Since this process is time dependent, secondary pollutants can be formed many miles downwind of the emission sources. Southern California also has abundant sunshine, which drives the photochemical reactions that form pollutants such as ozone (O_3) and a substantial portion of fine particulate matter ($PM_{2.5}$ or particulate matter 2.5 microns or less in diameter). In the SCAB, high concentrations of O_3 are normally recorded during the late spring, summer, and early autumn months, when more intense sunlight drives enhanced photochemical reactions. Because of the prevailing daytime winds and time-delayed nature of photochemical smog, oxidant concentrations are highest in the inland areas of Southern California.

Temperature Inversions

Under ideal meteorological conditions and irrespective of topography, pollutants emitted into the air mix and disperse into the upper atmosphere. However, the Southern California region frequently experiences temperature inversions in which pollutants are trapped and accumulate close to the ground. The inversion, a layer of warm, dry air overlaying cool, moist marine air, is a normal condition in coastal Southern California. The cool, damp, and hazy sea air capped by coastal clouds is heavier than the warm, clear air, which acts as a lid through which the cooler marine layer cannot rise. The height of the inversion is important in determining pollutant concentration. When the inversion is approximately 2,500 feet above mean sea level, the sea breezes carry the pollutants inland to escape over the mountain slopes or through the passes. At a height of 1,200 feet above mean sea level, the terrain prevents the pollutants from entering the upper atmosphere, resulting in the pollutants settling in the foothill communities. Below 1,200 feet above mean sea level, the inversion puts a tight lid on pollutants, concentrating them in a shallow layer over the entire coastal basin. Usually, inversions are lower before sunrise than during the daylight hours.

Mixing heights for inversions are lower in the summer and inversions are more persistent, being partly responsible for the high levels of O_3 observed during summer months in the SCAB. Smog in Southern California is generally the result of these temperature inversions combining with coastal day winds and local mountains to contain the pollutants for long periods, allowing them to form secondary pollutants by reacting in the presence of sunlight. The SCAB has a limited ability to disperse these pollutants due to typically low wind speeds and the surrounding mountain ranges.

As with other regions within the SCAB, the County is susceptible to air inversions, which trap a layer of stagnant air near the ground where pollutants are further concentrated. These inversions produce haziness, which is caused by moisture, suspended dust, and a variety of chemical aerosols emitted by trucks, automobiles, furnaces, and other sources. Elevated concentrations of coarse particulate matter (PM_{10}; particulate matter 10 microns or less in diameter) and $PM_{2.5}$ can occur in the SCAB throughout the year, but they occur most frequently in fall and winter. Although there are some changes in emissions by day of the week and by season, the observed variations in pollutant concentrations are primarily the result of seasonal differences in weather conditions.

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3 NO_x is a general term pertaining to compounds of nitric oxide, nitrogen dioxide, and other oxides of nitrogen.

Pollutants and Effects

Criteria Air Pollutants

Criteria air pollutants are defined as pollutants for which the federal and state governments have established ambient air quality standards, or criteria, for outdoor concentrations to protect public health. The national and California standards have been set, with an adequate margin of safety, at levels above which concentrations could be harmful to human health and welfare. These standards are designed to protect the most sensitive persons from illness or discomfort. Pollutants of concern include O_3, nitrogen dioxide (NO_2), carbon monoxide (CO), sulfur dioxide, PM_{10}, $PM_{2.5}$, and lead. In California, sulfates, vinyl chloride, hydrogen sulfide, and visibility-reducing particles are also regulated as criteria air pollutants. These pollutants, as well as TACs, are discussed in the following paragraphs.[4]

Ozone (O_3). O_3 is a strong-smelling, pale blue, reactive, toxic chemical gas consisting of three oxygen atoms. It is a secondary pollutant formed in the atmosphere by a photochemical process involving the sun's energy and O_3 precursors. These precursors are mainly NO_x and volatile organic compounds (VOCs). The maximum effects of precursor emissions on O_3 concentrations usually occur several hours after they are emitted and many miles from the source. Meteorology and terrain play major roles in O_3 formation, and ideal conditions occur during summer and early autumn on days with low wind speeds or stagnant air, warm temperatures, and cloudless skies. O_3 exists in the upper atmosphere O_3 layer (stratospheric O_3) and at the Earth's surface in the troposphere (ground-level O_3).[5] The O_3 that EPA and CARB regulate as a criteria air pollutant is produced close to the ground level, where people live, exercise, and breathe. Ground-level O_3 is a harmful air pollutant that causes numerous adverse health effects, described below, and is thus considered "bad" O_3. Stratospheric, or "good," O_3 occurs naturally in the upper atmosphere, where it reduces the amount of ultraviolet light (i.e., solar radiation) entering the Earth's atmosphere. Without the protection of the beneficial stratospheric O_3 layer, plant and animal life would be seriously harmed.

O_3 in the troposphere (near the surface) causes numerous adverse health effects; short-term exposures (lasting for a few hours) to O_3 at levels typically observed in Southern California can result in breathing pattern changes, reduction of breathing capacity, increased susceptibility to infections, inflammation of the lung tissue, and some immunological changes (EPA 2013).

Inhalation of O_3 causes inflammation and irritation of the tissues lining human airways, causing and worsening a variety of symptoms. Exposure to O_3 can reduce the volume of air that the lungs breathe in, thereby causing shortness of breath. O_3 in sufficient doses increases the permeability of lung cells, rendering them more susceptible to toxins and microorganisms. The occurrence and severity of health effects from O_3 exposure vary widely among individuals, even when the dose and the duration of exposure are the same. Research shows adults and children who spend more time outdoors participating in vigorous physical activities are at greater risk from the harmful health effects of O_3 exposure. While there are relatively few studies on the effects of O_3 on children, the available studies show that children are no more or less likely to suffer harmful effects than adults. However, there are a number of reasons why children may be more susceptible to O_3 and other pollutants. Children and teens spend nearly twice as much time outdoors and engaged in vigorous activities as adults. Children breathe more rapidly than adults and inhale more pollution per pound of their body weight than adults. Also, children are less likely than adults to notice their own symptoms and avoid harmful exposures. Further research may be able to better distinguish between health effects in

4 The descriptions of the criteria air pollutants and associated health effects are based on EPA's "Criteria Air Pollutants" (EPA 2018a), as well as CARB's "Glossary" (CARB 2019a) and "Fact Sheet: Air Pollution Sources, Effects and Control" (CARB 2009).

5 The troposphere is the layer of the Earth's atmosphere nearest to the surface of the Earth. The troposphere extends outward about 5 miles at the poles and about 10 miles at the equator.

children and adults. Children, adolescents, and adults who exercise or work outdoors, where O_3 concentrations are the highest, are at the greatest risk of harm from this pollutant (CARB 2019b).

Volatile Organic Compounds. Hydrocarbons are organic gases that are formed from hydrogen and carbon and sometimes other elements. Hydrocarbons that contribute to formation of O_3 are referred to and regulated as VOCs (also referred to as reactive organic gases). Combustion engine exhaust, oil refineries, and fossil-fueled power plants are the sources of hydrocarbons. Other sources of anthropogenic and bio-pedogenic hydrocarbons include evaporation from petroleum fuels, solvents, dry cleaning solutions, and paint.

The primary health effects of VOCs result from the formation of O_3 and its related health effects. High levels of VOCs in the atmosphere can interfere with oxygen intake by reducing the amount of available oxygen through displacement. Carcinogenic forms of hydrocarbons, such as benzene, are considered TACs. There are no separate ambient air quality standards for VOCs as a group.

Nitrogen Dioxide (NO_2). NO_2 is a brownish, highly reactive gas that is present in all urban atmospheres. The major mechanism for the formation of NO_2 in the atmosphere is the oxidation of the primary air pollutant nitric oxide, which is a colorless, odorless gas. NO_x plays a major role, together with VOCs, in the atmospheric reactions that produce O_3. NO_x is formed from fuel combustion under high temperature or pressure. In addition, NO_x is an important precursor to acid rain and may affect both terrestrial and aquatic ecosystems. The two major emissions sources are transportation and stationary fuel combustion sources such as electric utility and industrial boilers.

A large body of health science literature indicates that exposure to NO_2 can induce adverse health effects. The strongest health evidence, and the health basis for the ambient air quality standards for NO_2, results from controlled human exposure studies that show that NO_2 exposure can intensify responses to allergens in allergic asthmatics. In addition, a number of epidemiological studies have demonstrated associations between NO_2 exposure and premature death, cardiopulmonary effects, decreased lung function growth in children, respiratory symptoms, emergency room visits for asthma, and intensified allergic responses. Infants and children are particularly at risk because they have disproportionately higher exposure to NO_2 than adults due to their greater breathing rate for their body weight and their typically greater outdoor exposure duration. Several studies have shown that long-term NO_2 exposure during childhood, the period of rapid lung growth, can lead to smaller lungs at maturity in children with higher levels of exposure compared to children with lower exposure levels. In addition, children with asthma have a greater degree of airway responsiveness compared with adult asthmatics. In adults, the greatest risk is to people who have chronic respiratory diseases, such as asthma and chronic obstructive pulmonary disease (CARB 2019c).

Carbon Monoxide (CO). CO is a colorless, odorless gas formed by the incomplete combustion of hydrocarbon, or fossil fuels. CO is emitted almost exclusively from motor vehicles, power plants, refineries, industrial boilers, ships, aircraft, and trains. In urban areas, such as the Project location, automobile exhaust accounts for the majority of CO emissions. CO is a nonreactive air pollutant that dissipates relatively quickly; therefore, ambient CO concentrations generally follow the spatial and temporal distributions of vehicular traffic. CO concentrations are influenced by local meteorological conditions—primarily wind speed, topography, and atmospheric stability. CO from motor vehicle exhaust can become locally concentrated when surface-based temperature inversions are combined with calm atmospheric conditions, which is a typical situation at dusk in urban areas from November to February. The highest levels of CO typically occur during the colder months of the year, when inversion conditions are more frequent.

CO is harmful because it binds to hemoglobin in the blood, reducing the ability of blood to carry oxygen. This interferes with oxygen delivery to the body's organs. The most common effects of CO exposure are fatigue, headaches, confusion and reduced mental alertness, light-headedness, and dizziness due to inadequate oxygen delivery to the brain. For people with cardiovascular disease, short-term CO exposure can further reduce their body's already compromised ability to respond to the increased oxygen demands of exercise, exertion, or stress. Inadequate oxygen delivery to the heart muscle leads to chest pain and decreased exercise tolerance. Unborn babies whose mothers experience high levels of CO exposure during pregnancy are at risk of adverse developmental effects. Unborn babies, infants, elderly people, and people with anemia or with a history of heart or respiratory disease are most likely to experience health effects with exposure to elevated levels of CO (CARB 2019d).

Sulfur Dioxide (SO_2). SO_2 is a colorless, pungent gas formed primarily from incomplete combustion of sulfur-containing fossil fuels. The main sources of SO_2 are coal and oil used in power plants and industries; as such, the highest levels of SO_2 are generally found near large industrial complexes. In recent years, SO_2 concentrations have been reduced by the increasingly stringent controls placed on stationary source emissions of SO_2 and limits on the sulfur content of fuels.

Controlled human exposure and epidemiological studies show that children and adults with asthma are more likely to experience adverse responses with SO_2 exposure, compared with the non-asthmatic population. Effects at levels near the 1-hour standard are those of asthma exacerbation, including bronchoconstriction accompanied by symptoms of respiratory irritation such as wheezing, shortness of breath, and chest tightness, especially during exercise or physical activity. Also, exposure at elevated levels of SO_2 (above 1 part per million [ppm]) results in increased incidence of pulmonary symptoms and disease, decreased pulmonary function, and increased risk of mortality. Older people and people with cardiovascular disease or chronic lung disease (such as bronchitis or emphysema) are most likely to experience these adverse effects (CARB 2019e).

SO_2 is of concern both because it is a direct respiratory irritant and because it contributes to the formation of sulfate and sulfuric acid in particulate matter (NRC 2005). People with asthma are of particular concern, both because they have increased baseline airflow resistance and because their SO_2-induced increase in airflow resistance is greater than in healthy people, and it increases with the severity of their asthma (NRC 2005). SO_2 is thought to induce airway constriction via neural reflexes involving irritant receptors in the airways (NRC 2005).

Particulate Matter. Particulate matter pollution consists of very small liquid and solid particles floating in the air, which can include smoke, soot, dust, salts, acids, and metals. Particulate matter can form when gases emitted from industries and motor vehicles undergo chemical reactions in the atmosphere. $PM_{2.5}$ and PM_{10} represent fractions of particulate matter. Coarse particulate matter (PM_{10}) consists of particulate matter that is 10 microns or less in diameter, which is about 1/7 the thickness of a human hair. Major sources of PM_{10} include crushing or grinding operations; dust stirred up by vehicles traveling on roads; wood-burning stoves and fireplaces; dust from construction, landfills, and agriculture; wildfires and brush/waste burning; industrial sources; windblown dust from open lands; and atmospheric chemical and photochemical reactions. Fine particulate matter ($PM_{2.5}$) consists of particulate matter that is 2.5 microns or less in diameter, which is roughly 1/28 the diameter of a human hair. $PM_{2.5}$ results from fuel combustion (e.g., from motor vehicles and power generation and industrial facilities), residential fireplaces, and woodstoves. In addition, $PM_{2.5}$ can be formed in the atmosphere from gases such as sulfur oxides (SO_x), NO_x, and VOCs.

$PM_{2.5}$ and PM_{10} pose a greater health risk than larger-size particles. When inhaled, these tiny particles can penetrate the human respiratory system's natural defenses and damage the respiratory tract. $PM_{2.5}$ and PM_{10} can increase the number and severity of asthma attacks, cause or aggravate bronchitis and other lung diseases, and reduce the body's ability to fight infections. Very small particles of substances such as lead, sulfates, and nitrates can cause lung damage directly or be absorbed into the bloodstream, causing damage elsewhere in the body. Additionally, these substances can transport adsorbed gases such as chlorides or ammonium into the lungs, also causing injury. Whereas PM_{10} tends to collect in the upper portion of the respiratory system, $PM_{2.5}$ is so tiny that it can penetrate deeper into the lungs and damage lung tissue. Suspended particulates also damage and discolor surfaces on which they settle and produce haze and reduce regional visibility.

A number of adverse health effects have been associated with exposure to both $PM_{2.5}$ and PM_{10}. For $PM_{2.5}$, short-term exposures (up to 24-hour duration) have been associated with premature mortality, increased hospital admissions for heart or lung causes, acute and chronic bronchitis, asthma attacks, emergency room visits, respiratory symptoms, and restricted activity days. These adverse health effects have been reported primarily in infants, children, and older adults with preexisting heart or lung diseases. In addition, of all of the common air pollutants, $PM_{2.5}$ is associated with the greatest proportion of adverse health effects related to air pollution, both in the United States and worldwide based on the World Health Organization's Global Burden of Disease Project. Short-term exposures to PM_{10} have been associated primarily with worsening of respiratory diseases, including asthma and chronic obstructive pulmonary disease, leading to hospitalization and emergency department visits (CARB 2017a).

Long-term exposure (months to years) to $PM_{2.5}$ has been linked to premature death, particularly in people who have chronic heart or lung diseases, and reduced lung function growth in children. The effects of long-term exposure to PM_{10} are less clear, although several studies suggest a link between long-term PM_{10} exposure and respiratory mortality. The International Agency for Research on Cancer published a review in 2015 that concluded that particulate matter in outdoor air pollution causes lung cancer (CARB 2017a).

Lead. Lead in the atmosphere occurs as particulate matter. Sources of lead include leaded gasoline; the manufacturing of batteries, paints, ink, ceramics, and ammunition; and secondary lead smelters. Prior to 1978, mobile emissions were the primary source of atmospheric lead. Between 1978 and 1987, the phaseout of leaded gasoline reduced the overall inventory of airborne lead by nearly 95%. With the phaseout of leaded gasoline, secondary lead smelters, battery recycling, and manufacturing facilities are becoming lead-emissions sources of greater concern.

Prolonged exposure to atmospheric lead poses a serious threat to human health. Health effects associated with exposure to lead include gastrointestinal disturbances, anemia, kidney disease, and in severe cases, neuromuscular and neurological dysfunction. Of particular concern are low-level lead exposures during infancy and childhood. Such exposures are associated with decrements in neurobehavioral performance, including intelligence quotient (IQ) performance, psychomotor performance, reaction time, and growth. Children are highly susceptible to the effects of lead.

Sulfates. Sulfates are the fully oxidized form of sulfur, which typically occur in combination with metals or hydrogen ions. Sulfates are produced from reactions of SO_2 in the atmosphere and can result in respiratory impairment, as well as reduced visibility.

Vinyl Chloride. Vinyl chloride is a colorless gas with a mild, sweet odor, which has been detected near landfills, sewage plants, and hazardous waste sites, due to the microbial breakdown of chlorinated solvents. Short-term exposure to high levels of vinyl chloride in air can cause nervous system effects, such as dizziness, drowsiness, and headaches. Long-term exposure through inhalation can cause liver damage, including liver cancer (CARB 2021a).

Hydrogen Sulfide. Hydrogen sulfide is a colorless and flammable gas that has a characteristic odor of rotten eggs. Sources of hydrogen sulfide include geothermal power plants, petroleum refineries, sewers, sewage treatment plants, and stagnant runoff from clogged water basins. Exposure to hydrogen sulfide can result in nuisance odors, as well as headaches and breathing difficulties at higher concentrations.

Visibility-Reducing Particles. Visibility-reducing particles are any particles in the air that obstruct the range of visibility. Effects of reduced visibility can include obscuring the viewshed of natural scenery, reducing airport safety, and discouraging tourism. Sources of visibility-reducing particles are the same as for $PM_{2.5}$.

Non-Criteria Air Pollutants

Toxic Air Contaminants (TACs). A substance is considered toxic if it has the potential to cause adverse health effects in humans, including increasing the risk of cancer upon exposure, or acute and/or chronic non-cancer health effects. A toxic substance released into the air is considered a TAC. TACs are identified by federal and state agencies based on a review of available scientific evidence. In the state of California, TACs are identified through a two-step process that was established in 1983 under the Toxic Air Contaminant Identification and Control Act. This two-step process of risk identification and risk management and reduction was designed to protect residents from the health effects of toxic substances in the air. In addition, the California Air Toxics “Hot Spots” Information and Assessment Act, AB 2588, was enacted by the legislature in 1987 to address public concern over the release of TACs into the atmosphere. The law requires facilities emitting toxic substances to provide local air pollution control districts with information that will allow an assessment of the air toxics problem, identification of air toxics emissions sources, location of resulting hotspots, notification of the public exposed to significant risk, and development of effective strategies to reduce potential risks to the public over 5 years.

Examples include diesel particulate matter, certain aromatic and chlorinated hydrocarbons, certain metals, and asbestos. TACs are generated by a number of sources, including stationary sources, such as dry cleaners, gas stations, combustion sources, and laboratories; mobile sources, such as automobiles; and area sources, such as landfills and oil and gas facilities. Adverse health effects associated with exposure to TACs may include carcinogenic (i.e., cancer-causing) and non-carcinogenic effects. Non-carcinogenic effects typically affect one or more target organ systems and may be experienced on either short-term (acute) or long-term (chronic) exposure to a given TAC.

Diesel Particulate Matter (DPM). DPM is part of a complex mixture that makes up diesel exhaust. Diesel exhaust is composed of two phases, gas and particle, both of which contribute to health risks. More than 90% of DPM is less than 1 micrometer in diameter (about 1/70 the diameter of a human hair), and thus is a subset of $PM_{2.5}$ (CARB 2019f). DPM is typically composed of carbon particles (“soot,” also called black carbon) and numerous organic compounds, including over 40 known cancer-causing organic substances. Examples of these chemicals include polycyclic aromatic hydrocarbons, benzene, formaldehyde, acetaldehyde, acrolein, and 1,3-butadiene (CARB 2019f). The CARB classified “particulate emissions from diesel-fueled engines” (i.e., DPM) (17 CCR 93000) as a TAC in August 1998. DPM is emitted from a broad range of diesel engines: on-road diesel engines, including trucks, buses, and cars, and off-road diesel engines, including locomotives, marine vessels, and heavy-duty construction equipment, among others. Approximately 70% of all airborne cancer risk in California is associated with DPM (Propper et al. 2015). To reduce the cancer risk associated with DPM, CARB adopted a diesel risk reduction plan in 2000 (CARB 2000). Because it is part of $PM_{2.5}$, DPM also contributes to the same non-cancer health effects as

$PM_{2.5}$ exposure. These effects include premature death; hospitalizations and emergency department visits for exacerbated chronic heart and lung disease, including asthma; increased respiratory symptoms; and decreased lung function in children. Several studies suggest that exposure to DPM may also facilitate development of new allergies (CARB 2019f). Those most vulnerable to non-cancer health effects are children, whose lungs are still developing, and older people, who often have chronic health problems.

Odorous Compounds. Odors are generally regarded as an annoyance or a quality of life impact, rather than a health hazard. Manifestations of a person's reaction to odors can range from psychological (e.g., irritation, anger, or anxiety) to physiological (e.g., circulatory and respiratory effects, nausea, vomiting, and headache). The ability to detect odors varies considerably among the population and overall is quite subjective. People may have different reactions to the same odor. An odor that is offensive to one person may be perfectly acceptable to another (e.g., coffee roaster). An unfamiliar odor is more easily detected and is more likely to cause complaints than a familiar one. In a phenomenon known as odor fatigue, a person can become desensitized to almost any odor, and recognition may only occur with an alteration in the intensity. The occurrence and severity of odor impacts depend on the nature, frequency, and intensity of the source; wind speed and direction; microclimate; relative humidity; temperature; topography; and the sensitivity of receptors.

Ambient Air Quality

CARB, air districts, and other agencies monitor ambient air quality at approximately 250 air quality monitoring stations across the state. The SBCAPCD monitors local ambient air quality within the County. Air quality monitoring stations usually measure pollutant concentrations 10 feet above ground level; therefore, air quality is often referred to in terms of ground-level concentrations. The most recent background ambient air quality data from 2020 to 2022 are presented in Table 1, Local Ambient Air Quality Data.

The ambient data presented in Table 1 reflect the highest concentrations reported at the monitoring station located at 128 South H Street, Lompoc. Of the available monitoring stations within the SCCAB, the Lompoc station is considered representative of the air quality experienced in Alternative 2's vicinity. The ambient concentrations and number of days exceeding the ambient air quality standards is also shown in Table 1.

Table 1. Local Ambient Air Quality Data

Averaging Time	Unit	Agency/ Method	Ambient Air Quality Standard	Measured Concentration by Year			Exceedances by Year		
				2020	2021	2022	2020	2021	2022
Ozone (O_3)									
Maximum 1-hour concentration	ppm	California	0.12	0.038	0.040	0.067	0	0	0
Maximum 8-hour concentration	ppm	California	0.070	0.034	0.035	0.055	0	0	0
		National	0.070	0.030	0.035	0.055	0	0	0
Nitrogen Dioxide (NO_2)									
	ppm	California	0.18	0.028	0.027	0.024	0	0	0

Table 1. Local Ambient Air Quality Data

Averaging Time	Unit	Agency/ Method	Ambient Air Quality Standard	Measured Concentration by Year			Exceedances by Year		
				2020	2021	2022	2020	2021	2022
Maximum 1-hour concentration		National	0.100	0.028	0.027	0.024	0	0	0
Annual concentration	ppm	California	0.030	0.003	0.003	0.003	0	0	0
		National	0.053	0.003	0.003	0.003	0	0	0
Carbon Monoxide (CO)									
Maximum 1-hour concentration	ppm	California	20	2.5	1.9	0.9	0	0	0
		National	35	2.5	1.9	0.9	0	0	0
Maximum 8-hour concentration	ppm	California	9.0	0.7	0.8	0.7	0	0	0
		National	9	0.7	0.8	0.7	0	0	0
Sulfur Dioxide (SO_2)									
Maximum 1-hour concentration	ppm	National	0.075	0.026	0.002	0.002	0	0	0
Maximum 24-hour concentration	ppm	National	0.14	0.003	0.001	0.001	0	0	0
Annual concentration	ppm	National	0.030	0.0003	0.0002	0.0003	0	0	0
Coarse Particulate Matter (PM_{10})[a]									
Maximum 24-hour concentration	μg/m³	California	50	110.8	76.0	53.6	(17) 17.1	(1) ND	(1) 1.0
		National	150	106.7	73.1	50.9	(0) 0.0	(0) 0.0	(0) 0.0
Annual concentration	μg/m³	California	20	21.7	ND	17.1	0	0	0
Fine Particulate Matter ($PM_{2.5}$)[a]									
Maximum 24-hour concentration	μg/m³	National	35	85.6	18.4	20.7	(8) 8.5	(0) 0.0	(0) 0.0
Annual concentration	μg/m³	California	12	6.5	5.8	5.6	0	0	0
		National	12.0	6.5	5.7	5.6	0	0	0

Sources: CARB 2022a; EPA 2022.

Notes: ppm = parts per million by volume; — = not available; μg/m³ = micrograms per cubic meter; ND = insufficient data available to determine the value.

Data taken from CARB iADAM (http://www.arb.ca.gov/adam) and EPA AirData (http://www.epa.gov/airdata/) represent the highest concentrations experienced over a given year.

Exceedances of national and California standards are only shown for O_3 and particulate matter. Daily exceedances for particulate matter are estimated days because PM_{10} and $PM_{2.5}$ are not monitored daily. All other criteria pollutants did not exceed national or

California standards during the years shown. There is no national standard for 1-hour O_3, annual PM_{10}, or 24-hour SO_2, nor is there a California 24-hour standard for $PM_{2.5}$.

[a] Measurements of PM_{10} and $PM_{2.5}$ are usually collected every 6 days and every 1 to 3 days, respectively. Number of days exceeding the standards is a mathematical estimate of the number of days concentrations would have been greater than the level of the standard had each day been monitored. The numbers in parentheses are the measured number of samples that exceeded the standard.

2.2 Regulatory Setting

2.2.1 Federal Regulations

2.2.1.1 Criteria Air Pollutants

The federal Clean Air Act (CAA), passed in 1970 and last amended in 1990, forms the basis for the national air pollution control effort. The U.S. Environmental Protection Agency (EPA) is responsible for implementing most aspects of the CAA, including setting National Ambient Air Quality Standards (NAAQS) for major air pollutants; setting hazardous air pollutant (HAP) standards; approving state attainment plans; setting motor vehicle emission standards; issuing stationary source emission standards and permits; and establishing acid rain control measures, stratospheric ozone (O_3) protection measures, and enforcement provisions. Under the CAA, NAAQS are established for the following criteria pollutants: O_3, carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), particulate matter 10 microns in size or smaller (PM_{10}), and particulate matter 2.5 microns in size or smaller ($PM_{2.5}$), and lead.

The NAAQS describe acceptable air quality conditions designed to protect the health and welfare of the citizens of the United States. The NAAQS (other than for O_3, NO_2, SO_2, PM_{10}, $PM_{2.5}$, and those based on annual averages or arithmetic mean) are not to be exceeded more than once per year. NAAQS for O_3, NO_2, SO_2, PM_{10}, and $PM_{2.5}$ are based on statistical calculations over 1- to 3-year periods, depending on the pollutant. The CAA requires the EPA to reassess the NAAQS at least every 5 years to determine whether adopted standards are adequate to protect public health based on current scientific evidence. States with areas that exceed the NAAQS must prepare a state implementation plan that demonstrates how those areas will attain the NAAQS within mandated time frames. The NAAQS are presented in Table 2.

The CAA contains milestones for states to develop air pollution control plans. Areas within states that do not meet the NAAQS, usually identified at the county level, are designated as nonattainment areas. For areas designated as nonattainment areas, the state must develop a plan to implement pollution control strategies to attain the NAAQS. Once attainment is achieved, a state must develop a plan to maintain air quality.

Ozone is not emitted directly to the atmosphere by industrial or combustion processes. Rather, O_3 is formed through the reaction between volatile organic compounds (VOCs) and oxides of nitrogen (NO_x). VOCs and NO_x are known as O_3 precursors, and these precursor emissions are regulated by the EPA to achieve O_3 reductions.

Table 2. Ambient Air Quality Standards

Pollutant	Averaging Time	California Standards[a]	National Standards[b]	
		Concentration[c]	Primary[c,d]	Secondary[c,e]
O_3	1 hour	0.09 ppm (180 μg/m³)	—	Same as Primary Standard[f]
	8 hours	0.070 ppm (137 μg/m³)	0.070 ppm (137 μg/m³)[f]	
NO_2[g]	1 hour	0.18 ppm (339 μg/m³)	0.100 ppm (188 μg/m³)	Same as Primary Standard
	Annual Arithmetic Mean	0.030 ppm (57 μg/m³)	0.053 ppm (100 μg/m³)	
CO	1 hour	20 ppm (23 mg/m³)	35 ppm (40 mg/m³)	None
	8 hours	9 ppm (10 mg/m³)	9 ppm (10 mg/m³)	
SO_2[h]	1 hour	0.25 ppm (655 μg/m³)	0.075 ppm (196 μg/m³)	—
	3 hours	—	—	0.5 ppm (1,300 μg/m³)
	24 hours	0.04 ppm (105 μg/m³)	0.14 ppm (for certain areas)[g]	—
	Annual	—	0.030 ppm (for certain areas)[g]	—
PM_{10}[i]	24 hours	50 μg/m³	150 μg/m³	Same as Primary Standard
	Annual Arithmetic Mean	20 μg/m³	—	
$PM_{2.5}$[i]	24 hours	—	35 μg/m³	Same as Primary Standard
	Annual Arithmetic Mean	12 μg/m³	9.0 μg/m³	15.0 μg/m³
Lead[j,k]	30-day Average	1.5 μg/m³	—	—
	Calendar Quarter	—	1.5 μg/m³ (for certain areas)[k]	Same as Primary Standard
	Rolling 3-Month Average	—	0.15 μg/m³	
Hydrogen sulfide	1 hour	0.03 ppm (42 μg/m³)	—	—
Vinyl chloride[j]	24 hours	0.01 ppm (26 μg/m³)	—	—
Sulfates	24 hours	25 μg/m³	—	—

Table 2. Ambient Air Quality Standards

Pollutant	Averaging Time	California Standards[a]	National Standards[b]	
		Concentration[c]	Primary[c,d]	Secondary[c,e]
Visibility reducing particles	8 hour (10:00 a.m. to 6:00 p.m. PST)	Insufficient amount to produce an extinction coefficient of 0.23 per kilometer due to the number of particles when the relative humidity is less than 70%	—	—

Source: CARB 2023; EPA 2023.

Notes: O_3 = ozone; ppm = parts per million by volume; μg/m³ = micrograms per cubic meter; NO_2 = nitrogen dioxide; CO = carbon monoxide; mg/m³= milligrams per cubic meter; SO_2 = sulfur dioxide; PM_{10} = particulate matter with an aerodynamic diameter less than or equal to 10 microns; $PM_{2.5}$ = particulate matter with an aerodynamic diameter less than or equal to 2.5 microns.

[a] California standards for O_3, CO, SO_2 (1-hour and 24-hour), NO_2, suspended particulate matter (PM_{10}, $PM_{2.5}$), and visibility-reducing particles are values that are not to be exceeded. All others are not to be equaled or exceeded. California Ambient Air Quality Standards are listed in the Table of Standards in Section 70200 of Title 17 of the California Code of Regulations.

[b] National standards (other than O_3, NO_2, SO_2, particulate matter, and those based on annual averages or annual arithmetic mean) are not to be exceeded more than once per year. The O_3 standard is attained when the fourth highest 8-hour concentration measured at each site in a year, averaged over three years, is equal to or less than the standard. For PM_{10}, the 24-hour standard is attained when the expected number of days per calendar year with a 24-hour average concentration above 150 μg/m³ is equal to or less than one. For $PM_{2.5}$, the 24-hour standard is attained when 98% of the daily concentrations, averaged over 3 years, are equal to or less than the standard.

[c] Concentration expressed first in units in which it was promulgated. Equivalent units given in parentheses are based on a reference temperature of 25°C and a reference pressure of 760 torr. Most measurements of air quality are to be corrected to a reference temperature of 25°C and a reference pressure of 760 torr; ppm in this table refers to ppm by volume, or micromoles of pollutant per mole of gas.

[d] National Primary Standards: The levels of air quality necessary, with an adequate margin of safety, to protect the public health.

[e] National Secondary Standards: The levels of air quality necessary to protect the public welfare from any known or anticipated adverse effects of a pollutant.

[f] On October 1, 2015, the national 8-hour O_3 primary and secondary standards were lowered from 0.075 to 0.070 ppm.

[g] To attain the national 1-hour standard, the three-year average of the annual 98th percentile of the one-hour daily maximum concentrations at each site must not exceed 100 parts per billion (ppb). Note that the national 1-hour standard is in units of ppb. California standards are in units of ppm. To directly compare the national 1-hour standard to the California standards, the units can be converted from ppb to ppm. In this case, the national standard of 100 ppb is identical to 0.100 ppm.

[h] On June 2, 2010, a new 1-hour SO_2 standard was established, and the existing 24-hour and annual primary standards were revoked. To attain the national 1-hour standard, the three-year average of the annual 99th percentile of the one-hour daily maximum concentrations at each site must not exceed 75 ppb. The 1971 SO_2 national standards (24-hour and annual) remain in effect until one year after an area is designated for the 2010 standard, except that in areas designated nonattainment of the 1971 standards, the 1971 standards remain in effect until implementation plans to attain or maintain the 2010 standards are approved.

[i] On December 14, 2012, the national annual $PM_{2.5}$ primary standard was lowered from 15 μg/m³ to 12 μg/m³. The existing national 24-hour $PM_{2.5}$ standards (primary and secondary) were retained at 35 μg/m³, as was the annual secondary standard of 15 μg/m³. The existing 24-hour PM_{10} standards (primary and secondary) of 150 μg/m³ were also retained. The form of the annual primary and secondary standards is the annual mean averaged over three years.

[j] California Air Resources Board has identified lead and vinyl chloride as toxic air contaminants with no threshold level of exposure for adverse health effects determined. These actions allow for the implementation of control measures at levels below the ambient concentrations specified for these pollutants.

[k] The national standard for lead was revised on October 15, 2008, to a rolling three-month average. The 1978 lead standard (1.5 μg/m³ as a quarterly average) remains in effect until one year after an area is designated for the 2008 standard, except that in areas designated nonattainment for the 1978 standard, the 1978 standard remains in effect until implementation plans to attain or maintain the 2008 standard are approved.

Airborne particulate matter is not a single pollutant, but rather a mixture of many chemical species. PM_{10}, and $PM_{2.5}$ are derived from different emission sources, and also have different chemical compositions. Emissions from the combustion of gasoline, oil, diesel fuel, and wood produce much of the $PM_{2.5}$ pollution found in outdoor air, as well as a significant portion of PM_{10}. PM_{10} also includes dust from construction sites, landfills, and agriculture; wildfires and brush/waste burning; industrial sources; wind-blown dust from open lands; pollen; and fragments of bacteria. Particulate matter may be either directly emitted from sources (primary particles) or formed in the atmosphere through chemical reactions of gases (secondary particles) such as SO_2, NOx, VOCs, and ammonia. These organic compounds can be emitted by both natural sources, such as trees and vegetation, and anthropogenic sources, such as industrial processes and motor vehicle exhaust. Particulate matter emissions are regulated to achieve ambient $PM_{2.5}$ reductions.

2.2.1.2 Hazardous Air Pollutants

The 1977 federal CAA amendments required the EPA to identify national emission standards for HAPs to protect public health and welfare. HAPs include certain volatile organic chemicals, pesticides, herbicides, and radionuclides that present a tangible hazard based on scientific studies of exposure to humans and other mammals. Under the 1990 federal CAA Amendments, which expanded the control program for HAPs, 187 substances and chemical families were identified as HAPs.

2.2.1.3 General Conformity Determination

The General Conformity Rule applies to all federal actions for projects except highway and transit programs. Title I, Section 176(c)(1) of the CAA defines conformity as the upholding of "an implementation plan's purpose of eliminating or reducing the severity and number of violations of the NAAQS and achieving expeditious attainment of such standards." According to 40 CFR 93.152, "Federal action means any activity engaged in by a department, agency, or instrumentality of the Federal government, or any activity that a department, agency or instrumentality of the Federal government supports in any way, provides financial assistance for, licenses, permits, or approves, other than activities related to transportation plans, programs, and projects developed, funded, or approved under title 23 U.S.C. or the Federal Transit Act (49 U.S.C. 1601 et seq.)." Alternative 2 has activities within NAAQS nonattainment areas and entails support from the U.S. Space Force and permitting from the FAA; consequently, the action is a federal action and general conformity applies. Therefore, whether a General Conformity determination would apply for portions of the action within nonattainment/maintenance areas must be ascertained through a General Conformity applicability analysis. Finally, according to 40 CFR 93(e), "if an action would result in emissions originating in more than one nonattainment or maintenance area, the conformity must be evaluated for each area separately." As Alternative 2 occurs within more than one nonattainment or maintenance area, the conformity must be evaluated within each area.

2.2.2 State Regulations

California Clean Air Act of 1988

The California Clean Air Act requires air quality management districts to adopt and enforce regulations to achieve and maintain air quality that is within state air quality standards. The act also requires preparation of a Clean Air Plan (CAP).

Toxic Air Contaminants

A TAC is defined by California law as an air pollutant that may cause or contribute to an increase in mortality or an increase in serious illness, or which may pose a present or potential hazard to human health. Federal laws use the hazardous air pollutants to refer to the same types of compounds that are referred to as TACs under state law. California regulates TACs primarily through the Tanner Air Toxics Act (Assembly Bill [AB] 1807) and the Air Toxics Hot Spots Information and Assessment Act of 1987 (AB 2588).

AB 1807 sets forth a formal procedure for CARB to designate substances as TACs. This includes research, public participation, and scientific peer review before CARB can designate a substance as a TAC. Pursuant to AB 2588, existing facilities that emit air pollutants above specified levels were required to (1) prepare a TAC emission inventory plan and report; (2) prepare a risk assessment if TAC emissions were significant; (3) notify the public of significant risk levels; and (4) if health impacts were above specified levels, prepare and implement risk reduction measures.

The following regulatory measures pertain to the reduction of DPM and criteria pollutant emissions from off-road equipment and diesel-fueled vehicles.

Idling of Commercial Heavy Duty Trucks (13 CCR 2485)

In July 2004, CARB adopted an Airborne Toxic Control Measure (ATCM) to control emissions from idling trucks. The ATCM prohibits idling for more than 5 minutes for all commercial trucks with a gross vehicle weight rating over 10,000 pounds. The ATCM contains an exception that allows trucks to idle while queuing or involved in operational activities.

In-Use Off-Road Diesel-Fueled Fleets (13 CCR 2449 et seq.)

In July 2007, CARB adopted an ATCM for in-use off-road diesel vehicles. This regulation requires that specific fleet average requirements be met for NO_x emissions and for particulate matter emissions. Where average requirements cannot be met, best available control technology requirements apply. The regulation also includes several recordkeeping and reporting requirements.

In response to AB 8 2X, the regulations were revised in July 2009 (effective December 3, 2009) to allow a partial postponement of the compliance schedule in 2011 and 2012 for existing fleets. On December 17, 2010, CARB adopted additional revisions to further delay the deadlines reflecting reductions in diesel emissions due to the poor economy and overestimates of diesel emissions in California. The revisions delayed the first compliance date until no earlier than January 1, 2014, for large fleets, with final compliance by January 1, 2023. The compliance dates for medium fleets were delayed until an initial date of January 1, 2017, and final compliance date of January 1, 2023. The compliance dates for small fleets were delayed until an initial date of January 1, 2019, and final compliance date of January 1, 2028. Correspondingly, the fleet average targets were made more stringent in future compliance years. The revisions also accelerated the phaseout of older equipment with newer equipment added to existing large and medium fleets over time, requiring the addition of Tier 2 or higher engines starting on March 1, 2011, with some exceptions; Tier 2 or higher engines on January 1, 2013, without exception; and Tier 3 or higher engines on January 1, 2018 (January 1, 2023, for small fleets). SpaceX shall adhere to the CARB In-Use Off-Road Diesel-Fueled Fleets Regulation (CARB 2024) for fleet management and fuel selection.

On October 28, 2011 (effective December 14, 2011), the executive officer approved amendments to the regulation. The amendments included revisions to the applicability section and additions and revisions to the definition. The initial date for requiring the addition of Tier 2 or higher engines for large and medium fleets, with some exceptions, was revised to January 1, 2012. New provisions also allow for the removal of emission control devices for safety or visibility purposes. The regulation also was amended to combine the particulate matter and NO_x fleet average targets under one, instead of two, sections. The amended fleet average targets are based on the fleet's NO_x fleet average, and the previous section regarding particulate matter performance requirements was deleted completely. The best available control technology requirements, if a fleet cannot comply with the fleet average requirements, were restructured and clarified. Other amendments to the regulations included minor administrative changes to the regulatory text.

In-Use On-Road Diesel-Fueled Vehicles (13 CCR 2025)

On December 12, 2008, CARB adopted an ATCM to reduce NO_x and particulate matter emissions from most in-use on-road diesel trucks and buses with a gross vehicle weight rating greater than 14,000 pounds. The original ATCM regulation required fleets of on-road trucks to limit their NO_x and particulate matter emissions through a combination of exhaust retrofit equipment and new vehicles. The regulation limited particulate matter emissions for most fleets by 2011, and limited NO_x emissions for most fleets by 2013. The regulation did not require any vehicle to be replaced before 2012 and never required all vehicles in a fleet be replaced.

In December 2009, the CARB Governing Board directed staff to evaluate amendments that would provide additional flexibility for fleets adversely affected by the struggling California economy. On December 17, 2010, CARB revised this ATCM to delay its implementation along with limited relaxation of its requirements. Starting on January 1, 2015, lighter trucks with a gross vehicle weight rating of 14,001 to 26,000 pounds with 20-year-old or older engines need to be replaced with newer trucks (2010 model year emissions equivalent as defined in the regulation). Trucks with a gross vehicle weight rating greater than 26,000 pounds with 1995 model year or older engines needed to be replaced as of January 1, 2015. Trucks with 1996 to 2006 model year engines must install a Level 3 (85% control) diesel particulate filter starting on January 1, 2012, to January 1, 2014, depending on the model year, and then must be replaced after 8 years. Trucks with 2007 to 2009 model year engines have no requirements until 2023, at which time they must be replaced with 2010 model year emissions-equivalent engines, as defined in the regulation. Trucks with 2010 model year engines would meet the final compliance requirements. The ATCM provides a phase-in optio2n under which a fleet operator would equip a percentage of trucks in the fleet with diesel particulate filters, starting at 30% as of January 1, 2012, with 100% by January 1, 2016. Under each option, delayed compliance is granted to fleet operators who have or will comply with requirements before the required deadlines.

On September 19, 2011 (effective December 14, 2011), the Executive Officer approved amendments to the regulations, including revisions to the compliance schedule for vehicles with a gross vehicle weight rating of 26,000 pounds or less to clarify that all vehicles must be equipped with 2010 model year emissions equivalent engines by 2023. The amendments included revised and additional credits for fleets that have downsized; implemented early particulate matter retrofits; incorporated hybrid vehicles, alternative-fueled vehicles, and vehicles with heavy-duty pilot ignition engines; and implemented early addition of newer vehicles. The amendments included provisions for additional flexibility, such as for low-usage construction trucks, and revisions to previous exemptions, delays, and extensions. Other amendments to the regulations included minor administrative changes to the regulatory text, such as recordkeeping and reporting requirements related to other revisions.

California Health and Safety Code Section 41700

Section 41700 of the California Health and Safety Code states that a person shall not discharge from any source whatsoever quantities of air contaminants or other material that cause injury, detriment, nuisance, or annoyance to any considerable number of persons or to the public, or that endanger the comfort, repose, health, or safety of any of those persons or the public, or that cause, or have a natural tendency to cause, injury or damage to business or property. This section also applies to sources of objectionable odors.

2.3 Regional and Local Air Quality Conditions

2.3.1 Attainment Designation

Pursuant to the 1990 federal CAA Amendments, the EPA classifies air basins (or portions thereof) as "attainment" or "nonattainment" for each criteria air pollutant based on whether the NAAQS have been achieved. Generally, if the recorded concentrations of a pollutant are lower than the standard, the area is classified as "attainment" for that pollutant. If an area exceeds the standard, the area is classified as "nonattainment" for that pollutant. If there is not enough data available to determine whether the standard is exceeded in an area, the area is designated as "unclassified" or "unclassifiable." The designation of "unclassifiable/attainment" means that the area meets the standard or is expected to meet the standard despite a lack of monitoring data. Areas that achieve the standards after a nonattainment designation are re-designated as maintenance areas and must have approved Maintenance Plans to ensure continued attainment of the standards.

Santa Barbara County (where the action will occur) is within the Santa Barbara County Air Pollution Control District (SBCAPCD) and is in attainment for all NAAQSs; however, the county is nonattainment for the state 8-hour O_3 and 24-hour and annual PM_{10} standards.

Ventura County (where the action will occur) is within the Ventura County Air Pollution Control District (VCAPCD) and is in serious nonattainment for the 2008 and 2015 8-hour O_3 NAAQS. Additionally, the county is nonattainment for O_3 and the 24-hour and annual state PM_{10} standard and attainment for all other state and federal standards.

Los Angeles County (where the action will occur) is within the South Coast Air Quality Management District (SCAQMD) is extreme nonattainment for the 2008 and 2015 8-hour O_3 NAAQSs; maintenance for the 1971 CO NAAQS; nonattainment for the 2008 Pb NAAQS; maintenance for the 1987 PM_{10} NAAQS with a classification of serious; and nonattainment for the 1997, 2006, and 2012 $PM_{2.5}$ NAAQSs with a classification of serious. Additionally, the SCAQMD is nonattainment for the 1-hour O_3, 8-hour O_3, 24-hour and annual PM_{10}, and annual $PM_{2.5}$ state standards.

2.4 Insignificance Criteria and Methodology

2.4.1 Insignificance Thresholds and Indicators

For air quality impact assessments, significance is defined by the degree to which the effects of Alternative 2 potentially could affect public health or safety. The U.S. Air Force (USAF) conducts National Environmental Policy Act (NEPA) and General Conformity Rule air quality impact assessments in tandem within the Environmental Impact Analysis Process (EIAP) (HQ AFCEC/CZTQ 2023a). The air quality EIAP process is broken into three progressive levels of assessment: Level I, Exempt Action Screening (determine if a formal Air Quality Assessment is required);

Level II, Quantitative Air Quality Assessment (a formal emissions quantifying assessment to eliminate insignificant air impacts from further assessment); and Level III, Advanced Air Quality Assessment (part science and part art, both quantitative and qualitative assessments of air impact). These levels are designed to ensure completion of an air quality assessment at the lowest level possible; with each level of assessment having a specific significance threshold or indicator that, if not exceeded, allows exiting the assessment.

If an action is not exempt for Air Quality EIAP, it must proceed to a Level II, Quantitative Assessment. A Level II assessment is a quantification of annual net change in emissions that are compared against levels of annual emissions (i.e., thresholds or indicator) that are known to have de minimis (insignificant) effects on public health or safety. De minimis values were established in the General Conformity Rule (40 CFR 93 Subpart B) as definitive insignificance thresholds for actions occurring within areas designated as nonattainment or maintenance for one or more National Ambient Air Quality Standard (NAAQS). However, for Level II NEPA air impact assessments, the USAF had to establish legally defensible insignificance values (indicators) for actions occurring within attainment areas. Insignificance thresholds are EPA-established annual emission rates that, if exceeded, would trigger a regulatory requirement. Insignificance indicators are EPA-established rate thresholds that are partially applied or applied out of context to their intended use; however, can provide a direct gauge of potential impact. Although indicators do not trigger a regulatory requirement, they do provide an indication or a warning that the action is potentially approaching a threshold which would trigger a significant regulatory requirement.

The air quality impact evaluation for this action requires two separate analyses: the Clean Air Act (CAA) General Conformity Analysis and an analysis under NEPA. Impacts of air pollutants emitted by activities in the Pacific Ocean, bays, and inland locations in State waters (i.e., up to 3 nm from the coast) are assessed under the General Conformity Rule. Impacts of air pollutants emitted by activities in the Pacific Ocean, bays, and inland locations in U.S. territorial seas (i.e., up to 12 nm from the coast) are assessed under NEPA. Each coastal state may claim the territorial sea that extends seaward up to 12 nm from its shores and exercise sovereignty over its territorial sea, the air space above it, and the seabed and subsoil beneath it (National Oceanic and Atmospheric Administration [NOAA] 2017). The state jurisdictions may extend the full distance of territorial seas or may retain historical limits.

Table 3 presents the air quality DAF insignificance thresholds and indicators that would be applied to Alternative 2's emissions.

Table 3. DAF Insignificance Thresholds/Indicators

Pollutant	Santa Barbara County (SBCAPCD)	Ventura County (VCAPCD)	Los Angeles County (SCAQMD)
	Tons Per Year		
Ozone (NO_x or VOC)	250	50*	10*
Carbon Monoxide (CO)	250	250	100*
SO_2 or NOx	250	250	250
PM_{10}	250	250	100*
$PM_{2.5}$ (NOx, VOC, SOx, or NH_3)	250	250	70*
Lead (Pb)	25	25	25*

Source: HQ AFCEC/CZTQ 2023a.
Notes: * Indicates a General Conformity Threshold.

NOx = oxides of nitrogen; SO_2 = sulfur dioxide; NO_2 = nitrogen dioxide; VOC = volatile organic compound; CO = carbon monoxide; PM_{10} = particulate matter with an aerodynamic diameter less than or equal to 10 microns; $PM_{2.5}$ = particulate matter with an aerodynamic diameter less than or equal to 2.5 microns; NH_3 = ammonia; Pb = lead; SBCAPCD = Santa Barbara County Air Pollution Control District; VCAPCD = Ventura County Air Pollution Control District; SCAQMD = South Coast Air Quality Management District.

2.4.2 Approach and Methodology

An air quality impact assessment is accomplished with a net-change inventory analyses for each nonattainment/maintenance area the action will occur within. In accordance with DAF guidance, NEPA (40 CFR 1508), and the General Conformity Rule (40 CFR 93 Subpart B), a net-change inventory analyses is an evaluation of the total action-related annual increased emissions (direct and indirect emissions) of the criteria pollutant (or their precursors) combined with the total action-related annual decreased emissions results in an overall annual net change in emissions for the entire action. Alternative 2's worst-year (highest emission year) annual net change in emissions for each pollutant (or precursors) are screened against the applicable insignificance indicators or thresholds (de minimis values). If the results of net-change inventory analyses indicate all criteria pollutant (or precursors) are below the insignificance indicators or thresholds, the action is considered to have an insignificant impact on air quality for both NEPA and General Conformity. If the results of net-change inventory analyses indicate one or more criteria pollutant (or precursors) are equal to or above the insignificance indicators or thresholds, the action is considered to have a potentially significant impact on air quality and further assessment is required and a General Conformity determination is required if a threshold is exceeded.

2.4.2.1 Operational Activities

Baseline

Baseline operational activity emissions from SLC-4 were taken from the 2023 EA. These include emissions from launches and landings, payload fairing recovery, booster roll-on roll-off, and operation of SLC-4.

Alternative 2

Alternative 2 would generate criteria air pollutant emissions during operation from launches and landings, payload fairing recovery, booster roll-on roll-off, and operation of SLC-4. The following section discusses the emission calculation methodology for each activity.

Falcon 9 Launch

SpaceX would launch Falcon 9 up to 50 times per year from VSFB in the same manner as described in the 2020 EA (EA for SpaceX Falcon Launches at Kennedy Space Center and Cape Canaveral Air Force Station). It is estimated that it takes a Falcon 9 up to 23 seconds to reach 3,000 feet elevation after a launch. Static fire tests last a duration of 7 seconds. The emission factors for estimating emissions from Falcon 9 launches were taken from the *Exhaust Plume Calculations for SpaceX Merlin5 Booster Engine* by Sierra Engineering & Software, Inc. (included as Appendix B). The analysis was done using a single engine firing into a stable environment within 516 feet of the engine exhaust. This assumes the gas generator exhaust is efficiently entrained into the rocket exhaust. The analysis from the single engine was then extrapolated to estimate the emissions for all 9 engines for the Falcon 9. The Performance Correlation Program (PERCORP) is a model that uses known engine performance to estimate mixing and vaporization efficiencies in liquid rocket engines and provide a simple method of predicting nozzle exit-plane flow constituents and properties. The PERCORP analysis model was used to estimate the oxidizer/fuel mixture ratio variations that exist within the M1D thrust chamber. The fuel-rich combustion model in PERCORP was also used to estimate the gas generator exhaust constituents. PERCORP was run iteratively with VIPER (version 4.5 Beta Apr-2018) until the VIPER output ISP matched the target value. The VIPER output includes details of the pressure, temperature, velocity and species concentration across the nozzle exit plane. The SPF III code (Version 4.2.3a Patch 2) was used to predict the flow structure of the free exhaust plume and the entrainment of ambient air. The M8 chemical system was augmented with CH_4, C_2H_2 and C_2H_4. However, there were several species in the PERCORP-generated GG exhaust ($C_{12}H_{23}$, C_7H_{14}, C_3H_6, C_2H_6) that were not included in the SPF DATABANK. Rather than trying to add the species, Sierra's kerosene cracking reactions, plus some judicious chemistry analogs, were used to convert these species into simpler constituents the code can handle. The subsequent TDK simulation of the plume chemistry requires an approximate fit of the air entrainment rate. The SPF air entrainment profile was fit to an "availability profile" for the TDK simulations, allowing ambient air to be "mixed" into the plume flow. Achieving a good fit of the entrainment with the simple availability model within TDK requires running the 1-D analysis in 3-pieces, restarting the simulation with temperature and species information from the previous analysis and updating the air availability rate parameters. The one-dimensional kinetic model (ODK) in the TDK code was used to model chemical reactions within the evolving plume flow field. The pollutant flow rates were calculated in terms of lb_m generated per second of steady engine operation.

Although the exhaust is fuel-rich and contains high concentrations of CO, subsequent entrainment of ambient air results in complete conversion of the CO into CO_2 and oxidation of the soot from the gas generator exhaust. A small amount of thermal NOx is formed as NO. Each takeoff may be preceded by a static fire test of the engines, which lasts a few seconds. The need to conduct a static fire test is mission dependent, but there would be no more than 30 static fire events per year. Emissions were estimated using a spreadsheet model.

Payload Fairing Recovery

After each launch, the fairing is recovered from the Pacific Ocean via a support marine vessel. The fairing and parafoil would be recovered by a salvage ship stationed in the Proposed Landing Area near the anticipated splashdown site, but no closer than 12 nm offshore. Emissions from the support vessel were calculated using a spreadsheet model and emission factors based on the engine tier and the activity data for the recovery.

Landings

Similar to launch operations, there are emissions of NOx during the landing of the Falcon first stage. Landings occur both on land and on water in the Pacific Ocean. For water landings, the first stage and barge are towed using a marine vessel back to the Port of Long Beach. Emissions were estimated using a spreadsheet model with emission factors based on the engine tier and activity data. During landing, only 3 of the 9 engines are used in a Falcon 9 booster. The engines burn 18 seconds during a landing below 3,000 feet. It was assumed that there were 7 return to the launch site missions and 43 water landings.

Booster Roll-On-Roll-Off

SpaceX proposes to transport first stages and fairings from the Port of Long Beach to the VSFB Harbor via a "roll-on-roll-off" (RORO) barge. The first stage would be transferred from the droneship to SpaceX's Self-Propelled Modular Transport (SPMT) that is positioned on a small, low draft barge. The first stage would be pulled by a tug using a Tier 3 (or better) engine from the Port of Long Beach into the VSFB Harbor. The first stage would then be driven off the barge by the SPMT and travel from VSFB Harbor to the hangar at SLC-4E, where it would be unloaded.

A support tug would be launched from the Port of Hueneme or Port of Long Beach and travel up the coast to assist the barge and primary tug in maneuvering into and out of the VSFB Harbor, the exact arrival time would depend on tide. The SPMT would then be loaded back on to the barge and travel back to the Port of Long Beach. The support tug would then return to the Port of Hueneme or Port of Long Beach. Alternative 2 would include up to 50 events per year utilizing the RORO barge and tugs. Emissions were estimated using a spreadsheet model with emission factors based on the engine tier and activity data. Emissions were estimated within each jurisdiction based on an assumption of the vessels operating at 7 knots. It was conservatively assumed that each marine vessel would operate at 100% engine load based on previous RORO operations. The previously permitted route around the Channel Islands was assumed for 23 operations and 20 operations for the route up the Santa Barabara Channel.

Payload Processing, Refurbishment, and Operations

Payloads and their associated materials/fuels/volumes are mission dependent but would be similar to current commercial and government payloads. In November 2011, NASA, with the USAF as a cooperating agency, prepared an EA for Launch of NASA Routine Payloads on Expendable Launch Vehicles (NASA 2011). SpaceX would continue to process payloads at existing SpaceX facilities, including Building 398, and the SLC-4 hangar. Operations include refurbishing the recovered first stage and fairing for reuse in future missions. Up to four boosters and six fairings may be refurbished concurrently. With 50 Falcon 9 launches from SLC-4, up to 50 boosters and 50 fairings would be refurbished each year. Solvents such as isopropyl alcohol, isopar, and Simple Green would be used during these operations, as well for launch pad operations, facility maintenance, and system flushing. SpaceX recovers solvents in accordance with a solvent recovery plan and thus not all solvents used are emitted. Emissions were estimated using permitted emission factors from SLC-4 as well as anticipated activity data from the increase in operations at SLC-4. Emissions were estimated using a spreadsheet model and ACAM.

2.4.3 Air Quality Impact Assessment

Operational emissions were estimated for the project and are discussed separately below. Alternative 2 will occur within three counties: Santa Barbara, Ventura, and Los Angeles. Santa Barbara County falls within the SBCAPCD's jurisdiction and has no nonattainment/maintenance areas. Ventura County falls within the VCAPCD's jurisdiction and has only one nonattainment area. Los Angeles County falls within the SCAQMD's jurisdiction; however, Los Angeles County has multiple nonattainment and maintenance areas for the same criteria pollutant with differing severity classifications and boundaries. It was determined that the portion of Los Angeles County where the action will occur encompasses five nonattainment areas and two maintenance areas. Therefore, the air quality impact assessment is divided into three independent assessments to ensure that each nonattainment or maintenance area is evaluated separately as required under 40 CFR 93(e).

2.4.3.1 Santa Barbara County

Operation of Alternative 2 would generate criteria pollutant and HAP emissions from mobile sources, including vehicle trips from passenger vehicles and heavy-duty trucks, marine vessels, booster launches and landings, launch vehicle processing, and off-road equipment used for maintenance. Table 4 presents the annual operational emissions associated with Alternative 2 (year 2025) as estimated as described in Section 2.4.2.1 within Santa Barbara County. The baseline emissions from the 2023 EA are included to show the net emissions for Alternative 2. Details of the emission calculations are provided in Appendix A.

Table 4. Annual Project Operational Emissions, Santa Barbara County – Alternative 2

Emission Source	VOC	NO_x	CO	SO_x	PM_{10}	$PM_{2.5}$	Pb	NH_3
	Tons Per Year							
Solvent Use	5.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Emergency Generators	1.08	6.03	3.32	0.87	0.99	0.99	0.00	0.00
Worker Vehicles	1.13	0.55	6.93	0.01	0.07	0.03	0.00	0.14
Fleet Vehicle Use	0.08	0.04	0.50	0.00	0.01	0.00	0.00	0.01
Vendor-Contractor Vehicles	0.11	0.05	0.66	0.00	0.01	0.00	0.00	0.01
Off-Road Equipment	1.49	13.33	17.98	0.04	0.41	0.38	0.00	0.00
RP-1, RSV Loading, and Payload Fueling	0.06	0.11	0.00	0.00	0.00	0.00	0.00	0.00
Roll-On-Roll-Off	1.41	16.72	27.42	0.35	0.35	0.34	0.01	0.00
Launch	0.00	7.07	0.00	0.00	0.00	0.00	0.00	0.00
Booster and Payload Fairing Recovery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Landings and Static Fire	0.00	1.19	0.00	0.00	0.00	0.00	0.00	0.00
Total	**11.29**	**45.09**	**56.81**	**1.27**	**1.84**	**1.74**	**0.01**	**0.16**
Baseline	**8.02**	**8.01**	**2.89**	**0.05**	**0.10**	**0.10**	**0.00**	**0.04**
Net (Alternative 2 – Baseline)	**3.27**	**37.08**	**53.92**	**1.22**	**1.74**	**1.64**	**0.01**	**0.12**
DAF Insignificance Thresholds	*250*	*250*	*250*	*250*	*250*	*250*	*25*	*250*
Threshold Exceeded?	**No**	**No**	**No**	**No**	**No**	**No**	**No**	**No**

Notes: VOC = volatile organic compound; NO_x = oxides of nitrogen; CO = carbon monoxide; SO_x = sulfur oxides; PM_{10} = coarse particulate matter; $PM_{2.5}$ = fine particulate matter; <0.01 = reported value less than 0.01; Pb = lead; NH_3 = ammonia; DAF = Department of the Air Force.
See Appendix A for complete results.
Totals may not sum due to rounding.

As shown in Table 4, net annual emissions of Alternative 2 within Santa Barbara County would not exceed the DAF insignificance thresholds. As such, the project would not have an adverse effect on air quality within Santa Barbara County.

2.4.3.2 Ventura County

Operation of Alternative 2 would generate criteria pollutant and HAP emissions from marine vessels. Table 5 presents the annual operational emissions associated with Alternative 2 (year 2025) as estimated as described in Section 2.4.2.1 within Ventura County.

Table 5. Annual Project Operational Emissions – Alternative 2 Ventura County

Emission Source	VOC	NO_x	CO	SO_x	PM_{10}	$PM_{2.5}$	Pb	NH_3
	Tons Per Year							
Solvent Use	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Emergency Generators	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Worker Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fleet Vehicle Use	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vendor-Contractor Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Off-Road Equipment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RP-1, RSV Loading, and Payload Fueling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Roll-On-Roll-Off	0.88	10.49	15.99	0.22	0.22	0.22	0.00	0.00
Launch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Booster and Payload Fairing Recovery	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Landings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**0.88**	**10.49**	**15.99**	**0.22**	**0.22**	**0.22**	**0.00**	**0.00**
Baseline	**0.19**	**0.88**	**0.85**	**0.00**	**0.03**	**0.03**	**0.00**	**0.00**
Net (Alternative 2 – Baseline)	**0.69**	**9.61**	**15.14**	**0.22**	**0.19**	**0.19**	**0.00**	**0.00**
DAF Insignificance Thresholds	*50**	*50**	*250*	*250*	*250*	*250*	*25*	*250*
Threshold Exceeded?	**No**	**No**	**No**	**No**	**No**	**No**	**No**	**No**

Notes: * Indicates a General Conformity Threshold.
VOC = volatile organic compound; NO_x = oxides of nitrogen; CO = carbon monoxide; SO_x = sulfur oxides; PM_{10} = coarse particulate matter; $PM_{2.5}$ = fine particulate matter; <0.01 = reported value less than 0.01; Pb = lead; NH_3 = ammonia; DAF = Department of the Air Force.
See Appendix A for complete results.
Totals may not sum due to rounding.

As shown in Table 5, annual emissions of Alternative 2 would not exceed the DAF insignificance thresholds. As such, Alternative 2 would not have an adverse effect on air quality in Ventura County.

2.4.3.3 Los Angeles County

Operation of Alternative 2 would generate VOCs, NO_x, CO, SO_x, PM_{10}, and $PM_{2.5}$ emissions from marine vessels, booster landing, and recovery operations within Los Angeles County. Table 6 presents the annual operational emissions associated with Alternative 2 (year 2025) as estimated as described in Section 2.4.2.1 within Los Angeles County.

Table 6. Annual Project Operational Emissions – Alternative 2 Los Angeles County

Emission Source	VOC	NO_x	CO	SO_x	PM_{10}	$PM_{2.5}$	Pb	NH_3
	Tons Per Year							
Solvent Use	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Emergency Generators	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Worker Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fleet Vehicle Use	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vendor-Contractor Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Off-Road Equipment	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RP-1, RSV Loading, and Payload Fueling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Roll-On-Roll-Off	0.63	7.24	13.60	0.17	0.16	0.16	0.01	0.00
Launch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Booster and Payload Fairing Recovery	0.15	0.76	0.32	0.12	0.06	0.06	0.00	0.00
Landings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**0.78**	**8.00**	**13.92**	**0.29**	**0.22**	**0.22**	**0.01**	**0.00**
Baseline	**0.34**	**2.10**	**1.35**	**0.05**	**0.07**	**0.07**	**0.00**	**0.00**
Net (Alternative 2 – Baseline)	**0.44**	**5.90**	**12.57**	**0.24**	**0.15**	**0.15**	**0.01**	**0.00**
DAF Insignificance Thresholds	*10**	*10**	*100**	*250*	*100**	*70**	*25**	*70**
Threshold Exceeded?	**No**	**No**	**No**	**No**	**No**	**No**	**No**	**No**

Notes: * Indicates a General Conformity Threshold.
VOC = volatile organic compound; NO_x = oxides of nitrogen; CO = carbon monoxide; SO_x = sulfur oxides; PM_{10} = coarse particulate matter; $PM_{2.5}$ = fine particulate matter; <0.01 = reported value less than 0.01; Pb = lead; NH_3 = ammonia; DAF = Department of the Air Force.
See Appendix A for complete results.
Totals may not sum due to rounding.

As shown in Table 6, annual emissions of Alternative 2 would not exceed the DAF insignificance thresholds for VOC, NOx, CO, SO_x, PM_{10}, $PM_{2.5}$, Pb, or NH_3. As such, a general conformity determination is not necessary to determine if Alternative 2 would have an adverse effect on air quality within Los Angeles County.

2.4.3.4 General Conformity Analysis

The general conformity determination process is intended to demonstrate that a proposed Federal action will not: (1) cause or contribute to new violations of a national ambient air quality standard (NAAQS); (2) interfere with provisions in the applicable SIP for maintenance of any NAAQS; (3) increase the frequency or severity of existing violations of any standard; or (4) delay the timely attainment of any standard. As such, for general conformity determination, the proposed federal action needs to conform to the latest approved SIP/AQMP. As discussed in Section 2.3.1, Santa Barbara County is in attainment for all NAAQS; therefore, general conformity does not apply. Ventura County is in serious nonattainment for the 2008 and 2015 8-hour O_3 NAAQS. As shown in Table 5, the net emissions from Alternative 2 would not exceed the General Conformity de minimis thresholds for VOC or NOx.

Therefore, Alternative 2 would have an insignificant impact on air quality within Ventura County. Los Angeles County is designated as an extreme non-attainment area for ozone, serious non-attainment for $PM_{2.5}$ and maintenance area for CO. As shown in Table 6, Alternative 2 would not exceed the General Conformity de minimis threshold for any pollutant. Therefore, Alternative 2 would have an insignificant impact on air quality within Los Angeles County.

No Action Alternative

Under the No Action Alternative, the project would not be built. There would be no criteria air pollutant emissions generated because operation would not occur. Therefore, there would be no emissions resulting from the No Action Alternative compared to Alternative 2. There would be **no impact** on air quality.

3 Greenhouse Gases

3.1 Environmental Setting

A greenhouse gas (GHG) is any gas that absorbs infrared radiation in the atmosphere; in other words, GHGs trap heat in the atmosphere. Some GHGs, such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), occur naturally and are emitted into the atmosphere through natural processes and human activities. Of these gases, CO_2 and CH_4 are emitted in the greatest quantities from human activities. Manufactured GHGs, which have a much greater heat-absorption potential than CO_2, include fluorinated gases, such as hydrochlorofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6), which are associated with certain industrial products and processes.

CO_2 is the primary anthropogenic (human-caused) GHG and has been established as the reference gas to demonstrate the relative effect of different GHGs of equal mass. The effect that each of the GHGs has on global warming is the product of the mass of their emissions and their global warming potential (GWP). GWP indicates how much a gas is predicted to contribute to global warming relative to how much warming would be predicted to be caused by the same mass of CO_2. For example, methane and nitrous oxide are substantially more potent GHGs than CO_2, with GWPs of 25 and 298 times that of CO_2 respectively, which has a GWP of 1, as the reference gas.

In emissions inventories, GHG emissions are typically reported as metric tons (MT) of CO_2 equivalent (CO_2e). CO_2e is calculated as the product of the mass emitted of a given GHG and its specific GWP.CO_2e = (metric tons of a GHG) × (GWP of the GHG)

Climate change refers to any significant change in measures of climate, such as temperature, precipitation, or wind patterns, lasting for an extended period of time (decades or longer). The greenhouse effect, which is the trapping and build-up of heat in the atmosphere near the Earth's surface, is a natural process that contributes to regulating the Earth's temperature. Human activities that emit additional GHGs to the atmosphere increase the amount of infrared radiation that gets absorbed before escaping into space, thus enhancing the greenhouse effect and causing the Earth's surface temperature to rise.

Potential Effects of Climate Change

Globally, climate change has the potential to affect numerous environmental resources through uncertain impacts related to future air temperatures and precipitation patterns. The 2014 IPCC Synthesis Report (IPCC 2014) indicated that warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. Signs that global climate change has occurred include warming of the atmosphere and ocean, diminished amounts of snow and ice, rising sea levels, and ocean acidification (IPCC 2014). As global temperatures rise, the county's historically arid climate could intensify, exacerbating water scarcity and altering the delicate balance of its semi-arid landscapes. The Sierra Nevada snowpack, a critical water source, may diminish due to earlier melting, impacting downstream water availability and agricultural practices. Increased temperatures could also lead to extended wildfire seasons, threatening both human settlements and natural habitats. Furthermore, changing precipitation patterns may disrupt traditional water management strategies and necessitate adaptive measures to ensure sustained water resources.

Sources of Greenhouse Gas Emissions

Per the EPA's Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2019 (EPA 2021), total United States GHG emissions were approximately 6,558.3 million metric tons (MMT) CO_2e in 2019 (EPA 2021). The primary GHG emitted by human activities in the United States was CO_2, which represented approximately 80.1% of total GHG emissions (5,255.8 MMT CO_2e). The largest source of CO_2, and of overall GHG emissions, was fossil-fuel combustion, which accounted for approximately 92.4% of CO_2 emissions in 2019 (4,856.7 MMT CO_2e). Relative to 1990, gross United States GHG emissions in 2019 were 1.8% higher; however, the gross emissions were down from a high of 15.6% above 1990 levels in 2007. GHG emissions decreased from 2018 to 2019 by 1.7% (113.1 MMT CO_2e) and overall, net emissions in 2019 were 13% below 2005 levels (EPA 2021).

According to California's 2000–2019 GHG emissions inventory (2021 edition), California emitted 418 MMT CO_2e in 2019, including emissions resulting from out-of-state electrical generation (CARB 2021b). The sources of GHG emissions in California include transportation, industry, electric power production from both in-state and out-of-state sources, residential and commercial activities, agriculture, high GWP substances, and recycling and waste. The California GHG emission source categories and their relative contributions in 2019 are presented in Table 7, Greenhouse Gas Emissions Sources in California.

Table 7. Greenhouse Gas Emissions Sources in California

Source Category	Annual GHG Emissions (MMT CO_2e)	Percent of Total[a]
Transportation	166.1	39.7%
Industrial	88.2	21.1%
Electric power	58.8	14.1%
Commercial and Residential	43.8	10.5%
Agriculture	31.8	7.6%
High global-warming potential substances	20.6	4.9%
Recycling and waste	8.9	2.1%
Total	**418.2**	**100%**

Source: CARB 2021b.
Notes: GHG = greenhouse gas; MMT CO_2e = million metric tons of carbon dioxide equivalent.
Emissions reflect the 2018 California GHG inventory.
a Percentage of total has been rounded, and total may not sum due to rounding.

Between 2000 and 2019, per-capita GHG emissions in California have dropped from a peak of 14.0 MT CO_2e per person in 2001 to 10.5 MT CO_2e per person in 2019, representing an approximate 25% decrease. In addition, total GHG emissions in 2019 were approximately 7 MMT CO_2e lower than 2018 emissions (CARB 2021b).

3.2 Regulatory Setting

3.2.1 Federal Regulations

Greenhouse Gas Endangerment

On April 2, 2007, in Massachusetts v. USEPA, 549 US 497, the Supreme Court found that GHGs are air pollutants covered by the Clean Air Act (CAA). The Court held that EPA must determine whether emissions of GHGs from new motor vehicles cause or contribute to air pollution, which may reasonably be anticipated to endanger public health or welfare, or whether the science is too uncertain to make a reasoned decision. In making these decisions, EPA is required to follow the language of Section 202(a) of the CAA.

On April 17, 2009, EPA Administrator signed proposed "endangerment" and "cause or contribute" findings for GHGs under Section 202(a) of the CAA. EPA held a 60-day public comment period, considered public comments, and issued final findings. EPA found that six GHGs taken in combination endanger both the public health and the public welfare of current and future generations. EPA also found that the combined emissions of these GHGs from new motor vehicles and new motor vehicle engines contribute to the greenhouse effect as air pollution that endangers public health and welfare under CAA Section 202(a).

Mandatory Reporting of Greenhouse Gases

The Consolidated Appropriations Act of 2008, passed in December 2007, requires the establishment of mandatory GHG reporting requirements. On September 22, 2009, EPA issued the Final Mandatory Reporting of Greenhouse Gases Rule, which became effective January 1, 2010. The rule requires reporting of GHG emissions from large sources and suppliers in the U.S. and is intended to collect accurate and timely emissions data to inform future policy decisions. Under the rule, suppliers of fossil fuels or industrial GHGs, manufacturers of vehicles and engines, and facilities that emit 25,000 metric tons or more per year of GHG emissions are required to submit annual reports to EPA.

Executive Order 13990

On January 20, 2021, President Biden issued Executive Order (EO) 13990, "Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis." Section 7(e) of this EO directs the White House Council on Environmental Quality (CEQ) to rescind the 2019 Draft GHG Guidance and review, revise, and update its 2016 GHG Guidance. Among its key provisions, the order directed federal agencies to review and potentially revise a range of policies, regulations, and actions that were inconsistent with the Biden administration's commitment to combatting climate change and promoting environmental sustainability. The order also sought to reestablish interagency working groups and committees that had been disbanded or sidelined during the previous administration, with a focus on restoring evidence-based decision-making processes.

The Interagency Working Group on the Social Cost of Greenhouse Gases (IWG) is a collaborative effort involving multiple U.S. federal agencies with the goal of providing scientifically sound estimates for the social cost of greenhouse gases (SC-GHG). This metric assigns a monetary value to the long-term damages caused by the emission of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) emissions, considering their impacts on climate change, public health, ecosystems, and the economy. The IWG under the authority of Executive Order

13990 released the "Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990" in February 2021. The Technical Support Document contains methodologies, data and analyses used by the IWG to develop interim estimates for the social cost of carbon (SC-CO2), methane (SC-CH_4), and nitrous oxide (SC-N2O) emissions under EO 13990.

Inflation Reduction Act

The Inflation Reduction Act was signed into law by President Biden in August 2022. The bill includes specific investment in energy and climate reform and is projected to reduce GHG emissions within the United States by 40% as compared to 2005 levels by 2030. The bill allocates funds to boost renewable energy infrastructure (e.g., solar panels and wind turbines), includes tax credits for the purchase of electric vehicles, and includes measures that will make homes more energy efficient.

The Inflation Reduction Act authorized the EPA to implement the Greenhouse Gas Reduction Fund (GGRF) program, which a is a historic, $27 billion investment to mobilize financing and private capital to combat the climate crisis and ensure American economic competitiveness. The GGRF will be designed to achieve the following program objectives: reduce GHG emissions and other air pollutants; deliver the benefits of GHG- and air-pollution-reducing projects to American communities, particularly low-income and disadvantaged communities; and mobilize financing and private capital to stimulate additional deployment of greenhouse gas and air pollution reducing projects (EPA 2023).

EPA External Review Draft of Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances. EPA released its "Supplementary Material for the Regulatory Impact Analysis for the Supplemental Proposed Rulemaking, "Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review". The report presented new estimates of the social cost of carbon dioxide (SC-CO_2), social cost of methane (SC-CH_4), and social cost of nitrous oxide (SC-N_2O) based on advances in scientific literature on climate change and its economic impacts and incorporating recommendations made by the National Academies of Science, Engineering and Medicine. EPA is a member of the IWG and participates in IWG's work under EO 13990. While the IWG work continues, EPA's draft report presents a set of SC-GHG estimates that incorporates numerous methodological updates addresses the near-term recommendations of the National Academies. Primary differences between EPA's draft report and IWG's interim estimates are the increase in the SC-GHGs and the discount rates. Uncertainty in the starting discount rate is addressed by using three near-term target rates (1.5, 2.0, and 2.5 percent) based on multiple lines of evidence on observed market interest rates (USEPA 2022).

Interim Guidance on Consideration of Greenhouse Gas Emissions and Climate Change

On January 6, 2023, the CEQ released new guidance to disclose climate impacts in environmental reviews under the National Environmental Policy Act (NEPA). The guidance replaces 2016 emissions guidance that was withdrawn by the previous Administration. CEQ's new climate change guidance recommends that agencies account for greenhouse gas (GHG) emissions in NEPA reviews. It provides Federal agencies a common approach for assessing their Alternative 2s, while recognizing each agency's unique circumstances and authorities.

3.2.2 State Regulations

The Statewide GHG emissions regulatory framework is summarized as follows by category: State climate change targets, building energy, renewable energy and energy procurement, mobile sources, solid waste, water, and other State regulations and goals. The following text describes EOs, assembly bills (ABs), senate bills (SBs), and other regulations and plans that would directly or indirectly reduce GHG emissions. The State's adoption and implementation of various legislation demonstrates California's leadership in addressing the critical challenge of addressing climate change. Of importance, the Project and/or users of the Project would be required to comply with the various regulatory measures that would reduce GHG emissions, which would reduce the Project's contribution to cumulative GHG emissions and associated climate change impacts.

State Climate Change Targets

The State has taken a number of actions to address climate change. These include EOs, legislation, and CARB plans and requirements. These are summarized as follows.

Executive Order S-3-05

EO S-3-05 (June 2005) established California's GHG emissions reduction targets and laid out responsibilities among the State agencies for implementing the EO and for reporting on progress toward the targets. This EO established the following targets:

- By 2010, reduce GHG emissions to 2000 levels
- By 2020, reduce GHG emissions to 1990 levels
- By 2050, reduce GHG emissions to 80% below 1990 levels

Assembly Bill 32

In furtherance of the goals established in EO S-3-05, the Legislature enacted AB 32 (Núñez and Pavley). The bill is referred to as the California Global Warming Solutions Act of 2006 (September 27, 2006). AB 32 provided initial direction on creating a comprehensive multiyear program to limit California's GHG emissions at 1990 levels by 2020 and initiate the transformations required to achieve the State's long-range climate objectives.

Senate Bill 32 and Assembly Bill 197

SB 32 and AB 197 (enacted in 2016) are companion bills. SB 32 codified the 2030 emissions reduction goal of EO B-30-15 by requiring CARB to ensure that Statewide GHG emissions are reduced to 40% below 1990 levels by 2030.

California Air Resources Board's Climate Change Scoping Plan

One specific requirement of AB 32 is for CARB to prepare a "scoping plan" for achieving the maximum technologically feasible and cost-effective GHG emission reductions by 2020 (Health and Safety Code, Section 38561(a)), and to update the plan at least once every 5 years. In 2008, CARB approved the first scoping plan. The *Climate Change Scoping Plan: A Framework for Change* (*Scoping Plan*) included a mix of recommended strategies that combined direct regulations, market-based approaches, voluntary measures, policies, and other emission reduction programs calculated to meet the 2020 Statewide GHG emission limit and initiate the transformations needed to achieve the State's long-range climate objectives.

In 2014, CARB approved the first update to the Scoping Plan. The *First Update to the Climate Change Scoping Plan: Building on the Framework* (*First Update)* defined the State's GHG emission reduction priorities for the next 5 years and laid the groundwork to start the transition to the post-2020 goals set forth in Eos S-3-05 and B-16-2012 (discussed below). The *First Update* concluded that California is on track to meet the 2020 target but recommended a 2030 mid-term GHG reduction target be established to ensure a continuum of action to reduce emissions (CARB 2014).

In 2015, as directed by EO B-30-15, CARB began working on an update to the Scoping Plan to incorporate the 2030 target of 40% below 1990 levels by 2030 to keep California on its trajectory toward meeting or exceeding the long-term goal of reducing GHG emissions to 80% below 1990 levels by 2050 as set forth in S-3-05.

In December 2017, CARB adopted the *2017 Climate Change Scoping Plan Update (2030 Scoping Plan)* (CARB 2017b). The 2030 Scoping Plan builds on the successful framework established in the initial Scoping Plan and First Update, while identifying new, technologically feasible and cost-effective strategies that will serve as the framework to achieve the 2030 GHG target and define the State's climate change priorities to 2030 and beyond.

The 2030 Scoping Plan recommends strategies for implementation at the Statewide level to meet the goals of AB 32, SB 32, and the Eos and establishes an overall framework for the measures that will be adopted to reduce California's GHG emissions. A project is considered consistent with the statutes and Eos if it meets the general policies in reducing GHG emissions to facilitate the achievement of the State's goals and does not impede attainment of those goals. As discussed in several cases, a given project need not be in perfect conformity with each and every planning policy or goals to be consistent. A project would be consistent, if it will further the objectives and not obstruct their attainment.

CARB's 2022 Scoping Plan Update.

The Proposed Final 2022 Scoping Plan for Achieving Carbon Neutrality (2022 Scoping Plan) was issued on November 16, 2022 (CARB 2022b). The 2022 Scoping Plan lays out a path not just to carbon neutrality by 2045 but also to the 2030 GHG emissions reduction target. The modeling indicates that, if the plan described in the Proposed Scenario is fully implemented, and done so on schedule, the State would cut GHG emissions by 85% below 1990 levels, result in a 71% reduction in smog-forming air pollution, reduce fossil fuel consumption by 94%, create 4 million new jobs, among other benefits (CARB 2022b).

The 2022 Scoping Plan details "Local Actions" In Appendix D. The Local Actions includes recommendations intended to build momentum for local government actions that align with the State's climate goals, with a focus on local GHG reduction strategies (commonly referred to as climate action planning) and approval of new land use development projects. The recommendations provided in Appendix D are non-binding and should not be interpreted as a directive to local governments, but rather as evidence-based analytical tools to assist local governments with their role as essential partners in achieving California's climate goals.[6] Absent a qualified GHG reduction plan, Appendix D provides recommendations for key attributes that residential and mixed-use projects should achieve

6 The threshold approaches outlined in the 2022 Scoping Plan, Appendix D, are recommendations only and are not requirements; they do not supplant lead agencies' discretion to develop their own evidence-based approaches for determining whether a project would have a potentially significant impact on GHG emissions (CARB 2022c).

that would align with the State's climate goals including EV charging infrastructure, infill location, no loss or conversion of natural and working lands, transit-supportive densities or proximity to transit stops, reducing parking requirements, provision of affordable housing (20% of units), and all-electric appliances with no natural gas connection (CARB 2022c). Projects that achieve all key attributes are considered clearly consistent with the State's climate and housing goals and would have a less-than-significant GHG impact (CARB 2022c). However, projects that do not achieve all attributes are not considered to result in a potentially significant GHG emission impact. Although net zero targets can often be valuable and achievable, targets should be considered in the larger context of these goals, and any GHG targets on a local scale should take into consideration the actions and outcomes included in this Scoping Plan (CARB 2022c). The CARB Scoping Plan states that jurisdictions considering "net zero" targets should carefully consider the implications such targets may have on emissions in neighboring communities and the ability of the state to meet collective targets (CARB 2022c).

Executive Order B-55-18

EO B-55-18 (September 2018) establishes a Statewide policy for California to achieve carbon neutrality as soon as possible, and no later than 2045, and achieve and maintain net-negative emissions thereafter. The goal is an addition to the existing Statewide targets of reducing the State's GHG emissions. CARB will work with relevant State agencies to ensure that future Scoping Plans identify and recommend measures to achieve the carbon neutrality goal.

The Inflation Reduction Act of 2022

The Inflation Reduction Act was signed into law by President Biden in August 2022. The bill includes specific investment in energy and climate reform and is projected to reduce GHG emissions within the U.S. by 40 percent as compared to 2005 levels by 2030. The bill allocates funds to boost renewable energy infrastructure (e.g., solar panels and wind turbines), includes tax credits for the purchase of electric vehicles, and includes measures that will make homes more energy efficient.

Assembly Bill 1279

The Legislature enacted AB 1279, the California Climate Crisis Act, in September 2022. The bill declares the policy of the state to achieve net zero GHG emissions as soon as possible, but no later than 2045, and achieve and maintain net negative GHG emissions thereafter. Additionally, the bill requires that by 2045, statewide anthropogenic GHG emissions be reduced to at least 85% below 1990 levels.

Assembly Bill 1757

AB 1757 (September 2022) requires the CNRA to determine a range of targets for natural carbon sequestration, and for nature-based climate solutions that reduce GHG emissions for future years 2030, 2038, and 2045. These targets are to be determined by no later than January 1, 2024, and are established to support the state's goals to achieve carbon neutrality and foster climate adaptation and resilience.

Senate Bill 1020

SB 1020 (September 2022) revises the standards from SB 100, requiring the following percentage of retail sales of electricity to California end-use customers come from eligible renewable energy resources and zero-carbon resources: 90% by December 31, 2035; 95% by December 31, 2040; and 100% by December 31, 2045

Building Energy

Title 24, Part 6

Title 24 of the California Code of Regulations was established in 1978 and serves to enhance and regulate California's building standards. While not initially promulgated to reduce GHG emissions, Part 6 of Title 24 specifically established Building Energy Efficiency Standards that are designed to ensure new and existing buildings in California achieve energy efficiency and preserve outdoor and indoor environmental quality. These regulations are carefully scrutinized and analyzed for technological and economic feasibility (California Public Resources Code, Section 25402(d)) and cost effectiveness (California Public Resources Code, Sections 25402(b)(2) and (b)(3)). As a result, these standards save energy, increase electricity supply reliability, increase indoor comfort, avoid the need to construct new power plants, and help preserve the environment.

The Title 24 standards that CalEEMod incorporates are the 2019 Title 24 Building Energy Efficiency Standards, which became effective January 1, 2020. In general, single-family residences built to the 2019 standards are anticipated to use approximately 7% less energy due to energy efficiency measures than those built to the 2016 standards; once rooftop solar electricity generation is factored in, single-family residences built under the 2019 standards will use approximately 53% less energy than those under the 2016 standards (CEC 2018a). Nonresidential buildings built to the 2019 standards are anticipated to use an estimated 30% less energy than those built to the 2016 standards (CEC 2018a).

On August 11, 2021, the CEC adopted the 2022 Building Energy Efficiency Standards (Energy Code). In December 2021, the 2022 Energy Code was approved by the California Building Standards Commission for inclusion into the California Building Standards Code. The 2022 Energy Code encourages efficient electric heat pumps, establishes electric-ready requirements for new homes, expands solar photovoltaic and battery storage standards, strengthens ventilation standards, and more. Buildings whose permit applications are applied for on or after January 1, 2023, must comply with the 2022 Energy Code. Under the 2022 amendments, California buildings would consume approximately 198,600 GWh of electricity and 6.14 billion therms of fossil fuel natural gas in 2023 compared to approximately 199,500 GWh and 6.17 billion therms of electricity and fossil fuel natural gas, respectively, under the 2019 Energy Code (CEC 2021). On a statewide basis throughout 2023, all measures for newly constructed buildings and altered components of existing buildings collectively would save approximately 33 million therms of fossil fuel natural gas and 1.3 billion kWh of electricity (CEC 2021).

Title 24, Part 11

In addition to the CEC's efforts, in 2008, the California Building Standards Commission adopted the nation's first green building standards. The California Green Building Standards Code (Part 11 of Title 24) is commonly referred to as CALGreen and establishes minimum mandatory standards as well as voluntary standards pertaining to the planning and design of sustainable site development, energy efficiency (in excess of the California Energy Code requirements), water conservation, material conservation, and interior air quality. The 2019 CALGreen standards are the current applicable standards. For nonresidential projects (which the nonresidential portion of the Project is subject to), some of the key mandatory CALGreen 2019 standards involve requirements related to bicycle parking, designated parking for clean air vehicles, electric vehicle (EV) charging stations, shade trees, water conserving plumbing fixtures and fittings, outdoor potable water use in landscaped areas, recycled water supply systems, construction waste management, excavated soil and land clearing debris, and commissioning (24 CCR Part 11).

Title 20

Title 20 of the California Code of Regulations requires manufacturers of appliances to meet State and federal standards for energy and water efficiency. The CEC certifies an appliance based on a manufacturer's demonstration that the appliance meets the standards.

Renewable Energy and Energy Procurement

Senate Bill 1078, Executive Order-14-08, Senate Bill X1-2, Senate Bill 350, and Senate Bill 100

SB 1078 (Sher) (September 2002) established the Renewable Portfolio Standard (RPS) program, which required an annual increase in renewable generation by the utilities equivalent to at least 1% of sales, with an aggregate goal of 20% by 2017. EO S-14-08 (November 2008) required that all retail suppliers of electricity in California serve 33% of their load with renewable energy by 2020. SB X1 2 expanded the RPS by establishing a renewable energy target of 20% of the total electricity sold to retail customers in California per year by December 31, 2013, and 33% by December 31, 2020, and in subsequent years. SB 350 (October 2015) further expanded the RPS by establishing a goal of 50% of the total electricity sold to retail customers in California per year by December 31, 2030. SB 100 (2018) increased the standards set forth in SB 350 establishing that 44% of the total electricity sold to retail customers in California per year by December 31, 2024, 52% by December 31, 2027, and 60% by December 31, 2030, be secured from qualifying renewable energy sources. SB 100 states that it is the policy of the State that eligible renewable energy resources and zero-carbon resources supply 100% of the retail sales of electricity to California. On April 30, 2022 California supplied 100% of its statewide demand with renewables at 2:45 pm (Electrek 2022).

Mobile Sources

State Vehicle Standards (Assembly Bill 1493 and Executive Order B-16-12)

AB 1493 (July 2002) was enacted in a response to the transportation sector accounting for more than half of California's CO_2 emissions. AB 1493 required CARB to set GHG emission standards for passenger vehicles, light-duty trucks, and other vehicles determined by the State board to be vehicles that are primarily used for noncommercial personal transportation in the State. The bill required that CARB set GHG emission standards for motor vehicles manufactured in 2009 and all subsequent model years. CARB adopted the standards in September 2004. EO B-16-12 (March 2012) required that State entities under the governor's direction and control support and facilitate the rapid commercialization of zero-emissions vehicles. It ordered CARB, CEC, California Public Utilities Commission, and other relevant agencies to work with the Plug-in Electric Vehicle Collaborative and the California Fuel Cell Partnership to establish benchmarks to help achieve benchmark goals by 2015, 2020, and 2025. On a Statewide basis, EO B-16-12 established a target reduction of GHG emissions from the transportation sector equaling 80% less than 1990 levels by 2050. This directive did not apply to vehicles that have special performance requirements necessary for the protection of the public safety and welfare. As explained under the "Federal Vehicle Standards" description above, EPA and NHTSA approved the SAFE Vehicles Rule Part One and Two, which revoked California's authority to set its own GHG emissions standards and set zero-emission vehicle mandates in California.

As President Biden issued EO 13990 to review Part One and Part Two of the SAFE Vehicles Rule, this analysis continues to utilize the best available information at this time, as set forth in EMFAC and assumed in CalEEMod.

Heavy Duty Diesel (Title 13, Division 3, Chapter 1, Section 2025)

CARB adopted the final Heavy Duty Truck and Bus Regulation, Title 13, Division 3, Chapter 1, Section 2025, on December 31, 2014, to reduce particulate matter and NO_x emissions from heavy-duty diesel vehicles. The rule requires particulate matter filters be applied to newer heavier trucks and buses by January 1, 2012, with older vehicles required to comply by January 1, 2015. The rule will require nearly all diesel trucks and buses to be compliant with the 2010 model year engine requirement by January 1, 2023. CARB also adopted an Airborne Toxic Control Measure to limit idling of diesel-fueled commercial vehicles on December 12, 2013. This rule requires diesel-fueled vehicles with gross vehicle weights greater than 10,000 pounds to idle no more than 5 minutes at any location (13 CCR 2485).

Executive Order S-1-07

EO S-1-07 (January 2007, implementing regulation adopted in April 2009) sets a declining low carbon fuel standard (LCFS) for GHG emissions measured in CO_2e grams per unit of fuel energy sold in California. The initial target of the LCFS was to reduce the carbon intensity of California passenger vehicle fuels by at least 10% by 2020 (17 CCR 95480 et seq.). In September 2018, CARB approved amendments for the LCFS that require a 20% reduction in carbon intensity by year 2030.

Senate Bill 375

SB 375 (Steinberg) (September 2008) addresses GHG emissions associated with the transportation sector through regional transportation and sustainability plans. SB 375 requires CARB to adopt regional GHG reduction targets for the automobile and light-truck sector for 2020 and 2035 and to update those targets every 8 years. SB 375 requires the State's 18 regional metropolitan planning organizations (MPOs) to prepare a Sustainable Communities Strategy (SCS) as part of their Regional Transportation Plan (RTP) that will achieve the GHG reduction targets set by CARB.

Advanced Clean Cars Program and Zero-Emissions Vehicle Program

The Advanced Clean Cars (ACC) I program (January 2012) is an emissions-control program for model years 2015 through 2025. The program combines the control of smog- and soot-causing pollutants and GHG emissions into a single coordinated package of regulations: the Low-Emission Vehicle (LEV) regulation for criteria air pollutant and GHG emissions and a technology forcing regulation for zero-emission vehicles (ZEV) that contributes to both types of emission reductions (CARB 2021c). The package includes elements to reduce smog-forming pollution, reduce GHG emissions, promote clean cars, and provide the fuels for clean cars. To improve air quality, CARB has implemented new emission standards to reduce smog-forming emissions beginning with 2015 model year vehicles. It is estimated that in 2025 cars will emit 75 percent less smog-forming pollution than the average new car sold in 2015 (CARB 2021c). The ZEV program will act as the focused technology of the ACC I program by requiring manufacturers to produce increasing numbers of ZEVs and plug-in hybrid EVs in the 2018 to 2025 model years.

The ACC II program is currently in development to establish the next set of LEV and ZEV requirements for model years after 2025 to contribute to meeting federal ambient air quality ozone standards and California's carbon neutrality standards (CARB 2021c). The main objectives of ACC II are:

1. Maximize criteria and GHG emission reductions through increased stringency and real-world reductions.
2. Accelerate the transition to ZEVs through both increased stringency of requirements and associated actions to support wide-scale adoption and use.

An ACC II rulemaking package, which will consider technological feasibility, environmental impacts, equity, economic impacts, and consumer impacts, is anticipated to be presented to CARB for consideration in August 2022.

Assembly Bill 1236

AB 1236 (October 2015) required a city, county, or city and county to approve an application for the installation of EV charging stations, as defined, through the issuance of specified permits, unless the city or county makes specified written findings based upon substantial evidence in the record that the proposed installation would have a specific, adverse impact upon the public health or safety, and there is no feasible method to satisfactorily mitigate or avoid the specific, adverse impact. The bill provided for appeal of that decision to the planning commission, as specified. The bill provided that the implementation of consistent Statewide standards to achieve the timely and cost-effective installation of EV charging stations is a matter of Statewide concern. The bill required EV charging stations to meet specified standards.

Executive Order-79-20

EO N-79-20 (September 2020) requires CARB to develop regulations as follows: (1) Passenger vehicle and truck regulations requiring increasing volumes of new ZEVs sold in the State towards the target of 100% of in-State sales by 2035; (2) medium- and heavy-duty vehicle regulations requiring increasing volumes of new zero-emission trucks and buses sold and operated in the State towards the target of 100% of the fleet transitioning to zero-emission vehicles by 2045 everywhere feasible and for all drayage trucks to be zero emission by 2035; and (3) strategies, in coordination with other State agencies, the EPA and local air districts, to achieve 100% zero-emissions from off-road vehicles and equipment operations in the State by 2035. EO N-79-20 called for the development of a Zero-Emissions Vehicle Market Development Strategy, which was released February 2021, to be updated every 3 years, that ensures coordination and implementation of the EO and outlines actions to support new and used ZEV markets. In addition, the EO specifies identification of near-term actions, and investment strategies, to improve clean transportation, sustainable freight, and transit options; and calls for development of strategies, recommendations, and actions by July 15, 2021, to manage and expedite the responsible closure and remediation of former oil extraction sites as the State transitions to a carbon-neutral economy.

Advanced Clean Trucks (ACT) Regulation

The purpose of the ACT Regulation (June 2020) is to accelerate the market for zero-emission vehicles in the medium- and heavy-duty truck sector and to reduce emissions NO_X, fine particulate matter, TACs, GHGs, and other criteria pollutants generated from on-road mobile sources (CARB 2021d). Requiring medium- and heavy-duty vehicles to transition to zero-emissions technology will help California meet established near- and long-term air quality and climate mitigation targets.

Water

Executive Order B-29-15

In response to the ongoing drought in California, EO B-29-15 (April 2015) set a goal of achieving a Statewide reduction in potable urban water usage of 25% relative to water use in 2013. The term of the EO extended through February 28, 2016, although many of the directives have become permanent water-efficiency standards and requirements. The EO includes specific directives that set strict limits on water usage in the State.

Executive Order B-37-16

Issued May 2016, EO B-37-16 directed the State Water Resources Control Board (SWRCB) to adjust emergency water conservation regulations through the end of January 2017 to reflect differing water supply conditions across the State. The SWRCB also developed a proposal to achieve a mandatory reduction of potable urban water usage that builds off the mandatory 25% reduction called for in EO B-29-15. The SWRCB and Department of Water Resources will develop new, permanent water use targets that build upon the existing State law requirements that the State achieve 20% reduction in urban water usage by 2020. EO B-37-16 also specifies that the SWRCB permanently prohibit water-wasting practices such as hosing off sidewalks, driveways, and other hardscapes; washing automobiles with hoses not equipped with a shut-off nozzle; using non-recirculated water in a fountain or other decorative water feature; watering lawns in a manner that causes runoff, or within 48 hours after measurable precipitation; and irrigating ornamental turf on public street medians.

Executive Order N-10-21

In response to a state of emergency due to severe drought conditions, EO N-10-21 (July 2021) called on all Californians to voluntarily reduce their water use by 15% from their 2020 levels. Actions suggested in EO N-10-21 include reducing landscape irrigation, running dishwashers and washing machines only when full, finding and fixing leaks, installing water-efficient showerheads, taking shorter showers, using a shut-off nozzle on hoses, and taking cars to commercial car washes that use recycled water.

Executive Order N-7-22

On March 28, 2022, Governor Newsom directed the State Water Board to consider adopting emergency regulations focused on urban water suppliers under EO N-7-22. If adopted, the potential regulations would require the vast majority of urban water suppliers to enact Level 2 of their water shortage contingency plans. Those plans are developed by the suppliers and provide actions they will take if their water supplies are cut to certain levels. Here, Level 2 would represent the suppliers acting as if their water supply had been reduced by 20%. The executive order also directs the State Water Board to consider adopting emergency regulations defining “non-functional turf” by May 25, 2022. Both the executive order and corresponding press release confirm that the definition should only apply to ornamental turf that is not functional, excluding turf such as school fields, sports fields and parks from the definition. If the definition is adopted, the State Water Board must then consider banning irrigation of the non-functional turf in the commercial, industrial and institutional sectors (with limited exceptions). The proposed ban is anticipated to save several hundred thousand acre-feet of water per year.

Solid Waste

Assembly Bill 939, Assembly Bill 341, Assembly Bill 1826, and Senate Bill 1383

In 1989, AB 939, known as the Integrated Waste Management Act (California Public Resources Code, Sections 40000 et seq.), was passed because of the increase in waste stream and the decrease in landfill capacity. AB 939 mandated a reduction of waste being disposed where jurisdictions were required to meet diversion goals of all solid waste through source reduction, recycling, and composting activities of 25% by 1995 and 50% by the year 2000. AB 341 (Chapter 476, Statutes of 2011) amended the California Integrated Waste Management Act of 1989 to include a provision declaring that it is the policy goal of the State that not less than 75% of solid waste generated be source-reduced, recycled, or composted by the year 2020, and annually thereafter. AB 1826 (Chapter 727, Statutes of 2014, effective 2016) requires businesses to recycle their organic waste (i.e., food waste, green waste, landscape and pruning waste, nonhazardous wood waste, and food-soiled paper waste that is mixed in with food waste) depending on the amount of waste they generate per week. SB 1383 (Chapter 395, Statutes of 2016) establishes targets to achieve a 50% reduction in the level of the Statewide disposal of organic waste from the 2014 level by 2020 and a 75% reduction by 2025. CalRecycle was granted the regulatory authority required to achieve the organic waste disposal reduction targets and establishes an additional target that not less than 20% of currently disposed edible food is recovered for human consumption by 2025 (CalRecycle 2019).

3.3 Insignificance Criteria and Methodology

3.3.1 Insignificance Thresholds and Indicators

The CEQ Guidance recognizes that global climate change is a cumulative impact; a project participates in this potential impact through its incremental contribution combined with the cumulative increase of all other sources of GHGs. There are no federal numeric thresholds that delineate when Alternative 2 may have an adverse impact. As discussed in the interim CEQ Guidance when conducting climate change analyses in NEPA, agencies should consider: (1) the potential effects of Alternative 2 on climate change, including by assessing both GHG emissions and reductions from Alternative 2; and (2) the effects of climate change on Alternative 2 and its environmental impacts. The CEQ guidance recommends quantifying GHG emissions, understanding that GHG are a cumulative impact and not project-only impacts, including indirect emissions when relevant to the project, such as for fossil fuel supply or transport projects, and providing context for GHG emissions using the best available social cost of GHG (SC-GHG) estimates to translate climate impacts into the more accessible metric of dollars.

There is no established dollar-value threshold for the SC-GHGs. However, by assigning a dollar value to the damages associated with GHG emissions, policymakers and decision-makers can better evaluate the costs and benefits of actions aimed at reducing emissions. The SC-GHGs provides a tool to make more informed choices about climate-related policies, regulations, and investments.

The USAF has adopted the Prevention of Significant Deterioration (PSD) threshold for GHG of 75,000 ton per year (tpy) of CO_2e (or 68,039 metric ton per year, mtpy) as an indicator or threshold of insignificance for NEPA air quality impacts in all areas (HQ AFCEC/CZTQ. 2023b). This indicator does not define a significant impact; however, it provides a threshold to identify actions that are insignificant (de minimis, too trivial or minor to merit consideration). Actions with a net change in GHG (CO_2e) emissions below the insignificance indicator (threshold) are considered too insignificant on a global scale to warrant any further analysis beyond producing the in the ACAM GHG & Climate Change Reports. Note that actions (or alternatives) with a net change in GHG (CO_2e) emissions above the insignificance indicator (threshold) are only considered potentially significant and require further assessment (usually qualitative) to determine if the action poses a significant impact.

3.3.2 Approach and Methodology

Emissions of GHGs were estimated for operation of Alternative 2 consistent with the methodology presented in Section 2.4.2. Emissions of CO_2, CH_4, and N_2O were estimated from the combustion sources of Alternative 2. Additional sources of direct and indirect GHG emissions were estimated using the CalEEMod 2022 as discussed below.

Energy Sources

The estimation of operational energy emissions was based on applicant provided data. CalEEMod default energy intensity factors (CO_2, CH_4, and N_2O mass emissions per kilowatt hour) for PG&E is based on the value for PG&E's energy mix in 2019. SB-100 calls for further development of renewable energy, with a target of 44% by 2024, 52% by 2027, and 60% by 2030. Because PG&E is striving to meet the 60% RPS by December 31, 2030, the CO_2 emissions intensity factor is anticipated to be less than assumed in CalEEMod at full buildout from implementation of Alternative 2 (2025), which would reflect the increase in percentage of renewable energy in PG&E's energy portfolio.

Refrigerants

CalEEMod was utilized to estimate fugitive GHG emissions from refrigerants used for air conditioning and refrigeration equipment. Different types of refrigeration equipment are utilized for different types of land uses and CalEEMod generates default refrigerant values based on land use subtype and industry data from the EPA. CalEEMod quantifies refrigerant emissions from leaks during regular operation and routine servicing over the equipment lifetime and then derives average annual emissions from the lifetime estimate but does not quantify emissions from the disposal of refrigeration and air conditioning equipment at the end of its lifetime.

Most of the refrigerants used today are HFCs or blends thereof, which can have high GWP values. However, California is required to reduce HFC emissions 40% below 2013 levels by 2030 under SB 1383, and regulations have been adopted to place GWP limits on HFCs, such as SB 120. While CalEEMod default refrigerant values were assumed for the land use surrogate of commercial research and development land use, it is anticipated to be conservative.

Solid Waste

The Project would generate solid waste, and therefore, result in CO_2e emissions associated with landfill off-gassing. CalEEMod default values for solid waste generation were used to estimate GHG emissions associated with solid waste. Project compliance with Statewide solid waste diversion goals, including the 75% diversion rate by 2020 consistent with AB 341 (25% increase from the solid waste diversion requirements of AB 939, Integrated Waste Management Act), would reduce Project-generated GHG emissions associated with solid waste disposal. No diversion above the CalEEMod default assumptions was assumed.

Water and Wastewater

Supply, conveyance, treatment, and distribution of water for the Project require the use of electricity, which would result in associated indirect GHG emissions. Similarly, wastewater generated by the Project requires the use of electricity for conveyance and treatment, along with GHG emissions generated during wastewater treatment. Water consumption estimates for both indoor and outdoor water use was provided by the project applicant and associated electricity consumption from water use and wastewater generation were estimated using CalEEMod default values.

3.3.3 Greenhouse Gas Emissions Impact Assessment

3.3.3.1 Operational Emissions

Operation of Alternative 2 would generate GHG emissions through motor vehicle trips; landscape maintenance equipment operation and hearths (area sources); energy use (natural gas and electricity); solid waste disposal; and water supply, treatment, and distribution and wastewater treatment. CalEEMod was used to calculate the annual GHG emissions based on the operational assumptions described in Section 3.3.2, Methodology. The estimated operational Project-generated unmitigated GHG emissions from area sources, energy usage, motor vehicles, solid waste generation, water usage and wastewater generation, and off-road equipment are shown in Table 8, Project Operational GHG Emissions.

Table 8. Alternative 2 Operational GHG Emissions

Emission Source	CO_2	CH_4	N_2O	CO_2e
	Metric Tons per Year			
Solvent Use	0.00	0.00	0.00	0.00
Emergency Generators	133.78	0.01	0.00	134.23
Worker Vehicles	1,144.08	0.07	0.05	1,159.23
Fleet Vehicle Use	52.82	0.00	0.00	53.58
Vendor-Contractor Vehicles	25.56	0.00	0.00	25.92
Off-Road Equipment	2,998.48	0.12	0.02	3,008.77
RP-1, RSV Loading, and Payload Fueling	NA	NA	NA	2,724.48
Roll-On-Roll-Off	12,127.68	0.41	0.35	12,241.84
Launch	NA	NA	NA	13,679.79
Booster and Payload Fairing Recovery	145.11	0.00	0.01	147.10
Landings and Static Fire	NA	NA	NA	5,068.18
Energy	2,586.97	0.42	0.05	2,612.55
Refrigerants	0.00	0.00	0.00	0.04
Solid Waste	106.81	10.67	0.00	373.68
Water and Wastewater	25.56	0.03	0.02	31.56
			Total	41,260.95
			Baseline	28,055.95
			Net (Alternative 2 – Baseline)	13,205.00

Notes: GHG = greenhouse gas; CO_2 = carbon dioxide; CH_4 = methane; N_2O = nitrous oxide; CO_2e = carbon dioxide equivalent.
See Appendix A for complete results.

As shown in Table 8, estimated net operational GHG emissions from Alternative 2 would be approximately 13,205 MT CO_2e per year. GHG emissions of Alternative 2 would be below the DAF insignificance indicator for all years.

3.3.3.2 Social Cost of GHGs

The SC-GHG is an economic concept used to quantify the monetary value of the long-term societal damages caused by the emission of GHGs into the atmosphere. This metric seeks to capture the various adverse impacts associated with GHG emissions, such as climate change, health problems, ecosystem damage, and economic losses. By assigning a dollar value to these damages, the SC-GHG provides a tool for policymakers, businesses, and governments to assess the true costs of emitting CO_2, CH_4, N_2O, and other GHGs.

Table 9 provides the social cost of GHGs over the life of Alternative 2 based on the Interim Estimates under Executive Order 13990. As shown in Table 9, under a 5% discount rate, Alternative 2 would have a SC-GHGs of over $1.5 million, under a 3% discount rate over $4.9 million, and at a 2.5% discount rate over $7.1 million. Since publication of the Interim Estimates, USEPA has been working on new estimates for the SC-GHGs. These estimates reflect recent advances in the scientific literature on climate change and its economic impacts and incorporate recommendations made by the National Academies of Science, Engineering, and Medicine (National Academies 2017). Under USEPA's draft estimates for SC-GHGs, Alternative 2 would have a SC-GHG of over $9.4 million under the 2.5% discount rate, under the 2% discount rate over $15.1 million, and at a 1.5% discount rate over $25.4 million. However, by assigning a dollar value to the damages associated with GHG emissions, policymakers and decision-makers can better evaluate the costs and benefits of actions aimed at reducing emissions. The SC-GHGs provides a tool to make more informed choices about climate-related policies, regulations, and investments.

Table 9. Social Cost of GHGs Based On Interim Estimates Under Executive Order 13990 – Alternative 2

Year	SC-CO2 per Metric Ton			SC-CH4 per Metric Ton			SC-N2O per Metric Ton			Total Cost of GHGs		
	5.00%	3.00%	2.50%	5.00%	3.00%	2.50%	5.00%	3.00%	2.50%	5.00%	3.00%	2.50%
2025	$17	$56	$83	$800	$1,700	$2,200	$6,800	$21,000	$30,000	$230,808	$759,435	$1,121,497
2026	$17	$57	$84	$828	$1,760	$2,260	$7,000	$21,400	$30,600	$239,156	$773,740	$1,140,931
2027	$18	$58	$85	$856	$1,820	$2,320	$7,200	$21,800	$31,200	$244,964	$790,535	$1,158,053
2028	$18	$60	$87	$884	$1,880	$2,380	$7,400	$22,200	$31,800	$250,772	$807,331	$1,175,175
2029	$19	$61	$88	$912	$1,940	$2,440	$7,600	$22,600	$32,400	$256,580	$824,127	$1,192,296
2030	$19	$62	$89	$940	$2,000	$2,500	$7,800	$23,000	$33,000	$262,388	$840,922	$1,209,418
Total										**$1,484,666**	**$4,796,089**	**$6,997,371**

Notes: GHG = greenhouse gas emissions; SC-CO2 = social cost of carbon dioxide; SC-CH4 = social cost of methane; SC-N2O = social cost of nitrous oxide.

Climate Change Impacts

The analysis provided above shows Alternative 2's GHG contributions. As noted previously, Alternative 2 would not exceed the DAF insignificance threshold for GHG emissions. Furthermore, the impact of Alternative 2 is evaluated considering climate change effects and whether Alternative 2 would exacerbate climate change effects and how climate change may impact Alternative 2.

Alternative 2 Impact on the Environment Considering Climate Change Effects

As described in the CEQ Guidance document (CEQ 2023), the analysis of climate change effects should focus on those aspects of the human environment that are impacted by the potential action (i.e., Alternative 2 or its alternatives) on climate change. The Fourth National Climate Assessment (USGCRP 2018) describes key areas where climate change will affect resources that impact human environment. The following assesses how Alternative 2 may affect those areas.

- **Water Resources.** Water for humans and nature has declined because of climate change. There has been intensifying droughts and occasional large floods. The demand on water resources will become problematic as populations increase, infrastructure deteriorates, and groundwater is depleted, which will necessitate flexible water management techniques. Alternative 2 would use water for facility needs as well as launch support. Water usage is anticipated to be minimal and would not contribute to drought conditions or exacerbate climate change effects. Alternative 2 would not have an adverse effect on water.

- **Ecosystems and Ecosystem Services.** Drought and wildfire have contributed to the decline in the Southwest forests and other ecosystem's ability to provide natural habitat, clean water, and economic livelihoods. Alternative 2 would not contribute to drought conditions and does not involve forested lands. Alternative 2 does not include chemicals that would pollute water, soil, or air. Impacts to the ecosystem would be contained within the project boundaries. In addition, Alternative 2 includes BMPs to protect water quality, enhance native plantings (as reclamation activities occur), and minimize air emissions. Alternative 2 would have no effect on ecosystems and ecosystem services.

- **The Coast.** This resource area involves sea level rise, ocean warming, and reduce ocean oxygen. Alternative 2 is near the Pacific Ocean and would be subject to any sea level rise. Alternative 2 would indirectly contribute to the effects on rising sea levels due to an increase in GHGs. However, the contribution to global GHGs from Alternative 2 would be minimal.

- **Indigenous Peoples.** This area involves impacts on the ecosystems indigenous people depend on for their traditional existence and livelihood because of drought, wildfire, and changing oceans. As discussed above, Alternative 2 would not contribute to drought conditions and would not impact ecosystems or oceans.

- **Energy.** This area relates to the ability of hydropower and fossil fuel electricity generation to meet growing energy demands as result of the drought (decreasing hydropower), and rising temperatures (increasing energy demand). Alternative 2 would demand electricity from the grid for facility needs and launch support. Alternative 2 would include on-site generators to provide necessary power as well; thus it would not have adverse effect on energy demand. Alternative 2 would require diesel fuel for plant operations and customer vehicles. In addition, the employee vehicles would demand gasoline fuel. Alternative 2's action fuel demand would not be substantial.

- **Food.** This area relates to the ability of the region to produce food considering water shortages, and heat impacts to crops and livestock. There will be increased competition among agricultural, energy, and municipal uses for water, which may result in food insecurity. As noted above, Alternative 2 would not demand a substantial amount of water that would contribute to drought conditions.

- **Human Health.** This area relates to impacts to human health because of extreme heat, poor air quality, and conditions that foster pathogen growth and spread. Air quality emissions from Alternative 2 are summarized in Section 2.4.3 and are well below federal de minimis levels, which are established to determine if an action will confirm with the applicable State Implementation Plan for meeting air quality standards. Moreover, the majority of the emissions from Alternative 2 are not near any populated areas. It can be reasonably concluded that Alternative 2 would not contribute to poor air quality on a regional basis and would not jeopardize the attainment status of the region. Based on the evaluation, Alternative 2 would not have an adverse effect on human health or ambient air quality standards. Alternative 2 would not have an adverse effect on human health.

Impacts of Climate Change on Alternative 2

The CEQ Guidance (CEQ 2023) recommends evaluating how climate change may affect Alternative 2 so that a project may be developed to be resilient to climate change effects. The following summarizes the impacts of climate change on Alternative 2 and resiliency/adaptation measures that can be incorporated into the project.

- **Drought conditions, lack of water**. Alternative 2 would use water supplied by VSFB. As a private enterprise, the market would determine whether additional costs (if supplies were limited) for water imports would be financially acceptable. Alternative 2 would adapt to changing conditions by either limiting production to decrease water use, identifying additional conservation measures, or identifying additional water supplies as the market conditions dictate either on-site or through imports.

- **Rising temperatures/prolonged heatwaves.** As a private operation, Alternative 2 may implement additional safety measures to protect employee health and ensure continued production. Those measures may include additional rest/cooling areas, drinking water stations, etc. The operator of the facility would comply with California Occupational Safety and Health Administration regulations. Under the Occupational Safety and Health Act, employers are responsible for providing workplaces free of known safety and health hazards including heat-related hazards. The facility would have flexibility to adapt to changing conditions by increasing measures on-site to protect employee health or having to delay work if conditions became too extreme.

- **Major storm events/flooding.** Climate change will affect how precipitation occurs in the region, with some prolonged storm events potentially causing localized flooding. As a private operation, if the project site becomes flooded, the operator has flexibility to adapt operations to adjust to flood conditions by delaying work until the site is operable again.

In summary, many of the climate change effects on Alternative 2 may be addressed through changes in production and/or enhanced/changed operational measures. As a private operation, Alternative 2 has flexibility to adapt to these climate change stressors, such that no adverse effect would occur.

3.3.3.3 Relevant Climate Action Plans

The following provides a discussion of how Alternative 2 help meet or detract from achieving relevant climate action goals and commitments within the applicable plans. This section discusses the Long-Term Strategy of the United States, Pathways to Net-Zero Greenhouse Gas Emissions by 2050 and the CARB's Scoping Plan.

White House Long Term Strategy of the United States, Pathways to Net-Zero Greenhouse Gas Emissions by 2050

This 2021 Long-Term Strategy represents the next step: it lays out how the United States can reach its ultimate goal of net-zero emissions no later than 2050. Achieving net-zero emissions is how we—and our fellow nations around the globe—will keep a 1.5°C limit on global temperature rise within reach and prevent unacceptable climate change impacts and risks. The Long-Term Strategy shows that reaching net zero no later than 2050 will require actions spanning every sector of the economy. There are many potential pathways to get there, and all path-ways start with delivering on our 2030 Nationally Determined Contribution. This will put the United States firmly on track to reach net-zero by 2050 and support the overarching vision of building a more sustainable, resilient, and equitable economy. The United States can deliver net-zero emissions across all sectors and GHGs through multiple pathways, but all viable routes to net-zero involve five key transformations:

1. **DECARBONIZE ELECTRICITY.** Electricity delivers diverse services to all sectors of the American economy. The transition to a clean electricity system has been accelerating in recent years— driven by plummeting costs for solar and wind technologies, federal and subnational policies, and consumer demand. Building on this success, the United States has set a goal of 100% clean electricity by 2035, a crucial foundation for net-zero emissions no later than 2050. Alternative 2 and alternatives would not inhibit the decarbonization of the electric grid.
2. **ELECTRIFY END USES AND SWITCH TO OTHER CLEAN FUELS.** We can affordably and efficiently electrify most of the economy, from cars to buildings and industrial processes. In areas where electrification presents technology challenges—for instance aviation, shipping, and some industrial processes— we can prioritize clean fuels like carbon-free hydrogen and sustainable biofuels. Alternative 2 and alternatives would utilize advanced Tier 3 and Tier 4 engines and as technological advances are commercialized will adopt use of clean fuels and/or technology as applicable.
3. **CUT ENERGY WASTE.** Moving to cleaner sources of energy is made faster, cheaper, and easier when existing and new technologies use less energy to provide the same or better service. This can be achieved through diverse, proven approaches, ranging from more efficient appliances and the integration of efficiency into new and existing buildings, to sustainable manufacturing processes. Alternative 2 and alternatives would not inhibit the transition to cleaner sources of energy.
4. **REDUCE METHANE AND OTHER NON-CO_2 EMISSIONS.** Non-CO_2 gases such as methane, hydrofluorocarbons (HFCs), nitrous oxide (N_2O), and others, contribute significantly to warming— with methane alone contributing fully half of current net global warming of 1.0°C. There are many profitable or low-cost options to reduce non-CO_2 sources, such as implementing methane leak detection and repair for oil and gas systems and shifting from HFCs to climate-friendly working fluids in cooling equipment. The U.S. is committed to taking comprehensive and immediate actions to reduce methane domestically. And through the Global Methane Pledge, the U.S. and partners seek to reduce global methane emissions by at least 30% by 2030, which would eliminate over 0.2°C of warming by 2050. The U.S. will also prioritize research and development to unlock the innovation needed for deep emissions reductions beyond

currently available technologies. Alternative 2 and alternatives predominantly generate emissions of CO_2. However, Alternative 2 and alternatives would not inhibit the reduction in non-CO_2 gases.

5. **SCALE UP CO_2 REMOVAL.** In the three decades to 2050, our emissions from energy production can be brought close to zero, but certain emissions such as non-CO_2 from agriculture will be difficult to decarbonize completely by mid-century. Reaching net-zero emissions will therefore require removing carbon dioxide from the atmosphere, using processes and technologies that are rigorously evaluated and validated. This requires scaling up land carbon sinks as well as engineered strategies. Alternative 2 and alternatives would not inhibit the removal of carbon dioxide from the atmosphere.

Alternative 2 and alternatives would not conflict with the goals within the White House' Strategy to remove GHGs.

CARB's Scoping Plan

Project Consistency with State Reduction Targets and CARB's Scoping Plan

The California State Legislature passed the Global Warming Solutions Act of 2006 (Assembly Bill 32 [AB 32]) to provide initial direction to limit California's GHG emissions to 1990 levels by 2020 and initiate the state's long-range climate objectives. Since the passage of AB 32, the State has adopted GHG emissions reduction targets for future years beyond the initial 2020 horizon year. For the proposed project, the relevant GHG emissions reduction targets include those established by Senate Bill 32 (SB 32) and AB 1279, which require GHG emissions be reduced to 40%below 1990 levels by 2030, and 85% below 1990 levels by 2045, respectively. In addition, AB 1279 requires the state achieve net zero GHG emissions by no later than 2045 and achieve and maintain net negative GHG emissions thereafter.

As defined by AB 32, the CARB is required to develop The Scoping Plan, which provides the framework for actions to achieve the State's GHG emission targets. The Scoping Plan is required to be updated every 5 years and requires CARB and other state agencies to adopt regulations and initiatives that will reduce GHG emissions statewide. The first Scoping Plan was adopted in 2008, and was updated in 2014, 2017, and most recently in 2022. While the Scoping Plan is not directly applicable to specific projects, nor is it intended to be used for project-level evaluations, it is the official framework for the measures and regulations that will be implemented to reduce California's GHG emissions in alignment with the adopted targets. Therefore, a project would be found to not conflict with the statutes if it would meet the Scoping Plan policies and would not impede attainment of the goals therein.

CARB's 2017 Scoping Plan update was the first to address the state's strategy for achieving the 2030 GHG reduction target set forth in SB 32 (CARB 2017b), and the most recent CARB 2022 Scoping Plan update outlines the state's plan to reduce emissions and achieve carbon neutrality by 2045 in alignment with AB 1279 and assesses progress is making toward the 2030 SB 32 target (CARB 2022). As such, given that SB 32 and AB 1279 are the relevant GHG emission targets, the 2017 and 2022 Scoping Plan updates that outline the strategy to achieve those targets, are the most applicable to the proposed project.

The 2017 *Climate Change Scoping Plan Update* (Second Update) included measures to promote renewable energy and energy efficiency (including the mandates of SB 350), increase stringency of the Low Carbon Fuel Standard (LCFS), measures identified in the Mobile Source and Freight Strategies, measures identified in the proposed Short-Lived Climate Pollutant Plan, and increase stringency of SB 375 targets. The *2022 Scoping Plan for Achieving Carbon Neutrality* (Third Update) builds upon and accelerates programs currently in place, including moving to zero-emission transportation; phasing out use of fossil gas use for heating homes and buildings; reducing chemical and refrigerants with high GWP; providing communities with sustainable options for walking, biking, and public transit; and displacement of fossil-fuel fired electrical generation through use of renewable energy alternatives (e.g., solar arrays and wind turbines) (CARB 2022).

Many of the measures and programs included in the Scoping Plan would result in the reduction of project-related GHG emissions with no action required at the project-level, including GHG emission reductions through increased energy efficiency and renewable energy production (SB 350), reduction in carbon intensity of transportation fuels (LCFS), and the accelerated efficiency and electrification of the statewide vehicle fleet (Mobile Source Strategy). Given that Alternative 2 and alternatives are also not anticipated to result in substantial increase in mobile trips, they would also not conflict with the Second Update's goal of reducing GHG emissions through reductions in VMT statewide.

The 2045 carbon neutrality goal required CARB to expand Alternative 2s in the Third Update to include those that capture and store carbon in addition to those that reduce only anthropogenic sources of GHG emissions. The Third Update emphasizes that reliance on carbon sequestration in the state's natural and working lands will not be sufficient to address residual GHG emissions, and achieving carbon neutrality will require research, development, and deployment of additional methods to capture atmospheric GHG emissions (e.g., mechanical direct air capture). Given that the specific path to neutrality will require development of technologies and programs that are not currently known or available, the project's role in supporting the statewide goal would be speculative and cannot be wholly identified at this time.

Overall, Alternative 2 and alternatives would comply with all regulations adopted in furtherance of the Scoping Plan to the extent applicable and required by law. As mentioned above, several Scoping Plan measures would result in reductions of project-related GHG emissions with no action required at the project-level, including those related to energy efficiency, reduced fossil fuel use, and renewable energy production. As demonstrated above, the proposed project would not conflict with CARB's 2017 or 2022 Scoping Plan updates and with the state's ability to achieve the 2030 and 2045 GHG reduction and carbon neutrality goals. Further, the proposed project's consistency with the applicable measures and programs would assist in meeting the GHG reduction targets in California.

No Action Alternative

Under the No Action Alternative, the project would not be built. No increase in GHG would occur. Therefore, there would be no GHG emissions resulting from the No Action Alternative compared to Alternative 2. There would be no impact on climate and meteorology.

4 References Cited

AFCEC. (Air Force Civil Engineer Center). 2013. Air Conformity Applicability Model. Solutionenv.com.

CalRecycle (California Department of Resources Recycling and Recovery). 2019. *Short-Lived Climate Pollutants (SLCP): Organic Waste Methane Emissions Reductions*. Last Updated April 16, 2019. Accessed January 2022. https://www.calrecycle.ca.gov/Climate/SLCP/

CAPCOA (California Air Pollution Control Officers Association). 2022. *California Emissions Estimator Model (CalEEMod) User's Guide Version 2022.* Prepared by Trinity Consultants and the California Air Districts. http://www.caleemod.com/.

CARB (California Air Resources Board). 2000. *Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles*. October 2000. Accessed May 2019. http://www.arb.ca.gov/diesel/documents/rrpfinal.pdf.

CARB. 2008. *Climate Change Scoping Plan: A Framework for Change*. October, approved December 12, 2008. Accessed June 20, 2018. http://climatechange.ca.gov/eaac/documents/state_reports/Adopted_ Scoping_Plan.pdf.

CARB. 2014. *First Update to the Climate Change Scoping Plan Building on the Framework Pursuant to AB 32 – The California Global Warming Solutions Act of 2006*. May 2014. Accessed February 17, 2016. http://www.arb.ca.gov/cc/scopingplan/2013_update/first_update_climate_change_scoping_plan.pdf.

CARB. 2017a. Inhalable Particulate Matter and Health ($PM_{2.5}$ and PM_{10}). Page last reviewed August 10, 2017. Accessed May 2019. https://www.arb.ca.gov/research/aaqs/common-pollutants/pm/pm.htm.

CARB. 2017b. *2017 Climate Change Scoping Plan Update*. November 2017. Accessed December 2017. https://www.arb.ca.gov/cc/scopingplan/scoping_plan_2017.pdf.

CARB. 2019a. "Glossary." Accessed April 2022. https://ww2.arb.ca.gov/about/glossary.

CARB. 2019b. "Ozone & Health." Accessed April 2022. https://ww2.arb.ca.gov/resources/ozone-and-health.

CARB. 2019c. "Nitrogen Dioxide & Health." Accessed April 2022. https://ww2.arb.ca.gov/resources/nitrogen-dioxide-and-health.

CARB. 2019d. "Carbon Monoxide & Health." Accessed April 2022. https://ww2.arb.ca.gov/resources/carbon-monoxide-and-health.

CARB. 2019e. "Sulfur Dioxide & Health." Accessed April 2022. https://ww2.arb.ca.gov/resources/sulfur-dioxide-and-health.

CARB. 2019f. "Overview: Diesel Exhaust and Health." Accessed April 2022. https://www.arb.ca.gov/research/diesel/diesel-health.htm.

CARB. 2021a. Vinyl Chloride & Health. Accessed April 2021. https://ww2.arb.ca.gov/resources/vinyl-chloride-and-health.

CARB. 2021b. Current California GHG Emission Inventory Data: 2000-2019 GHG Inventory (2021 Edition). Accessed July 2021 at https://ww2.arb.ca.gov/ghg-inventory-data?utm_medium=email&utm_source=govdelivery.

CARB. 2021c. Advanced Clean Cars Program. Accessed December 2021 at https://ww2.arb.ca.gov/our-work/programs/advanced-clean-cars-program/about.

CARB. 2021d. Advanced Clean Trucks Fact Sheet. August 20, 2021. Accessed at https://ww2.arb.ca.gov/sites/default/files/2021-08/200625factsheet_ADA.pdf

CARB. 2022a. "Ambient air quality data." [digital CARB data]. iADAM: Air Quality Data Statistics. http://www.arb.ca.gov/adam/topfour/topfour1.php.

CARB. 2022b. 2022 Scoping Plan for Achieving Carbon Neutrality. November 16. https://ww2.arb.ca.gov/sites/default/files/2022-12/2022-sp.pdf.

CARB. 2022c. California Air Resources Board 2022 Scoping Plan—Appendix D, Local Actions. November 2022. Accessed May 15, 2023. https://ww2.arb.ca.gov/sites/default/files/2022-11/2022-sp-appendix-d-local-actions.pdf.

CARB. 2023. Summaries of Historical Area Designations for State Standards. https://ww2.arb.ca.gov/our-work/programs/state-and-federal-area-designations/state-area-designations/summary-tables.

CEC (California Energy Commission). 2018a. 2019 Building Energy Efficiency Standards Fact Sheet. March 2018. https://www.energy.ca.gov/title24/2019standards/documents/2018_Title_24_2019_Building_Standards_FAQ.pdf

CEC. 2018b. Impact Analysis for the 2019 Update to the California Energy Efficiency Standards for Residential and Non-Residential Buildings. June.

CEC. 2021. Draft Environmental Impact Report Amendments to the Building Energy Efficiency Standards. May 19. Accessed July 2022. https://efiling.energy.ca.gov/GetDocument.aspx?tn=237853&DocumentContentId=71096.

Council on Environmental Quality (CEQ). 2023. Guidance: National Environmental Policy Act Guidance on Consideration of Greenhouse Gas Emissions and Climate Change. January. https://www.regulations.gov/document/CEQ-2022-0005-0001

CNRA (California Natural Resources Agency). 2009. *Final Statement of Reasons for Regulatory Action: Amendments to the State CEQA Guidelines Addressing Analysis and Mitigation of Greenhouse Gas Emissions Pursuant to SB 97*. December 2009. Accessed March 10, 2017. http://resources.ca.gov/ceqa/docs/Final_Statement_of_Reasons.pdf.

Department of Air Force. 2023. Falcon 9 Cadence Increase at Vandenberg Space Force Base, California. 31 March. https://files.ceqanet.opr.ca.gov/286761-1/attachment/b65kIGAAnH5v0R0m9xim5ACNy4OW3UJBvzdugC_vULNIpHPIjaMsC7nzfrnw2oKE3tX42zCgoZJsItQp0.

Electrek. 2022. California Runs on 100% Clean Energy for the First Time, with Solar Dominating. May 2. https://electrek.co/2022/05/02/california-runs-on-100-clean-energy-for-the-first-time-with-solar-dominating/#:~:text=May%202-,California%20runs%20on%20100%25%20clean%20energy%20for,first%20time%2C%20with%20solar%20dominating&text=For%20the%20first%20time%20ever,driven%20largely%20by%20solar%20power.

EPA (United States Environmental Protection Agency). 2013. *Integrated Science Assessment for Ozone and Related Photochemical Oxidants*. EPA/600/R-10/076F. February 2013. Accessed May 2019. https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=247492.

EPA. 2016. 40 CFR § 93.153(b)(1) and (b)(2). August 24. https://www.ecfr.gov/current/title-40/chapter-I/subchapter-C/part-93#93.153.

EPA. 2021. *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990–2019*. EPA 430-R-21-005. April 2021. Accessed July 2021 at https://www.epa.gov/sites/default/files/2021-04/documents/us-ghg-inventory-2021-main-text.pdf.

EPA. 2022. "AirData: Access to Air Pollution Data." https://www.epa.gov/outdoor-air-quality-data/monitor-values-report.

EPA. 2023. Current Nonattainment Counties for All Criteria Pollutants. Updated February 28, 2021. Accessed March 2021. https://www3.epa.gov/airquality/greenbook/ancl.html.

HQ AFCEC/CZTQ (Air Force Civil Engineer Center, Compliance Technical Support Branch). 2023a. Level II, Air Quality Quantitative Assessment, Insignificance Indicators. April. https://www.aqhelp.com/Documents/FINAL%20-%20Level%20II%20Air%20Quality%20Quantitative%20Assessment%20Insignificance%20Indicators%20-%20April%202023%20v2.pdf.

HQ AFCEC/CZTQ. 2023b. DAF Greenhouse Gas (GHG) & Climate Change Assessment Guide. December. https://www.aqhelp.com/Documents/FINAL-%20GHG-CLIMATE%20CHANGE%20ASSESSMENT%20GUIDANCE%20Dec%202023.pdf.

IPCC. 2014. "Summary for Policymakers." In *Climate Change 2014 Synthesis Report.* A Report of the Intergovernmental Panel on Climate Change. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Accessed March 10, 2017. http://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf.

NRC (National Research Council). 2005. *Interim Report of the Committee on Changes in New Source Review Programs for Stationary Sources of Air Pollutants*. Washington, DC: The National Academies Press. https://doi.org/10.17226/11208.

NASA (National Aeronautics and Space Administration). 2011. 2011 *Environmental Assessment for Launch of NASA Routine Payloads. https://repository.library.noaa.gov/view/noaa/12540*

NOAA (National Oceanic and Atmospheric Administration). 2017. Maritime Zones and Boundaries. https://www.noaa.gov/maritime-zones-and-boundaries.

Propper et al. 2015. Environmental Science & Technology49(19):11329–11339.

SCAQMD (South Coast Air Quality Management District). 1993. CEQA Air Quality Handbook.

SCAQMD. 2017. 2016 Air Quality Management Plan. March. https://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2016-air-quality-management-plan/final-2016-aqmp/final2016aqmp.pdf?sfvrsn=15.

U.S. Global Change Research Program (USGCRP). 2018. Fourth National Climate Assessment, Volume II Impacts, Risks, and Adaptation in the United States. November. https://nca2018.globalchange.gov/downloads/NCA4_2018_FullReport.pdf.

WRCC (Western Regional Climate Center). 2016. *Santa Barbara Muni Ap, California (047905)*. Accessed August 2018. https://wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca7905.

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Appendix A
Modeling Files

Table of Contents

DETAIL AIR CONFORMITY APPLICABILITY MODEL REPORT

1. General Information

- Action Location
Base: VANDENBERG AFB
State: California
County(s): Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Action Title: Falcon Program at Vandenberg Space Force Base - Baseline

- Project Number/s (if applicable):

- Projected Action Start Date: 1 / 2023

- Action Purpose and Need:
Space Exploration Technologies Corporation (SpaceX) has applied to the United States Space Force (USSF) to increase Falcon flight opportunities at Vandenberg Space Force Base (VSFB) in support of manifested and anticipated vehicle operations for Falcon 9. SpaceX currently launches commercial and government payloads from VSFB at SLC-4 and has been allocated SLC-6 by the USSF. SpaceX supports, and is under contract for, the full spectrum of U.S. Government space mission requirements, including crew and cargo transportation for the National Aeronautics and Space Administration (NASA) and spacecraft launches for NASA and the U.S. Department of Defense (DOD).

- Action Description:
The baseline includes 36 Falcon 9 launches from VSFB per year. This includes both land and sea landings of the Falcon 9, fair recovery, booster roll-on roll-off, and SLC-4 operations.

- Point of Contact
Name: Adam Poll
Title: Civilian/Senior Air Quality Specialist
Organization: Dudek
Email: apoll@dudek.com
Phone Number: 8053088516

- Activity List:

Activity Type		Activity Title
2.	Degreaser	Solvent use
3.	Emergency Generator	ES DICE1-3
4.	Emergency Generator	ES DICE4
5.	Emergency Generator	ES DICE 5
6.	Emergency Generator	Prime Engine
7.	Personnel	Worker Vehicles
8.	Personnel	Fleet Vehicle Use
9.	Personnel	Vendor-Contractor Vehicles
10.	Construction / Demolition	Operational Equipment Use

Emission factors and air emission estimating methods come from the United States Air Force's Air Emissions Guide for Air Force Stationary Sources, Air Emissions Guide for Air Force Mobile Sources, and Air Emissions Guide for Air Force Transitory Sources.

2. Degreaser

2.1 General Information & Timeline Assumptions

DETAIL AIR CONFORMITY APPLICABILITY MODEL REPORT

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: Solvent use

- Activity Description:
solvent use

- Activity Start Date
Start Month: 1
Start Year: 2023

- Activity End Date
Indefinite: Yes
End Month: N/A
End Year: N/A

- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	5.926830
SO_x	0.000000
NO_x	0.000000
CO	0.000000

Pollutant	Emissions Per Year (TONs)
PM 10	0.000000
PM 2.5	0.000000
Pb	0.000000
NH_3	0.000000

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)
CH_4	0.000000
N_2O	0.000000

Pollutant	Emissions Per Year (TONs)
CO_2	0.000000
CO_2e	0.000000

2.2 Degreaser Assumptions

- Degreaser
Net solvent usage (total less recycle) (gallons/year): 1820

- Default Settings Used: Yes

- Degreaser Consumption
Solvent used: Mineral Spirits CAS#64475-85-0 (default)
Specific gravity of solvent: 0.78 (default)
Solvent VOC content (%): 100 (default)
Efficiency of control device (%): 0 (default)

2.3 Degreaser Formula(s)

- Degreaser Emissions per Year
DE_{VOC}= (VOC / 100) * NS * SG * 8.35 * (1 - (CD / 100)) / 2000

DE_{VOC}: Degreaser VOC Emissions (TONs per Year)
VOC: Solvent VOC content (%)
(VOC / 100): Conversion Factor percent to decimal
NS: Net solvent usage (total less recycle) (gallons/year)

SG: Specific gravity of solvent
8.35: Conversion Factor the density of water
CD: Efficiency of control device (%)
(1 - (CD / 100)): Conversion Factor percent to decimal (Not effected by control device)
2000: Conversion Factor pounds to tons

3. Emergency Generator

3.1 General Information & Timeline Assumptions

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: ES DICE1-3

- Activity Description:
DICE1-3

- Activity Start Date
Start Month: 1
Start Year: 2023

- Activity End Date
Indefinite: Yes
End Month: N/A
End Year: N/A

- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	0.020916
SO_x	0.000365
NO_x	0.756604
CO	0.200982

Pollutant	Emissions Per Year (TONs)
PM 10	0.023633
PM 2.5	0.023633
Pb	0.000000
NH_3	0.000000

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)
CH_4	0.001352
N_2O	0.000270

Pollutant	Emissions Per Year (TONs)
CO_2	33.594375
CO_2e	38.852625

3.2 Emergency Generator Assumptions

- Emergency Generator
Type of Fuel used in Emergency Generator: Diesel
Number of Emergency Generators: 3

- Default Settings Used: No

- Emergency Generators Consumption
Emergency Generator's Horsepower: 779
Average Operating Hours Per Year (hours): 25

DETAIL AIR CONFORMITY APPLICABILITY MODEL REPORT

3.3 Emergency Generator Emission Factor(s)

- Emergency Generators Criteria Pollutant Emission Factor (lb/hp-hr)

VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3
0.000716	0.0000125	0.0259	0.00688	0.000809	0.000809		

- Emergency Generators Greenhouse Gasses Pollutant Emission Factor (lb/hp-hr)

CH_4	N_2O	CO_2	CO_2e
0.000046297	0.000009259	1.15	1.33

3.4 Emergency Generator Formula(s)

- Emergency Generator Emissions per Year

AE_{POL}= (NGEN * HP * OT * EF_{POL}) / 2000

AE_{POL}: Activity Emissions (TONs per Year)
NGEN: Number of Emergency Generators
HP: Emergency Generator's Horsepower (hp)
OT: Average Operating Hours Per Year (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hp-hr)

4. Emergency Generator

4.1 General Information & Timeline Assumptions

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: ES DICE4

- Activity Description:
ES DICE4

- Activity Start Date
Start Month: 1
Start Year: 2023

- Activity End Date
Indefinite: Yes
End Month: N/A
End Year: N/A

- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	0.012799
SO_x	0.010781
NO_x	0.052756
CO	0.035232

Pollutant	Emissions Per Year (TONs)
PM 10	0.011515
PM 2.5	0.011515
Pb	0.000000
NH_3	0.000000

DETAIL AIR CONFORMITY APPLICABILITY MODEL REPORT

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)
CH_4	0.000212
N_2O	0.000042

Pollutant	Emissions Per Year (TONs)
CO_2	5.275625
CO_2e	6.101375

4.2 Emergency Generator Assumptions

- Emergency Generator
Type of Fuel used in Emergency Generator: Diesel
Number of Emergency Generators: 1

- Default Settings Used: No

- Emergency Generators Consumption
Emergency Generator's Horsepower: 367
Average Operating Hours Per Year (hours): 25

4.3 Emergency Generator Emission Factor(s)

- Emergency Generators Criteria Pollutant Emission Factor (lb/hp-hr)

VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3
0.00279	0.00235	0.0115	0.00768	0.00251	0.00251		

- Emergency Generators Greenhouse Gasses Pollutant Emission Factor (lb/hp-hr)

CH_4	N_2O	CO_2	CO_2e
0.000046297	0.000009259	1.15	1.33

4.4 Emergency Generator Formula(s)

- Emergency Generator Emissions per Year
AE_{POL}= (NGEN * HP * OT * EF_{POL}) / 2000

AE_{POL}: Activity Emissions (TONs per Year)
NGEN: Number of Emergency Generators
HP: Emergency Generator's Horsepower (hp)
OT: Average Operating Hours Per Year (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hp-hr)

5. Emergency Generator

5.1 General Information & Timeline Assumptions

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: ES DICE 5

- Activity Description:
ES DICE 5

DETAIL AIR CONFORMITY APPLICABILITY MODEL REPORT

- Activity Start Date
Start Month: 1
Start Year: 2023

- Activity End Date
Indefinite: Yes
End Month: N/A
End Year: N/A

- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	0.011160
SO_x	0.009400
NO_x	0.046000
CO	0.030720

Pollutant	Emissions Per Year (TONs)
PM 10	0.010040
PM 2.5	0.010040
Pb	0.000000
NH_3	0.000000

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)
CH_4	0.000185
N_2O	0.000037

Pollutant	Emissions Per Year (TONs)
CO_2	4.600000
CO_2e	5.320000

5.2 Emergency Generator Assumptions

- Emergency Generator
Type of Fuel used in Emergency Generator: Diesel
Number of Emergency Generators: 1

- Default Settings Used: No

- Emergency Generators Consumption
Emergency Generator's Horsepower: 320
Average Operating Hours Per Year (hours): 25

5.3 Emergency Generator Emission Factor(s)

- Emergency Generators Criteria Pollutant Emission Factor (lb/hp-hr)

VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3
0.00279	0.00235	0.0115	0.00768	0.00251	0.00251		

- Emergency Generators Greenhouse Gasses Pollutant Emission Factor (lb/hp-hr)

CH_4	N_2O	CO_2	CO_2e
0.000046297	0.000009259	1.15	1.33

5.4 Emergency Generator Formula(s)

- Emergency Generator Emissions per Year

AE_{POL}= (NGEN * HP * OT * EF_{POL}) / 2000

AE_{POL}: Activity Emissions (TONs per Year)
NGEN: Number of Emergency Generators
HP: Emergency Generator's Horsepower (hp)
OT: Average Operating Hours Per Year (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hp-hr)

DETAIL AIR CONFORMITY APPLICABILITY MODEL REPORT

6. Emergency Generator

6.1 General Information & Timeline Assumptions

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: Prime Engine

- Activity Description:
Prime Engine

- Activity Start Date
Start Month: 1
Start Year: 2023

- Activity End Date
Indefinite: Yes
End Month: N/A
End Year: N/A

- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	0.252305
SO_x	0.212515
NO_x	1.039968
CO	0.694518

Pollutant	Emissions Per Year (TONs)
PM 10	0.226984
PM 2.5	0.226984
Pb	0.000000
NH_3	0.000000

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)
CH_4	0.004187
N_2O	0.000837

Pollutant	Emissions Per Year (TONs)
CO_2	103.996800
CO_2e	120.274560

6.2 Emergency Generator Assumptions

- Emergency Generator
Type of Fuel used in Emergency Generator: Diesel
Number of Emergency Generators: 1

- Default Settings Used: No

- Emergency Generators Consumption
Emergency Generator's Horsepower: 314
Average Operating Hours Per Year (hours): 576

6.3 Emergency Generator Emission Factor(s)

- Emergency Generators Criteria Pollutant Emission Factor (lb/hp-hr)

VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3
0.00279	0.00235	0.0115	0.00768	0.00251	0.00251		

- Emergency Generators Greenhouse Gasses Pollutant Emission Factor (lb/hp-hr)

CH_4	N_2O	CO_2	CO_2e
0.000046297	0.000009259	1.15	1.33

6.4 Emergency Generator Formula(s)

- Emergency Generator Emissions per Year

AE_{POL}= (NGEN * HP * OT * EF_{POL}) / 2000

AE_{POL}: Activity Emissions (TONs per Year)
NGEN: Number of Emergency Generators
HP: Emergency Generator's Horsepower (hp)
OT: Average Operating Hours Per Year (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hp-hr)

7. Personnel

7.1 General Information & Timeline Assumptions

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: Worker Vehicles

- Activity Description:
Worker Vehicles

- Activity Start Date
Start Month: 1
Start Year: 2023

- Activity End Date
Indefinite: Yes
End Month: N/A
End Year: N/A

- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	0.269893
SO_x	0.002877
NO_x	0.148110
CO	1.748344

Pollutant	Emissions Per Year (TONs)
PM 10	0.015638
PM 2.5	0.005678
Pb	0.000000
NH_3	0.030252

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)
CH_4	0.019539
N_2O	0.012402

Pollutant	Emissions Per Year (TONs)
CO_2	291.190113
CO_2e	295.373763

7.2 Personnel Assumptions

DETAIL AIR CONFORMITY APPLICABILITY MODEL REPORT

- Number of Personnel

Active Duty Personnel:	0
Civilian Personnel:	0
Support Contractor Personnel:	155
Air National Guard (ANG) Personnel:	0
Reserve Personnel:	0

- Default Settings Used: Yes

- Average Personnel Round Trip Commute (mile): 20 (default)

- Personnel Work Schedule

Active Duty Personnel:	5 Days Per Week (default)
Civilian Personnel:	5 Days Per Week (default)
Support Contractor Personnel:	5 Days Per Week (default)
Air National Guard (ANG) Personnel:	4 Days Per Week (default)
Reserve Personnel:	4 Days Per Month (default)

7.3 Personnel On Road Vehicle Mixture

- On Road Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	37.55	60.32	0	0.03	0.2	0	1.9
GOVs	54.49	37.73	4.67	0	0	3.11	0

7.4 Personnel Emission Factor(s)

- On Road Vehicle Criteria Pollutant Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	NH_3
LDGV	0.16904	0.00283	0.09975	1.33620	0.01659	0.00589	0.03317
LDGT	0.22348	0.00353	0.18982	1.84661	0.01814	0.00661	0.03551
HDGV	0.27952	0.00543	0.30809	2.13074	0.02887	0.01031	0.03592
LDDV	0.02840	0.00215	0.26527	0.33316	0.03307	0.02166	0.00310
LDDT	0.01793	0.00291	0.08851	0.15977	0.02554	0.01387	0.00310
HDDV	0.11489	0.01085	2.41615	0.54050	0.11955	0.05993	0.17455
MC	5.54743	0.00207	0.76123	18.49768	0.01924	0.00825	0.00852

- On Road Vehicle Greenhouse Gasses Emission Factors (grams/mile)

	CH_4	N_2O	CO_2	CO_2e
LDGV	0.01403	0.01042	286.76828	290.22297
LDGT	0.01924	0.01494	357.01221	361.94499
HDGV	0.02515	0.02098	549.42311	556.30477
LDDV	0.00132	0.03569	226.51907	237.18712
LDDT	0.00083	0.04832	306.71107	321.13196
HDDV	0.00534	0.18045	1145.32741	1199.23397
MC	0.26904	0.04866	209.32706	230.55474

7.5 Personnel Formula(s)

- Personnel Vehicle Miles Travel for Work Days per Year

$VMT_P = NP * WD * AC$

VMT_P: Personnel Vehicle Miles Travel (miles/year)
NP: Number of Personnel

WD: Work Days per Year
AC: Average Commute (miles)

- Total Vehicle Miles Travel per Year
$VMT_{Total} = VMT_{AD} + VMT_{C} + VMT_{SC} + VMT_{ANG} + VMT_{AFRC}$

VMT_{Total}: Total Vehicle Miles Travel (miles)
VMT_{AD}: Active Duty Personnel Vehicle Miles Travel (miles)
VMT_{C}: Civilian Personnel Vehicle Miles Travel (miles)
VMT_{SC}: Support Contractor Personnel Vehicle Miles Travel (miles)
VMT_{ANG}: Air National Guard Personnel Vehicle Miles Travel (miles)
VMT_{AFRC}: Reserve Personnel Vehicle Miles Travel (miles)

- Vehicle Emissions per Year
$V_{POL} = (VMT_{Total} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{Total}: Total Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Personnel On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

8. Personnel

8.1 General Information & Timeline Assumptions

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: Fleet Vehicle Use

- Activity Description:
Fleet Vehicle Use

- Activity Start Date
Start Month: 1
Start Year: 2023

- Activity End Date
Indefinite: Yes
End Month: N/A
End Year: N/A

- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	0.053979
SO_x	0.000575
NO_x	0.029622
CO	0.349669

Pollutant	Emissions Per Year (TONs)
PM 10	0.003128
PM 2.5	0.001136
Pb	0.000000
NH_3	0.006050

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- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)
CH_4	0.003908
N_2O	0.002480

Pollutant	Emissions Per Year (TONs)
CO_2	58.238023
CO_2e	59.074753

8.2 Personnel Assumptions

- Number of Personnel

Active Duty Personnel: 0
Civilian Personnel: 0
Support Contractor Personnel: 31
Air National Guard (ANG) Personnel: 0
Reserve Personnel: 0

- Default Settings Used: Yes

- Average Personnel Round Trip Commute (mile): 20 (default)

- Personnel Work Schedule

Active Duty Personnel: 5 Days Per Week (default)
Civilian Personnel: 5 Days Per Week (default)
Support Contractor Personnel: 5 Days Per Week (default)
Air National Guard (ANG) Personnel: 4 Days Per Week (default)
Reserve Personnel: 4 Days Per Month (default)

8.3 Personnel On Road Vehicle Mixture

- On Road Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	37.55	60.32	0	0.03	0.2	0	1.9
GOVs	54.49	37.73	4.67	0	0	3.11	0

8.4 Personnel Emission Factor(s)

- On Road Vehicle Criteria Pollutant Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	NH_3
LDGV	0.16904	0.00283	0.09975	1.33620	0.01659	0.00589	0.03317
LDGT	0.22348	0.00353	0.18982	1.84661	0.01814	0.00661	0.03551
HDGV	0.27952	0.00543	0.30809	2.13074	0.02887	0.01031	0.03592
LDDV	0.02840	0.00215	0.26527	0.33316	0.03307	0.02166	0.00310
LDDT	0.01793	0.00291	0.08851	0.15977	0.02554	0.01387	0.00310
HDDV	0.11489	0.01085	2.41615	0.54050	0.11955	0.05993	0.17455
MC	5.54743	0.00207	0.76123	18.49768	0.01924	0.00825	0.00852

- On Road Vehicle Greenhouse Gasses Emission Factors (grams/mile)

	CH_4	N_2O	CO_2	CO_2e
LDGV	0.01403	0.01042	286.76828	290.22297
LDGT	0.01924	0.01494	357.01221	361.94499
HDGV	0.02515	0.02098	549.42311	556.30477
LDDV	0.00132	0.03569	226.51907	237.18712
LDDT	0.00083	0.04832	306.71107	321.13196
HDDV	0.00534	0.18045	1145.32741	1199.23397
MC	0.26904	0.04866	209.32706	230.55474

8.5 Personnel Formula(s)

- Personnel Vehicle Miles Travel for Work Days per Year
$VMT_P = NP * WD * AC$

VMT_P: Personnel Vehicle Miles Travel (miles/year)
NP: Number of Personnel
WD: Work Days per Year
AC: Average Commute (miles)

- Total Vehicle Miles Travel per Year
$VMT_{Total} = VMT_{AD} + VMT_C + VMT_{SC} + VMT_{ANG} + VMT_{AFRC}$

VMT_{Total}: Total Vehicle Miles Travel (miles)
VMT_{AD}: Active Duty Personnel Vehicle Miles Travel (miles)
VMT_C: Civilian Personnel Vehicle Miles Travel (miles)
VMT_{SC}: Support Contractor Personnel Vehicle Miles Travel (miles)
VMT_{ANG}: Air National Guard Personnel Vehicle Miles Travel (miles)
VMT_{AFRC}: Reserve Personnel Vehicle Miles Travel (miles)

- Vehicle Emissions per Year
$V_{POL} = (VMT_{Total} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{Total}: Total Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Personnel On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

9. Personnel

9.1 General Information & Timeline Assumptions

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: Vendor-Contractor Vehicles

- Activity Description:
Vendor-Contractor Vehicles

- Activity Start Date
Start Month: 1
Start Year: 2023

- Activity End Date
Indefinite: Yes
End Month: N/A
End Year: N/A

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- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	0.026119
SO_x	0.000278
NO_x	0.014333
CO	0.169195

Pollutant	Emissions Per Year (TONs)
PM 10	0.001513
PM 2.5	0.000549
Pb	0.000000
NH_3	0.002928

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)
CH_4	0.001891
N_2O	0.001200

Pollutant	Emissions Per Year (TONs)
CO_2	28.179688
CO_2e	28.584558

9.2 Personnel Assumptions

- Number of Personnel

Active Duty Personnel: 0
Civilian Personnel: 0
Support Contractor Personnel: 15
Air National Guard (ANG) Personnel: 0
Reserve Personnel: 0

- Default Settings Used: Yes

- Average Personnel Round Trip Commute (mile): 20 (default)

- Personnel Work Schedule

Active Duty Personnel: 5 Days Per Week (default)
Civilian Personnel: 5 Days Per Week (default)
Support Contractor Personnel: 5 Days Per Week (default)
Air National Guard (ANG) Personnel: 4 Days Per Week (default)
Reserve Personnel: 4 Days Per Month (default)

9.3 Personnel On Road Vehicle Mixture

- On Road Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	37.55	60.32	0	0.03	0.2	0	1.9
GOVs	54.49	37.73	4.67	0	0	3.11	0

9.4 Personnel Emission Factor(s)

- On Road Vehicle Criteria Pollutant Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	NH_3
LDGV	0.16904	0.00283	0.09975	1.33620	0.01659	0.00589	0.03317
LDGT	0.22348	0.00353	0.18982	1.84661	0.01814	0.00661	0.03551
HDGV	0.27952	0.00543	0.30809	2.13074	0.02887	0.01031	0.03592
LDDV	0.02840	0.00215	0.26527	0.33316	0.03307	0.02166	0.00310
LDDT	0.01793	0.00291	0.08851	0.15977	0.02554	0.01387	0.00310
HDDV	0.11489	0.01085	2.41615	0.54050	0.11955	0.05993	0.17455
MC	5.54743	0.00207	0.76123	18.49768	0.01924	0.00825	0.00852

- On Road Vehicle Greenhouse Gasses Emission Factors (grams/mile)

	CH_4	N_2O	CO_2	CO_2e
LDGV	0.01403	0.01042	286.76828	290.22297

LDGT	0.01924	0.01494	357.01221	361.94499
HDGV	0.02515	0.02098	549.42311	556.30477
LDDV	0.00132	0.03569	226.51907	237.18712
LDDT	0.00083	0.04832	306.71107	321.13196
HDDV	0.00534	0.18045	1145.32741	1199.23397
MC	0.26904	0.04866	209.32706	230.55474

9.5 Personnel Formula(s)

- Personnel Vehicle Miles Travel for Work Days per Year
$VMT_P = NP * WD * AC$

VMT_P: Personnel Vehicle Miles Travel (miles/year)
NP: Number of Personnel
WD: Work Days per Year
AC: Average Commute (miles)

- Total Vehicle Miles Travel per Year
$VMT_{Total} = VMT_{AD} + VMT_C + VMT_{SC} + VMT_{ANG} + VMT_{AFRC}$

VMT_{Total}: Total Vehicle Miles Travel (miles)
VMT_{AD}: Active Duty Personnel Vehicle Miles Travel (miles)
VMT_C: Civilian Personnel Vehicle Miles Travel (miles)
VMT_{SC}: Support Contractor Personnel Vehicle Miles Travel (miles)
VMT_{ANG}: Air National Guard Personnel Vehicle Miles Travel (miles)
VMT_{AFRC}: Reserve Personnel Vehicle Miles Travel (miles)

- Vehicle Emissions per Year
$V_{POL} = (VMT_{Total} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{Total}: Total Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Personnel On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

10. Construction / Demolition

10.1 General Information & Timeline Assumptions

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: Operational Equipment Use

- Activity Description:
Operational Equipment Use

- Activity Start Date
Start Month: 1
Start Month: 2023

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- Activity End Date
Indefinite: False
End Month: 0
End Month: 2053

- Activity Emissions:

Pollutant	Total Emissions (TONs)
VOC	1.153989
SO_x	0.030527
NO_x	10.831199
CO	12.802533

Pollutant	Total Emissions (TONs)
PM 10	0.375290
PM 2.5	0.345271
Pb	0.000000
NH_3	0.000000

- Activity Emissions of GHG:

Pollutant	Total Emissions (TONs)
CH_4	0.134105
N_2O	0.026833

Pollutant	Total Emissions (TONs)
CO_2	3305.934839
CO_2e	3317.279945

- Global Scale Activity Emissions for SCGHG:

Pollutant	Total Emissions (TONs)
CH_4	0.134105
N_2O	0.026833

Pollutant	Total Emissions (TONs)
CO_2	3305.934839
CO_2e	3317.279945

10.1 Site Grading Phase

10.1.1 Site Grading Phase Timeline Assumptions

- Phase Start Date
Start Month: 1
Start Quarter: 1
Start Year: 2023

- Phase Duration
Number of Month: 360
Number of Days: 0

10.1.2 Site Grading Phase Assumptions

- General Site Grading Information
Area of Site to be Graded (ft^2): 0
Amount of Material to be Hauled On-Site (yd^3): 0
Amount of Material to be Hauled Off-Site (yd^3): 0

- Site Grading Default Settings
Default Settings Used: No
Average Day(s) worked per week: 5

- Construction Exhaust

Equipment Name	Number Of Equipment	Hours Per Day
Aerial Lifts Composite	4	1
Forklifts Composite	5	1
Off-Highway Trucks Composite	3	1
Rough Terrain Forklifts Composite	4	1

- Vehicle Exhaust

Average Hauling Truck Capacity (yd^3): 20

Average Hauling Truck Round Trip Commute (mile): 0

- Vehicle Exhaust Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	0	0	0	0	0	100.00	0

- Worker Trips

Average Worker Round Trip Commute (mile): 0

- Worker Trips Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	50.00	50.00	0	0	0	0	0

10.1.3 Site Grading Phase Emission Factor(s)

- Construction Exhaust Criteria Pollutant Emission Factors (g/hp-hour)

Aerial Lifts Composite [HP: 46] [LF: 0.31]						
	VOC	SO_x	NO_x	CO	PM 10	PM 2.5
Emission Factors	0.16245	0.00542	2.89521	3.11979	0.02309	0.02124
Forklifts Composite [HP: 82] [LF: 0.2]						
	VOC	SO_x	NO_x	CO	PM 10	PM 2.5
Emission Factors	0.31648	0.00487	2.98060	3.63043	0.18246	0.16787
Off-Highway Trucks Composite [HP: 376] [LF: 0.38]						
	VOC	SO_x	NO_x	CO	PM 10	PM 2.5
Emission Factors	0.18613	0.00488	1.32512	1.21081	0.04772	0.04390
Rough Terrain Forklifts Composite [HP: 96] [LF: 0.4]						
	VOC	SO_x	NO_x	CO	PM 10	PM 2.5
Emission Factors	0.12495	0.00488	1.83570	3.21682	0.04497	0.04138

- Construction Exhaust Greenhouse Gasses Pollutant Emission Factors (g/hp-hour)

Aerial Lifts Composite [HP: 46] [LF: 0.31]				
	CH_4	N_2O	CO_2	CO_2e
Emission Factors	0.02381	0.00476	586.92167	588.93584
Forklifts Composite [HP: 82] [LF: 0.2]				
	CH_4	N_2O	CO_2	CO_2e
Emission Factors	0.02138	0.00428	527.09658	528.90544
Off-Highway Trucks Composite [HP: 376] [LF: 0.38]				
	CH_4	N_2O	CO_2	CO_2e
Emission Factors	0.02144	0.00429	528.56916	530.38307
Rough Terrain Forklifts Composite [HP: 96] [LF: 0.4]				
	CH_4	N_2O	CO_2	CO_2e
Emission Factors	0.02144	0.00429	528.43465	530.24810

- Vehicle Exhaust & Worker Trips Criteria Pollutant Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	NH_3
LDGV	0.16904	0.00283	0.09975	1.33620	0.01659	0.00589	0.03317
LDGT	0.22348	0.00353	0.18982	1.84661	0.01814	0.00661	0.03551
HDGV	0.27952	0.00543	0.30809	2.13074	0.02887	0.01031	0.03592
LDDV	0.02840	0.00215	0.26527	0.33316	0.03307	0.02166	0.00310
LDDT	0.01793	0.00291	0.08851	0.15977	0.02554	0.01387	0.00310
HDDV	0.11489	0.01085	2.41615	0.54050	0.11955	0.05993	0.17455

MC	5.54743	0.00207	0.76123	18.49768	0.01924	0.00825	0.00852

- Vehicle Exhaust & Worker Trips Greenhouse Gasses Emission Factors (grams/mile)

	CH_4	N_2O	CO_2	CO_2e
LDGV	0.01403	0.01042	286.76828	290.22297
LDGT	0.01924	0.01494	357.01221	361.94499
HDGV	0.02515	0.02098	549.42311	556.30477
LDDV	0.00132	0.03569	226.51907	237.18712
LDDT	0.00083	0.04832	306.71107	321.13196
HDDV	0.00534	0.18045	1145.32741	1199.23397
MC	0.26904	0.04866	209.32706	230.55474

10.1.4 Site Grading Phase Formula(s)

- Fugitive Dust Emissions per Phase

$PM10_{FD}$ = (20 * ACRE * WD) / 2000

$PM10_{FD}$: Fugitive Dust PM 10 Emissions (TONs)
20: Conversion Factor Acre Day to pounds (20 lb / 1 Acre Day)
ACRE: Total acres (acres)
WD: Number of Total Work Days (days)
2000: Conversion Factor pounds to tons

- Construction Exhaust Emissions per Phase

CEE_{POL} = (NE * WD * H * HP * LF * EF_{POL}* 0.002205) / 2000

CEE_{POL}: Construction Exhaust Emissions (TONs)
NE: Number of Equipment
WD: Number of Total Work Days (days)
H: Hours Worked per Day (hours)
HP: Equipment Horsepower
LF: Equipment Load Factor
EF_{POL}: Emission Factor for Pollutant (g/hp-hour)
0.002205: Conversion Factor grams to pounds
2000: Conversion Factor pounds to tons

- Vehicle Exhaust Emissions per Phase

VMT_{VE} = (HA_{OnSite} + $HA_{OffSite}$) * (1 / HC) * HT

VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
HA_{OnSite}: Amount of Material to be Hauled On-Site (yd^3)
$HA_{OffSite}$: Amount of Material to be Hauled Off-Site (yd^3)
HC: Average Hauling Truck Capacity (yd^3)
(1 / HC): Conversion Factor cubic yards to trips (1 trip / HC yd^3)
HT: Average Hauling Truck Round Trip Commute (mile/trip)

V_{POL} = (VMT_{VE} * 0.002205 * EF_{POL} * VM) / 2000

V_{POL}: Vehicle Emissions (TONs)
VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Vehicle Exhaust On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

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- Worker Trips Emissions per Phase

VMT_{WT} = WD * WT * 1.25 * NE

VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
WD: Number of Total Work Days (days)
WT: Average Worker Round Trip Commute (mile)
1.25: Conversion Factor Number of Construction Equipment to Number of Works
NE: Number of Construction Equipment

V_{POL} = (VMT_{WT} * 0.002205 * EF_{POL} * VM) / 2000

V_{POL}: Vehicle Emissions (TONs)
VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

AIR CONFORMITY APPLICABILITY MODEL REPORT
RECORD OF AIR ANALYSIS (ROAA)

1. General Information: The Air Force's Air Conformity Applicability Model (ACAM) was used to perform a net change in emissions analysis to assess the potential air quality impact/s associated with the action. The analysis was performed in accordance with the Air Force Manual 32-7002, *Environmental Compliance and Pollution Prevention*; the *Environmental Impact Analysis Process* (EIAP, 32 CFR 989); the *General Conformity Rule* (GCR, 40 CFR 93 Subpart B); and the *USAF Air Quality Environmental Impact Analysis Process (EIAP) Guide*. This report provides a summary of the ACAM analysis.

a. Action Location:
Base: VANDENBERG AFB
State: California
County(s): Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

b. Action Title: Falcon Program at Vandenberg Space Force Base - Baseline

c. Project Number/s (if applicable):

d. Projected Action Start Date: 1 / 2023

e. Action Description:

The baseline includes 36 Falcon 9 launches from VSFB per year. This includes both land and sea landings of the Falcon 9, fair recovery, booster roll-on roll-off, and SLC-4 operations.

f. Point of Contact:

Name: Adam Poll
Title: Civilian/Senior Air Quality Specialist
Organization: Dudek
Email: apoll@dudek.com
Phone Number: 8053088516

2. Air Impact Analysis: Based on the attainment status at the action location, the requirements of the GCR are:

_____ applicable
__X__ not applicable

Total reasonably foreseeable net direct and indirect emissions associated with the action were estimated through ACAM on a calendar-year basis for the start of the action through achieving "steady state" (hsba.e., no net gain/loss in emission stabilized and the action is fully implemented) emissions. The ACAM analysis uses the latest and most accurate emission estimation techniques available; all algorithms, emission factors, and methodologies used are described in detail in the *USAF Air Emissions Guide for Air Force Stationary Sources*, the *USAF Air Emissions Guide for Air Force Mobile Sources*, and the *USAF Air Emissions Guide for Air Force Transitory Sources*.

"Insignificance Indicators" were used in the analysis to provide an indication of the significance of the proposed Action's potential impacts to local air quality. The insignificance indicators are trivial (de minimis) rate thresholds that have been demonstrated to have little to no impact to air quality. These insignificance indicators are the 250 ton/yr Prevention of Significant Deterioration (PSD) major source threshold and 25 ton/yr for lead for actions occurring in areas that are "Attainment" (hsba.e., not exceeding any National Ambient Air Quality Standard (NAAQS)). These indicators do not define a significant impact; however, they do provide a threshold to identify actions that are insignificant. Any action with net emissions below the insignificance indicators for all criteria pollutants is considered so insignificant that the action will not cause or contribute to an exceedance on one or more

AIR CONFORMITY APPLICABILITY MODEL REPORT
RECORD OF AIR ANALYSIS (ROAA)

NAAQS. For further detail on insignificance indicators, refer to *Level II, Air Quality Quantitative Assessment, Insignificance Indicators*.

The action's net emissions for every year through achieving steady state were compared against the Insignificance Indicators and are summarized below.

Analysis Summary:

2023

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2024

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2025

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2026

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No

AIR CONFORMITY APPLICABILITY MODEL REPORT
RECORD OF AIR ANALYSIS (ROAA)

CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2027

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2028

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2029

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2030

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No

SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2031

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2032

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2033

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2034

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No

PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2035

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2036

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2037

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2038

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No

PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2039

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2040

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2041

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2042

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No

Pb	0.000	25	No
NH3	0.039	250	No

2043

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2044

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2045

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2046

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No

NH3	0.039	250	No

2047

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2048

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2049

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2050

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

AIR CONFORMITY APPLICABILITY MODEL REPORT
RECORD OF AIR ANALYSIS (ROAA)

2051

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2052

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.612	250	No
NOx	2.448	250	No
CO	3.655	250	No
SOx	0.238	250	No
PM 10	0.305	250	No
PM 2.5	0.291	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2053

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.574	250	No
NOx	2.087	250	No
CO	3.229	250	No
SOx	0.237	250	No
PM 10	0.292	250	No
PM 2.5	0.280	250	No
Pb	0.000	25	No
NH3	0.039	250	No

2054 - (Steady State)

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	6.574	250	No
NOx	2.087	250	No
CO	3.229	250	No
SOx	0.237	250	No
PM 10	0.292	250	No
PM 2.5	0.280	250	No
Pb	0.000	25	No
NH3	0.039	250	No

AIR CONFORMITY APPLICABILITY MODEL REPORT
RECORD OF AIR ANALYSIS (ROAA)

None of the estimated annual net emissions associated with this action are above the insignificance indicators; therefore, the action will not cause or contribute to an exceedance of one or more NAAQSs and will have an insignificant impact on air quality. No further air assessment is needed.

Adam Poll, Civilian/Senior Air Quality Specialist	Nov 01 2023
Name, Title	**Date**

AIR CONFORMITY APPLICABILITY MODEL REPORT
GREENHOUSE GAS (GHG) EMISSIONS

1. General Information: The Air Force's Air Conformity Applicability Model (ACAM) was used to perform an analysis to estimate GHG emissions and assess the theoretical Social Cost of Greenhouse Gases (SC GHG) associated with the action. The analysis was performed in accordance with the Air Force Manual 32-7002, Environmental Compliance and Pollution Prevention; the Environmental Impact Analysis Process (EIAP, 32 CFR 989); and the USAF Air Quality Environmental Impact Analysis Process (EIAP) Guide. This report provides a summary of GHG emissions and SC GHG analysis.

a. Action Location:
Base: VANDENBERG AFB
State: California
County(s): Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

b. Action Title: Falcon Program at Vandenberg Space Force Base - Baseline

c. Project Number/s (if applicable):

d. Projected Action Start Date: 1 / 2023

e. Action Description:

The baseline includes 36 Falcon 9 launches from VSFB per year. This includes both land and sea landings of the Falcon 9, fair recovery, booster roll-on roll-off, and SLC-4 operations.

f. Point of Contact:
Name: Adam Poll
Title: Civilian/Senior Air Quality Specialist
Organization: Dudek
Email: apoll@dudek.com
Phone Number: 8053088516

2. Analysis: Total combined direct and indirect GHG emissions associated with the action were estimated through ACAM on a calendar-year basis from the action start through the expected life cycle of the action. The life cycle for Air Force actions with "steady state" emissions (SS, net gain/loss in emission stabilized and the action is fully implemented) is assumed to be 10 years beyond the SS emissions year or 20 years beyond SS emissions year for aircraft operations related actions.

GHG Emissions Analysis Summary:

GHGs produced by fossil-fuel combustion are primarily carbon dioxide (CO2), methane (CH4), and nitrous oxide (NO2). These three GHGs represent more than 97 percent of all U.S. GHG emissions. Emissions of GHGs are typically quantified and regulated in units of CO2 equivalents (CO2e). The CO2e takes into account the global warming potential (GWP) of each GHG. The GWP is the measure of a particular GHG's ability to absorb solar radiation as well as its residence time within the atmosphere. The GWP allows comparison of global warming impacts between different gases; the higher the GWP, the more that gas contributes to climate change in comparison to CO2. All GHG emissions estimates were derived from various emission sources using the methods, algorithms, emission factors, and GWPs from the most current Air Emissions Guide for Air Force Stationary Sources, Air Emissions Guide for Air Force Mobile Sources, and/or Air Emissions Guide for Air Force Transitory Sources.

The Air Force has adopted the Prevention of Significant Deterioration (PSD) threshold for GHG of 75,000 ton per year (ton/yr) of CO2e (or 68,039 metric ton per year, mton/yr) as an indicator or "threshold of insignificance" for NEPA air quality impacts in all areas. This indicator does not define a significant impact; however, it provides a threshold to identify actions that are insignificant (de minimis, too trivial or minor to merit consideration). Actions with a net change in GHG (CO2e) emissions below the insignificance indicator (threshold) are considered too insignificant on a global scale to warrant any further analysis. Note that actions with a net change in GHG (CO2e) emissions above the insignificance indicator (threshold) are only considered potentially significant and require further assessment to determine if the action poses a significant impact. For further detail on insignificance indicators see Level II, Air Quality Quantitative Assessment, Insignificance Indicators (April 2023).

The following table summarizes the action-related GHG emissions on a calendar-year basis through the projected life cycle of the action.

Action-Related Annual GHG Emissions (mton/yr)						
YEAR	**CO2**	**CH4**	**N2O**	**CO2e**	**Threshold**	**Exceedance**
2023	576	0.03242644	0.01647825	603	68,039	No
2024	576	0.03242644	0.01647825	603	68,039	No
2025	576	0.03242644	0.01647825	603	68,039	No
2026	576	0.03242644	0.01647825	603	68,039	No
2027	576	0.03242644	0.01647825	603	68,039	No
2028	576	0.03242644	0.01647825	603	68,039	No
2029	576	0.03242644	0.01647825	603	68,039	No
2030	576	0.03242644	0.01647825	603	68,039	No
2031	576	0.03242644	0.01647825	603	68,039	No
2032	576	0.03242644	0.01647825	603	68,039	No
2033	576	0.03242644	0.01647825	603	68,039	No
2034	576	0.03242644	0.01647825	603	68,039	No
2035	576	0.03242644	0.01647825	603	68,039	No
2036	576	0.03242644	0.01647825	603	68,039	No
2037	576	0.03242644	0.01647825	603	68,039	No
2038	576	0.03242644	0.01647825	603	68,039	No
2039	576	0.03242644	0.01647825	603	68,039	No
2040	576	0.03242644	0.01647825	603	68,039	No
2041	576	0.03242644	0.01647825	603	68,039	No
2042	576	0.03242644	0.01647825	603	68,039	No
2043	576	0.03242644	0.01647825	603	68,039	No
2044	576	0.03242644	0.01647825	603	68,039	No
2045	576	0.03242644	0.01647825	603	68,039	No
2046	576	0.03242644	0.01647825	603	68,039	No
2047	576	0.03242644	0.01647825	603	68,039	No
2048	576	0.03242644	0.01647825	603	68,039	No
2049	576	0.03242644	0.01647825	603	68,039	No
2050	576	0.03242644	0.01647825	603	68,039	No
2051	576	0.03242644	0.01647825	603	68,039	No
2052	576	0.03242644	0.01647825	603	68,039	No
2053	476	0.02837117	0.01566684	502	68,039	No
2054 [SS Year]	476	0.02837117	0.01566684	502	68,039	No
2055	476	0.02837117	0.01566684	502	68,039	No
2056	476	0.02837117	0.01566684	502	68,039	No
2057	476	0.02837117	0.01566684	502	68,039	No
2058	476	0.02837117	0.01566684	502	68,039	No
2059	476	0.02837117	0.01566684	502	68,039	No
2060	476	0.02837117	0.01566684	502	68,039	No
2061	476	0.02837117	0.01566684	502	68,039	No
2062	476	0.02837117	0.01566684	502	68,039	No
2063	476	0.02837117	0.01566684	502	68,039	No
2064	476	0.02837117	0.01566684	502	68,039	No

AIR CONFORMITY APPLICABILITY MODEL REPORT
GREENHOUSE GAS (GHG) EMISSIONS

The following U.S. and State's GHG emissions estimates (next two tables) are based on a five-year average (2016 through 2020) of individual state-reported GHG emissions (Reference: State Climate Summaries 2022, NOAA National Centers for Environmental Information, National Oceanic and Atmospheric Administration. https://statesummaries.ncics.org/downloads/).

State's Annual GHG Emissions (mton/yr)				
YEAR	CO2	CH4	N2O	CO2e
2023	336,950,322	1,567,526	55,459	338,573,307
2024	336,950,322	1,567,526	55,459	338,573,307
2025	336,950,322	1,567,526	55,459	338,573,307
2026	336,950,322	1,567,526	55,459	338,573,307
2027	336,950,322	1,567,526	55,459	338,573,307
2028	336,950,322	1,567,526	55,459	338,573,307
2029	336,950,322	1,567,526	55,459	338,573,307
2030	336,950,322	1,567,526	55,459	338,573,307
2031	336,950,322	1,567,526	55,459	338,573,307
2032	336,950,322	1,567,526	55,459	338,573,307
2033	336,950,322	1,567,526	55,459	338,573,307
2034	336,950,322	1,567,526	55,459	338,573,307
2035	336,950,322	1,567,526	55,459	338,573,307
2036	336,950,322	1,567,526	55,459	338,573,307
2037	336,950,322	1,567,526	55,459	338,573,307
2038	336,950,322	1,567,526	55,459	338,573,307
2039	336,950,322	1,567,526	55,459	338,573,307
2040	336,950,322	1,567,526	55,459	338,573,307
2041	336,950,322	1,567,526	55,459	338,573,307
2042	336,950,322	1,567,526	55,459	338,573,307
2043	336,950,322	1,567,526	55,459	338,573,307
2044	336,950,322	1,567,526	55,459	338,573,307
2045	336,950,322	1,567,526	55,459	338,573,307
2046	336,950,322	1,567,526	55,459	338,573,307
2047	336,950,322	1,567,526	55,459	338,573,307
2048	336,950,322	1,567,526	55,459	338,573,307
2049	336,950,322	1,567,526	55,459	338,573,307
2050	336,950,322	1,567,526	55,459	338,573,307
2051	336,950,322	1,567,526	55,459	338,573,307
2052	336,950,322	1,567,526	55,459	338,573,307
2053	336,950,322	1,567,526	55,459	338,573,307
2054 [SS Year]	336,950,322	1,567,526	55,459	338,573,307
2055	336,950,322	1,567,526	55,459	338,573,307
2056	336,950,322	1,567,526	55,459	338,573,307
2057	336,950,322	1,567,526	55,459	338,573,307
2058	336,950,322	1,567,526	55,459	338,573,307
2059	336,950,322	1,567,526	55,459	338,573,307
2060	336,950,322	1,567,526	55,459	338,573,307
2061	336,950,322	1,567,526	55,459	338,573,307
2062	336,950,322	1,567,526	55,459	338,573,307
2063	336,950,322	1,567,526	55,459	338,573,307
2064	336,950,322	1,567,526	55,459	338,573,307

U.S. Annual GHG Emissions (mton/yr)				
YEAR	CO2	CH4	N2O	CO2e
2023	5,136,454,179	25,626,912	1,500,708	5,163,581,798

2024	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2025	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2026	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2027	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2028	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2029	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2030	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2031	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2032	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2033	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2034	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2035	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2036	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2037	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2038	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2039	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2040	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2041	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2042	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2043	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2044	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2045	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2046	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2047	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2048	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2049	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2050	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2051	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2052	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2053	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2054 [SS Year]	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2055	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2056	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2057	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2058	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2059	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2060	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2061	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2062	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2063	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2064	5,136,454,179	25,626,912	1,500,708	5,163,581,798

GHG Relative Significance Assessment:

A Relative Significance Assessment uses the rule of reason and the concept of proportionality along with the consideration of the affected area (yGba.e., global, national, and regional) and the degree (intensity) of the proposed action's effects. The Relative Significance Assessment provides real-world context and allows for a reasoned choice against alternatives through a relative comparison analysis. The analysis weighs each alternative's annual net change in GHG emissions proportionally against (or relative to) global, national, and regional emissions.

The action's surroundings, circumstances, environment, and background (context associated with an action) provide the setting for evaluating the GHG intensity (impact significance). From an air quality perspective, context of an action is the local area's ambient air quality relative to meeting the NAAQSs, expressed as attainment, nonattainment, or maintenance areas (this designation is considered the attainment status). GHGs are non-hazardous to health at normal ambient concentrations and, at a cumulative global scale, action-related GHG emissions can only potentially cause warming of the climatic system. Therefore, the action-related GHGs generally have an insignificant impact to local air quality.

However, the affected area (context) of GHG/climate change is global. Therefore, the intensity or degree of the proposed action's GHG/climate change effects are gauged through the quantity of GHG associated with the action as compared to a baseline of the state, U.S., and global GHG inventories. Each action (or alternative) has significance, based on their annual net change in GHG emissions, in relation to or proportionally to the global, national, and regional annual GHG emissions.

To provide real-world context to the GHG and climate change effects on a global scale, an action's net change in GHG emissions is compared relative to the state (where action will occur) and U.S. annual emissions. The following table provides a relative comparison of an action's net change in GHG emissions vs. state and U.S. projected GHG emissions for the same time period.

Total GHG Relative Significance (mton)					
		CO2	**CH4**	**N2O**	**CO2e**
2023-2064	State Total	14,151,913,505	65,836,095	2,329,292	14,220,078,892
2023-2064	U.S. Total	215,731,075,518	1,076,330,291	63,029,721	216,870,435,529
2023-2064	Action	23,005	1.313247	0.682349	24,102
Percent of State Totals		0.00016256%	0.00000199%	0.00002929%	0.00016949%
Percent of U.S. Totals		0.00001066%	0.00000012%	0.00000108%	0.00001111%

Climate Change Assessment (as SC GHG):

On a global scale, the potential climate change effects of an action are indirectly addressed and put into context through providing the theoretical SC GHG associated with an action. The SC GHG is an administrative and theoretical tool intended to provide additional context to a GHG's potential impacts through approximating the long-term monetary damage that may result from GHG emissions affect on climate change. It is important to note that the SC GHG is a monetary quantification, in 2020 U.S. dollars, of the theoretical economic damages that could result from emitting GHGs into the atmosphere.

The SC GHG estimates are derived using the methodology and discount factors in the "Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990," released by the Interagency Working Group on Social Cost of Greenhouse Gases (IWG SC GHGs) in February 2021.

The speciated IWG Annual SC GHG Emission associated with an action (or alternative) are first estimated as annual unit cost (cost per metric ton, $/mton). Results of the annual IWG Annual SC GHG Emission Assessments are tabulated in the IWG Annual SC GHG Cost per Metric Ton Table below:

IWG SC GHG Discount Factor: 2.5%

IWG Annual SC GHG Cost per Metric Ton ($/mton [In 2020 $])			
YEAR	**CO2**	**CH4**	**N2O**
2023	$80.00	$2,100.00	$29,000.00
2024	$82.00	$2,200.00	$29,000.00
2025	$83.00	$2,200.00	$30,000.00
2026	$84.00	$2,300.00	$30,000.00
2027	$86.00	$2,300.00	$31,000.00
2028	$87.00	$2,400.00	$32,000.00

2029	$88.00	$2,500.00	$32,000.00
2030	$89.00	$2,500.00	$33,000.00
2031	$91.00	$2,600.00	$33,000.00
2032	$92.00	$2,600.00	$34,000.00
2033	$94.00	$2,700.00	$35,000.00
2034	$95.00	$2,800.00	$35,000.00
2035	$96.00	$2,800.00	$36,000.00
2036	$98.00	$2,900.00	$36,000.00
2037	$99.00	$3,000.00	$37,000.00
2038	$100.00	$3,000.00	$38,000.00
2039	$102.00	$3,100.00	$38,000.00
2040	$103.00	$3,100.00	$39,000.00
2041	$104.00	$3,200.00	$39,000.00
2042	$106.00	$3,300.00	$40,000.00
2043	$107.00	$3,300.00	$41,000.00
2044	$108.00	$3,400.00	$41,000.00
2045	$110.00	$3,500.00	$42,000.00
2046	$111.00	$3,500.00	$43,000.00
2047	$112.00	$3,600.00	$43,000.00
2048	$114.00	$3,700.00	$44,000.00
2049	$115.00	$3,700.00	$45,000.00
2050	$116.00	$3,800.00	$45,000.00
2051	$118.00	$3,827.00	$45,817.00
2052	$119.00	$3,888.00	$46,423.00
2053	$120.00	$3,950.00	$47,028.00
2054 [SS Year]	$122.00	$4,011.00	$47,634.00
2055	$123.00	$4,072.00	$48,240.00
2056	$124.00	$4,134.00	$48,845.00
2057	$126.00	$4,195.00	$49,451.00
2058	$127.00	$4,257.00	$50,057.00
2059	$128.00	$4,318.00	$50,662.00
2060	$130.00	$4,379.00	$51,268.00
2061	$131.00	$4,441.00	$51,874.00
2062	$132.00	$4,502.00	$52,479.00
2063	$134.00	$4,563.00	$53,085.00
2064	$135.00	$4,625.00	$53,691.00

Action-related SC GHG were estimated by calendar-year for the projected action's lifecycle. Annual estimates were found by multiplying the annual emission for a given year by the corresponding IWG Annual SC GHG Emission value (see table above).

Action-Related Annual SC GHG ($K/yr [In 2020 $])				
YEAR	**CO2**	**CH4**	**N2O**	**GHG**
2023	$46.10	$0.07	$0.48	$46.65
2024	$47.26	$0.07	$0.48	$47.81
2025	$47.83	$0.07	$0.49	$48.40
2026	$48.41	$0.07	$0.49	$48.98
2027	$49.56	$0.07	$0.51	$50.15
2028	$50.14	$0.08	$0.53	$50.74
2029	$50.72	$0.08	$0.53	$51.32
2030	$51.29	$0.08	$0.54	$51.92
2031	$52.44	$0.08	$0.54	$53.07
2032	$53.02	$0.08	$0.56	$53.67
2033	$54.17	$0.09	$0.58	$54.84

2034	$54.75	$0.09	$0.58	$55.42
2035	$55.33	$0.09	$0.59	$56.01
2036	$56.48	$0.09	$0.59	$57.17
2037	$57.05	$0.10	$0.61	$57.76
2038	$57.63	$0.10	$0.63	$58.35
2039	$58.78	$0.10	$0.63	$59.51
2040	$59.36	$0.10	$0.64	$60.10
2041	$59.94	$0.10	$0.64	$60.68
2042	$61.09	$0.11	$0.66	$61.85
2043	$61.67	$0.11	$0.68	$62.45
2044	$62.24	$0.11	$0.68	$63.03
2045	$63.39	$0.11	$0.69	$64.20
2046	$63.97	$0.11	$0.71	$64.79
2047	$64.55	$0.12	$0.71	$65.37
2048	$65.70	$0.12	$0.73	$66.54
2049	$66.28	$0.12	$0.74	$67.14
2050	$66.85	$0.12	$0.74	$67.72
2051	$68.00	$0.12	$0.75	$68.88
2052	$68.58	$0.13	$0.76	$69.47
2053	$57.16	$0.11	$0.74	$58.01
2054 [SS Year]	$58.11	$0.11	$0.75	$58.97
2055	$58.59	$0.12	$0.76	$59.46
2056	$59.07	$0.12	$0.77	$59.95
2057	$60.02	$0.12	$0.77	$60.91
2058	$60.50	$0.12	$0.78	$61.40
2059	$60.97	$0.12	$0.79	$61.89
2060	$61.92	$0.12	$0.80	$62.85
2061	$62.40	$0.13	$0.81	$63.34
2062	$62.88	$0.13	$0.82	$63.83
2063	$63.83	$0.13	$0.83	$64.79
2064	$64.31	$0.13	$0.84	$65.28

The following two tables summarize the U.S. and State's Annual SC GHG by calendar-year. The U.S. and State's Annual SC GHG are in 2020 dollars and were estimated by each year for the projected action lifecycle. Annual SC GHG estimates were found by multiplying the U.S. and State's annual five-year average GHG emissions for a given year by the corresponding IWG Annual SC GHG Cost per Metric Ton value.

State's Annual SC GHG ($K/yr [In 2020 $])				
YEAR	**CO2**	**CH4**	**N2O**	**GHG**
2023	$26,956,025.72	$3,291,804.77	$1,608,320.85	$31,856,151.35
2024	$27,629,926.37	$3,448,557.38	$1,608,320.85	$32,686,804.60
2025	$27,966,876.69	$3,448,557.38	$1,663,780.19	$33,079,214.26
2026	$28,303,827.01	$3,605,309.99	$1,663,780.19	$33,572,917.19
2027	$28,977,727.65	$3,605,309.99	$1,719,239.53	$34,302,277.18
2028	$29,314,677.97	$3,762,062.60	$1,774,698.87	$34,851,439.44
2029	$29,651,628.30	$3,918,815.21	$1,774,698.87	$35,345,142.37
2030	$29,988,578.62	$3,918,815.21	$1,830,158.21	$35,737,552.04
2031	$30,662,479.26	$4,075,567.81	$1,830,158.21	$36,568,205.29
2032	$30,999,429.58	$4,075,567.81	$1,885,617.55	$36,960,614.95
2033	$31,673,330.22	$4,232,320.42	$1,941,076.89	$37,846,727.54
2034	$32,010,280.55	$4,389,073.03	$1,941,076.89	$38,340,430.47
2035	$32,347,230.87	$4,389,073.03	$1,996,536.23	$38,732,840.13
2036	$33,021,131.51	$4,545,825.64	$1,996,536.23	$39,563,493.38
2037	$33,358,081.83	$4,702,578.25	$2,051,995.57	$40,112,655.65

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GREENHOUSE GAS (GHG) EMISSIONS

2038	$33,695,032.15	$4,702,578.25	$2,107,454.91	$40,505,065.31
2039	$34,368,932.80	$4,859,330.86	$2,107,454.91	$41,335,718.56
2040	$34,705,883.12	$4,859,330.86	$2,162,914.25	$41,728,128.23
2041	$35,042,833.44	$5,016,083.46	$2,162,914.25	$42,221,831.16
2042	$35,716,734.08	$5,172,836.07	$2,218,373.59	$43,107,943.75
2043	$36,053,684.40	$5,172,836.07	$2,273,832.93	$43,500,353.41
2044	$36,390,634.73	$5,329,588.68	$2,273,832.93	$43,994,056.34
2045	$37,064,535.37	$5,486,341.29	$2,329,292.27	$44,880,168.93
2046	$37,401,485.69	$5,486,341.29	$2,384,751.61	$45,272,578.59
2047	$37,738,436.01	$5,643,093.90	$2,384,751.61	$45,766,281.52
2048	$38,412,336.66	$5,799,846.51	$2,440,210.95	$46,652,394.11
2049	$38,749,286.98	$5,799,846.51	$2,495,670.29	$47,044,803.77
2050	$39,086,237.30	$5,956,599.11	$2,495,670.29	$47,538,506.70
2051	$39,760,137.94	$5,998,922.32	$2,540,980.57	$48,300,040.83
2052	$40,097,088.26	$6,094,541.41	$2,574,588.93	$48,766,218.60
2053	$40,434,038.58	$6,191,728.03	$2,608,141.83	$49,233,908.44
2054 [SS Year]	$41,107,939.23	$6,287,347.12	$2,641,750.19	$50,037,036.54
2055	$41,444,889.55	$6,382,966.21	$2,675,358.55	$50,503,214.31
2056	$41,781,839.87	$6,480,152.83	$2,708,911.45	$50,970,904.15
2057	$42,455,740.51	$6,575,771.92	$2,742,519.81	$51,774,032.24
2058	$42,792,690.84	$6,672,958.53	$2,776,128.17	$52,241,777.54
2059	$43,129,641.16	$6,768,577.62	$2,809,681.07	$52,707,899.85
2060	$43,803,541.80	$6,864,196.72	$2,843,289.43	$53,511,027.95
2061	$44,140,492.12	$6,961,383.33	$2,876,897.79	$53,978,773.25
2062	$44,477,442.44	$7,057,002.42	$2,910,450.69	$54,444,895.56
2063	$45,151,343.09	$7,152,621.51	$2,944,059.05	$55,248,023.65
2064	$45,488,293.41	$7,249,808.13	$2,977,667.41	$55,715,768.95

U.S. Annual SC GHG ($K/yr [In 2020 $])				
YEAR	**CO2**	**CH4**	**N2O**	**GHG**
2023	$410,916,334.32	$53,816,514.53	$43,520,521.44	$508,253,370.29
2024	$421,189,242.68	$56,379,205.70	$43,520,521.44	$521,088,969.82
2025	$426,325,696.86	$56,379,205.70	$45,021,229.08	$527,726,131.63
2026	$431,462,151.04	$58,941,896.86	$45,021,229.08	$535,425,276.98
2027	$441,735,059.39	$58,941,896.86	$46,521,936.72	$547,198,892.97
2028	$446,871,513.57	$61,504,588.03	$48,022,644.35	$556,398,745.96
2029	$452,007,967.75	$64,067,279.20	$48,022,644.35	$564,097,891.30
2030	$457,144,421.93	$64,067,279.20	$49,523,351.99	$570,735,053.12
2031	$467,417,330.29	$66,629,970.37	$49,523,351.99	$583,570,652.65
2032	$472,553,784.47	$66,629,970.37	$51,024,059.62	$590,207,814.46
2033	$482,826,692.83	$69,192,661.54	$52,524,767.26	$604,544,121.62
2034	$487,963,147.01	$71,755,352.70	$52,524,767.26	$612,243,266.97
2035	$493,099,601.18	$71,755,352.70	$54,025,474.90	$618,880,428.78
2036	$503,372,509.54	$74,318,043.87	$54,025,474.90	$631,716,028.31
2037	$508,508,963.72	$76,880,735.04	$55,526,182.53	$640,915,881.29
2038	$513,645,417.90	$76,880,735.04	$57,026,890.17	$647,553,043.11
2039	$523,918,326.26	$79,443,426.21	$57,026,890.17	$660,388,642.63
2040	$529,054,780.44	$79,443,426.21	$58,527,597.80	$667,025,804.45
2041	$534,191,234.62	$82,006,117.38	$58,527,597.80	$674,724,949.80
2042	$544,464,142.97	$84,568,808.54	$60,028,305.44	$689,061,256.96
2043	$549,600,597.15	$84,568,808.54	$61,529,013.08	$695,698,418.77
2044	$554,737,051.33	$87,131,499.71	$61,529,013.08	$703,397,564.12
2045	$565,009,959.69	$89,694,190.88	$63,029,720.71	$717,733,871.28
2046	$570,146,413.87	$89,694,190.88	$64,530,428.35	$724,371,033.10

2047	$575,282,868.05	$92,256,882.05	$64,530,428.35	$732,070,178.44
2048	$585,555,776.41	$94,819,573.22	$66,031,135.98	$746,406,485.61
2049	$590,692,230.59	$94,819,573.22	$67,531,843.62	$753,043,647.42
2050	$595,828,684.76	$97,382,264.38	$67,531,843.62	$760,742,792.77
2051	$606,101,593.12	$98,074,191.00	$68,757,921.76	$772,933,705.88
2052	$611,238,047.30	$99,637,432.61	$69,667,350.59	$780,542,830.50
2053	$616,374,501.48	$101,226,301.14	$70,575,278.71	$788,176,081.32
2054 [SS Year]	$626,647,409.84	$102,789,542.75	$71,484,707.53	$800,921,660.12
2055	$631,783,864.02	$104,352,784.36	$72,394,136.36	$808,530,784.74
2056	$636,920,318.20	$105,941,652.89	$73,302,064.48	$816,164,035.56
2057	$647,193,226.55	$107,504,894.50	$74,211,493.31	$828,909,614.36
2058	$652,329,680.73	$109,093,763.02	$75,120,922.14	$836,544,365.89
2059	$657,466,134.91	$110,657,004.63	$76,028,850.26	$844,151,989.80
2060	$667,739,043.27	$112,220,246.25	$76,938,279.08	$856,897,568.60
2061	$672,875,497.45	$113,809,114.77	$77,847,707.91	$864,532,320.13
2062	$678,011,951.63	$115,372,356.38	$78,755,636.03	$872,139,944.04
2063	$688,284,859.99	$116,935,598.00	$79,665,064.86	$884,885,522.84
2064	$693,421,314.17	$118,524,466.52	$80,574,493.68	$892,520,274.37

Relative Comparison of SC GHG:

To provide additional real-world context to the potential climate change impact associate with an action, a Relative Comparison of SC GHG Assessment is also performed. While the SC GHG estimates capture an indirect approximation of global climate damages, the Relative Comparison of SC GHG Assessment provides a better perspective from a regional and global scale.

The Relative Comparison of SC GHG Assessment uses the rule of reason and the concept of proportionality along with the consideration of the affected area (yGba.e., global, national, and regional) and the SC GHG as the degree (intensity) of the proposed action's effects. The Relative Comparison Assessment provides real-world context and allows for a reasoned choice among alternatives through a relative contrast analysis which weighs each alternative's SC GHG proportionally against (or relative to) existing global, national, and regional SC GHG. The below table provides a relative comparison between an action's SC GHG vs. state and U.S. projected SC GHG for the same time period:

Total SC-GHG ($K [In 2020 $])					
		CO2	**CH4**	**N2O**	**GHG**
2023-2064	State Total	$1,523,352,403.67	$221,431,869.47	$95,753,544.95	$1,840,537,818.08
2023-2064	U.S. Total	$23,221,909,343.26	$3,620,108,797.74	$2,591,052,771.77	$29,433,070,912.77
2023-2064	Action	$2,452.34	$4.37	$27.96	$2,484.67
Percent of State Totals		0.00016098%	0.00000197%	0.00002920%	0.00013500%
Percent of U.S. Totals		0.00001056%	0.00000012%	0.00000108%	0.00000844%

From a global context, the action alternative's total SC GHG percentage of total global SC GHG for the same time period is: 0.00000113%.*

* Global value based on the U.S. emits 13.4% of all global GHG annual emissions (2018 Emissions Data, Center for Climate and Energy Solutions, accessed 7-6-2023, https://www.c2es.org/content/international-emissions).

Adam Poll, Civilian/Senior Air Quality Specialist Nov 01 2023

Name, Title **Date**

AIR CONFORMITY APPLICABILITY MODEL REPORT
GREENHOUSE GAS (GHG) EMISSIONS

Table 1: Permitted Emission Limits

Equipment	NO_x	ROC	CO	SO_x	PM	PM_{10}	$PM_{2.5}$
Falcon 9 RP-1							
lb/day		0.34					
TPY		0.01					
RSV Loading							
lb/day		69.12					
TPY		0.03					
Payload Fueling							
lb/day	14.84	0.15					
TPY	0.34	0.00					
Solvent Use							
lb/day		56.97					
TPY		7.42					
Total Emissions							
lb/day	**14.84**	**126.59**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
TPY	**0.34**	**7.46**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Falcon 9 Potential to Emit Calculations

Attachment: A-1
Permit Number: PTO 15069
Facility: SpaceX

RP-1 and System Input Data

Information	*Value*	*Units*	*Reference*
Specific Gravity at System Temp……………	0.840	--	Material Specifications
Vapor Pressure @ 20 °F………………………..	0.00088	psi	Material Specifications
Vapor Molecular Weight……………………….	148.00	lb/lb-mol	Material Specifications
Gas Constant……………………………………	10.73	scf-psi/°R-lb-mol	Ideal Gas Laws
System and RP-1 Temperature……..………	474.67	°R	Permit Application
RP-1 Emission Factor………………………	0.00003	lb/ft^3	Calculated Value

Maximum Process Event Summary

Event Name	*Value*	*Units*	*Reference*
Launches………………………………………….	36	events/year	Permit Application
Static Launch and Abort Events…………………	30	events/year	Permit Application
Event Vehicle RP-1 Throughput Volume……….	48,600	gals/event	Permit Application
Event Fill Line Throughput Volume…………….	1,543	gals/event	Permit Application
Daily Launch Volume…………………………….	50,143	gals/day	Calculated Value
Daily Static Launch and Abort Volume……….	50,143	gals/day	Calculated Value
Daily Launch Volume…………………………….	6,703	ft^3/day	Calculated Value
Daily Static Launch and Abort Volume……….	13,406	ft^3/day	Calculated Value
Annual Launch Volume………………………….	1,805,132	gals/year	Calculated Value
Annual Static Launch and Abort Volume……….	1,504,277	gals/year	Calculated Value
Annual Launch Volume………………………….	241,312	ft^3/yr	Calculated Value
Annual Static Launch and Abort Volume………	201,093	ft^3/yr	Calculated Value

ROC Potential to Emit

Process	lb/day	TPY
Launches	0.17	0.00
Static Launches/Abort	0.34	0.00
Total PTE	**0.34**	**0.01**

Notes:
1. One Falcon 9 launch or static launch/abort permitted per day. PTE reflects the worst case scenario.

Processed By: KMB

Date: 2/11/2020

RSV Loading Potential to Emit Calculations

Attachment: A-3
Permit Number: PTO 15069
Facility: SpaceX

RP-1 and System Input Data

Information	*Value*	*Units*	*Reference*
Specific Gravity at System Temp................	0.809	--	Material Specifications
Vapor Pressure @ 70 °F..............................	0.011	psi	Material Specifications
Vapor Molecular Weight..............................	148.00	lb/lb-mol	Material Specifications
Gas Constant...	10.73	scf-psi/°R-lb-mol	Ideal Gas Laws
System and RP-1 Temperature.................	529.67	°R	Permit Application
RP-1 Emission Factor..........................	0.00029	lb/ft^3	Calculated Value

RP-1 Fuel Consumption

Consumption Operations	*Value*	*Units*	*Reference*
Worst Case Daily RP-1 Consumption............	178,000	gals/day	Equal to Total RP-1 Tank Calcs
Worst Case Annual RP-1 Consumption.......	1,805,132	gals	Falcon 9 Annual Launch Volume
Falcon 9 RP-1 Consumption.........................	241,312	ft^3	Calculated Values

ROC Potential to Emit

lb/day	TPY
69.12	0.03

Processed By: KMB

Date: 2/11/2020

Payload Fueling Potential to Emit Calculations

Attachment: A-4
Permit Number: PTO 15069
Facility: SpaceX

Payload/Unloading Input Data

Information	*Value*	*Units*	*Reference*
Flow Rate (loading/unloading).............	5.00	scf/min	Permit Application
MMH Molecular Weight......................	60.10	lb/lb-mol	Permit Application
N_2O_4 Molecular Weight...................	92.01	lb/lb-mol	Permit Application
Molar Denisty...........................	0.00264	lb-mole/scf	Permit Application
Processing Time.........................	4	hours	Permit Application
Loading Annual Operations.................	36	events/year	Permit Application
Unloading Annual Operations.............	10	events/year	Permit Application
Loading Control Efficiency............	99.95	%	Permit Application
Unloading Control Efficiency..........	95.70	%	Permit Application
NO_x Fugitives Per Event..................	2.31	lb/event	Permit Application
ROC Fugitives Per Event..................	0.058	lb/event	Permit Application

Payload Loading Controlled Potential to Emit

Propellant	Pollutant	lb/day	TPY
N_2O_4	NO_x	12.53	0.23
MMH	ROC	0.10	0.00
N_2O_4	NO_x (Fugitives)	2.31	0.04
MMH	ROC (Fugitives)	0.06	0.00

Payload Unloading Controlled Potential to Emit

Propellant	Pollutant	lb/day	TPY
N_2O_4	NO_x	12.53	0.06
MMH	ROC	0.10	0.00
N_2O_4	NO_x (Fugitives)	2.31	0.01
MMH	ROC (Fugitives)	0.06	0.00

Total Potential to Emit

Propellant	Pollutant	lb/day	TPY
N_2O_4	NO_x	14.84	0.34
MMH	ROC	0.15	0.00

Notes:

1. One payload loading or unloading event permitted per day.
   PTE reflects the worst case scenario.

Processed By: KMB

Date: 2/11/2020

Project Emissions Roll-On Roll-Off - Baseline Los Angeles County

Source Category	VOC	NO_x	CO	SO_x	PM_{10}	$PM_{2.5}$	Pb	CO2	CH4	N2O	CO2e
	ton/yr							MT/yr			
Marine Vessel	0.28	3.77	3.63	0.05	0.08	0.08	0.00	469.39	0.02	0.01	471.83
Off-Road	0.03	0.64	0.84	0.00	0.02	0.02	0.00	142.66	0.04	0.02	149.29
Total	**0.32**	**4.41**	**4.47**	**0.05**	**0.10**	**0.10**	**0.00**	**612.06**	**0.06**	**0.03**	**621.12**

SpaceX Marine Transport Project Baseline Los Angeles County

Marine Emission Estimates - Elizabeth C Day 1 and 4

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (days/yr)
Tugboat	Transit	Propulsion	3	0.1%S	2	1,300	970	0.50	4.00	72
Tugboat	Transit	Auxiliary	3	0.1%S	2	99	74	0.31	4.00	72
Tugboat	Maneuvering	Propulsion	3	0.1%S	2	1,300	970	0.50	0.50	72
Tugboat	Maneuvering	Auxiliary	3	0.1%S	2	99	74	0.31	0.50	72

Boat Classification	Phase	Engine	Emission Factors (g/kW-hr)									
			VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
Tugboat	Transit	Propulsion	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03
Tugboat	Transit	Auxiliary	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03
Tugboat	Maneuvering	Propulsion	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03
Tugboat	Maneuvering	Auxiliary	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03

Boat Classification	Phase	Engine	Maximum Daily Emissions (lb/day)									
			VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
Tugboat	Transit	Propulsion	3.35	44.55	42.77	0.58	0.94	0.94	0.01	6,122.46	0.25	0.09
Tugboat	Transit	Auxiliary	0.15	2.03	2.02	0.03	0.05	0.05	0.00	265.41	0.01	0.00
Tugboat	Maneuvering	Propulsion	0.42	5.57	5.35	0.07	0.12	0.12	0.00	765.31	0.03	0.01
Tugboat	Maneuvering	Auxiliary	0.02	0.25	0.25	0.00	0.01	0.01	0.00	33.18	0.00	0.00
Emission Subtotals			**3.94**	**52.40**	**50.39**	**0.69**	**1.11**	**1.11**	**0.01**	**7,186.35**	**0.29**	**0.10**

Boat Classification	Phase	Engine	Annual Emissions (ton/yr)							Annual Emissions (MT/yr)			
			VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
Tugboat	Transit	Propulsion	0.12	1.60	1.54	0.02	0.03	0.03	0.00	199.95	0.01	0.00	200.99
Tugboat	Transit	Auxiliary	0.01	0.07	0.07	0.00	0.00	0.00	0.00	8.67	0.00	0.00	8.72
Tugboat	Maneuvering	Propulsion	0.02	0.20	0.19	0.00	0.00	0.00	0.00	24.99	0.00	0.00	25.12
Tugboat	Maneuvering	Auxiliary	0.00	0.01	0.01	0.00	0.00	0.00	0.00	1.08	0.00	0.00	1.09
Emission Subtotals			**0.14**	**1.89**	**1.81**	**0.02**	**0.04**	**0.04**	**0.00**	**234.70**	**0.01**	**0.00**	**235.92**

Note:
The project would operate from the Port of Long Beach within SCAQMD waters up to 30 nautical miles, assuming average transit speed of 7.5 knots.

Marine Emission Estimates - Elizabeth C Day 2 and 5

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (days/yr)
Tugboat	Transit	Propulsion	3	0.1%S	2	1,300	970	0.50	4.50	72
Tugboat	Transit	Auxiliary	3	0.1%S	2	99	74	0.31	4.50	72

Boat Classification	Phase	Engine	Emission Factors (g/kW-hr)									
			VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
Tugboat	Transit	Propulsion	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03
Tugboat	Transit	Auxiliary	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03

Boat Classification	Phase	Engine	Maximum Daily Emissions (lb/day)									
			VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
Tugboat	Transit	Propulsion	3.77	50.12	48.12	0.65	1.06	1.06	0.01	6,887.77	0.28	0.10
Tugboat	Transit	Auxiliary	0.17	2.29	2.28	0.03	0.05	0.05	0.00	298.58	0.01	0.00
Emission Subtotals			**3.94**	**52.40**	**50.39**	**0.69**	**1.11**	**1.11**	**0.01**	**7,186.35**	**0.29**	**0.10**

Boat Classification	Phase	Engine	Annual Emissions (ton/yr)							Annual Emissions (MT/yr)			
			VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
Tugboat	Transit	Propulsion	0.14	1.80	1.73	0.02	0.04	0.04	0.00	224.95	0.01	0.00	226.11
Tugboat	Transit	Auxiliary	0.01	0.08	0.08	0.00	0.00	0.00	0.00	9.75	0.00	0.00	9.81
Emission Subtotals			**0.14**	**1.89**	**1.81**	**0.02**	**0.04**	**0.04**	**0.00**	**234.70**	**0.01**	**0.00**	**235.92**

Note:
The project would operate within SCAQMD waters up to 33.75 nautical miles, assuming average transit speed of 7.5 knots.

Emission Factors

Marine Propulsion

Engine Type	Engine Family	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
					(g/kW-hr)									
Slow Speed Diesel		<=1999	Tier 0	0.1%S	0.600	17.01	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		<=1999	Tier 0	0.1%S	0.500	13.16	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2000-2010	Tier 1	0.1%S	0.600	15.98	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2000-2010	Tier 1	0.1%S	0.500	12.22	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2011-2015	Tier 2	0.1%S	0.600	14.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2011-2015	Tier 2	0.1%S	0.500	10.53	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2016+	Tier 3	0.1%S	0.600	3.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2016+	Tier 3	0.1%S	0.500	2.63	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
EPA Certification	HCEXN19.0AAA		Tier 3	0.1%S	0.392	5.21	5.0	0.07	0.11	0.11	0.0006067	716		

Notes:
Emission factors from Table 2.3 and 2.4 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
Load factors for propulsion engines based on Table 3.1 of the of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 1 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.

Marine Auxiliary

Engine Type	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
				(g/kW-hr)									
Aux High Speed Diesel	<=1999	Tier 0	0.1%S	0.600	10.9	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	<=1999	Tier 0	0.1%S	0.600	13.82	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	9.78	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	12.22	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	7.71	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	10.53	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	1.97	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	2.63	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux Med Speed Diesel Tier 3 Standard	2011-2015	Tier 3	0.1%S	0.378	5.022	5	0.068	0.12	0.12	0.0006067			

Notes:
Emission factors from Table 2.9 and 2.10 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
Load factors for propulsion engines based on Table 3.1 of the of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 5 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.

Marine exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\, EF_i \times Eng_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF	=	*Emission factor in grams per horse-power hour*
Eng	=	*Number of engines*
AvgHP	=	*Maximum rated average horsepower*
Load	=	*Load factor*
Activity	=	*Hours of operation*
i	=	*Equipment type*

SpaceX Marine Transport Project Baseline Los Angeles County

Off-Road Emission Estimates

Construction Equipment	OFFROAD Model Category	Engine Tier	Quantity	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (day/yr)	Emission Factors VOC (g/BHP-hr)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O	Daily Emissions VOC (lb/day)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	Annual Emissions CO2 (MT/yr)	CH4	N2O	CO2E
Crane-LR 1300	Crane	3	1	603	450	0.29	16	72	0.12	2.32	2.6	0.005	0.088	0.088	510.334	0.152	0.068138	0.74	14.31	16.04	0.03	0.54	0.54	3,147.87	0.94	0.42	102.81	0.03	0.01	107.66
Crane-Tadano ATF 220G	Crane	4	1	197	147	0.29	8	72	0.0600	0.2600	3.7000	0.0050	0.0080	0.0080	514.2600	0.1540	0.0690	0.06	0.26	3.73	0.01	0.01	0.01	518.16	0.16	0.07	16.92	0.01	0.00	17.73
KMAG	Off-Highway Truck	3	1	453	338	0.3	4.0	72	0.1200	2.3200	2.6000	0.0050	0.0088	0.0088	528.8080	0.1540	0.0690	0.14	2.78	3.12	0.01	0.01	0.01	634	0.18	0.08	20.71	0.01	0.00	21.66
Generator-Barge	Generator Sets	4	1	49	37	0.74	1.5	72	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081	0.01	0.33	0.49	0.00	0.00	0.00	68	0.00	0.00	2.23	0.00	0.00	2.24
Emission Subtotals																		**0.96**	**17.68**	**23.37**	**0.04**	**0.56**	**0.56**	**4,368.26**	**1.28**	**0.57**	**142.66**	**0.04**	**0.02**	**149.29**

Notes:
Emission factors are default emission factors from CalEEMod 2016.3.2, which relies on OFFROAD 2011.
Load factor for generator and cranes are defaults from CalEEMod 2016.3.2.
Load factor for KMAG based on average speed over route compared to rated maximum travel speed.
See Table D-12 of the Carl Moyer Program Guidelines. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/msprog/moyer/guidelines/2011/2011cmp_guidelinesVER4.pdf?_ga=2.218661721.1589730523.1723135078-1780396104.1706050686

Emission Factors

Equipment Type	Year	Low HP	High HP	VOC (g/BHP-hr)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
KMAG	Tier 3	300	599	0.1200	2.3200	2.6000	0.0050	0.0088	0.0088	528.8080	0.1540	0.0690
Generator Sets	Tier 4 Final	25	49	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081
Crane-LR 1300	Tier 3	600	750	0.1200	2.3200	2.6000	0.0050	0.0880	0.0880	510.3340	0.1520	0.0681
Crane-Tadano ATF 220G	Tier 4 Final	120	174	0.0600	0.2600	3.7000	0.0050	0.0080	0.0080	514.2600	0.1540	0.0690

Off-road mobile equipment exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\, EF_i \times Pop_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF	=	*Emission factor in grams per horse-power hour*
Pop	=	*Population, or the number of pieces of equipment*
AvgHP	=	*Maximum rated average horsepower*
Load	=	*Load factor*
Activity	=	*Hours of operation*
i	=	*Equipment type*

Baseline Emissions Roll-On Roll-Off Santa Barbara County

Source Category	VOC	NO_x	CO	SO_x	PM_{10}	$PM_{2.5}$	Pb	CO2	CH4	N2O	CO2e
	ton/yr							MT/yr			
Marine Vessel	0.76	10.09	9.72	0.13	0.22	0.22	0.00	1256.24	0.05	0.02	1262.79
Off-Road	0.02	0.43	0.61	0.00	0.02	0.01	0.00	91.95	0.02	0.01	94.46
Total	**0.78**	**10.52**	**10.32**	**0.13**	**0.23**	**0.22**	**0.00**	**1,348.19**	**0.07**	**0.02**	**1,357.25**

SpaceX Marine Transport Project Baseline Santa Barbara County

Marine Emission Estimates - Elizabeth C Day 2

											Emission Factors										Maximum Daily Emissions										Annual Emissions										
Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating	Engine Rating	Load Factor	Operation	Operation	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
						(hp)	(kW)		(hr/day)	(days/yr)	(g/kW-hr)										(lb/day)										(ton/year)							(MT/yr)			
Tugboat	Transit	Propulsion	3	0.1%S	2	1,300	969	0.50	9.50	36	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03	7.96	105.74	101.52	1.38	2.23	2.23	0.01	14,532.24	0.59	0.20	0.14	1.90	1.83	0.02	0.04	0.04	0.00	237.30	0.01	0.00	238.53
Tugboat	Transit	Auxiliary	3	0.1%S	2	99	74	0.31	9.50	36	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03	0.36	4.83	4.80	0.07	0.12	0.12	0.00	630.34	0.03	0.01	0.01	0.09	0.09	0.00	0.00	0.00	0.00	10.29	0.00	0.00	10.35
Emission Subtotals																					**8.32**	**110.56**	**106.32**	**1.45**	**2.35**	**2.35**	**0.01**	**15,162.58**	**0.62**	**0.21**	**0.15**	**1.99**	**1.91**	**0.03**	**0.04**	**0.04**	**0.00**	**247.60**	**0.01**	**0.00**	**248.88**

Note:
The project would operate within the SBCAPCD jurisdiction for 37.2 nautical miles.

Marine Emission Estimates - Elizabeth C Day 3

											Emission Factors										Maximum Daily Emissions										Annual Emissions										
Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating	Engine Rating	Load Factor	Operation	Operation	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
						(hp)	(kW)		(hr/day)	(days/yr)	(g/kW-hr)										(lb/day)										(ton/year)							(MT/yr)			
Tugboat	Transit	Propulsion	3	0.1%S	2	1,300	969	0.50	2.30	36	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03	1.93	25.60	24.58	0.33	0.54	0.54	0.00	3,518.33	0.14	0.05	0.03	0.46	0.44	0.01	0.01	0.01	0.00	57.45	0.00	0.00	57.75
Tugboat	Transit	Auxiliary	3	0.1%S	2	99	74	0.31	2.30	36	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03	0.09	1.17	1.16	0.02	0.03	0.03	0.00	152.61	0.01	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	2.49	0.00	0.00	2.51
Tugboat	Maneuvering	Propulsion	3	0.1%S	2	1,300	969	0.50	4.50	36	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03	3.77	50.09	48.09	0.65	1.06	1.06	0.01	6,883.69	0.28	0.10	0.07	0.90	0.87	0.01	0.02	0.02	0.00	112.41	0.00	0.00	112.99
Tugboat	Maneuvering	Auxiliary	3	0.1%S	2	99	74	0.31	4.50	36	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03	0.17	2.29	2.28	0.03	0.05	0.05	0.00	298.58	0.01	0.00	0.00	0.04	0.04	0.00	0.00	0.00	0.00	4.88	0.00	0.00	4.90
Tugboat	Contingency	Propulsion	3	0.1%S	2	1,300	969	0.50	0.33	36	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03	0.28	3.67	3.53	0.05	0.08	0.08	0.00	504.80	0.02	0.01	0.00	0.07	0.06	0.00	0.00	0.00	0.00	8.24	0.00	0.00	8.29
Tugboat	Contingency	Auxiliary	3	0.1%S	2	99	74	0.31	0.33	36	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03	0.01	0.17	0.17	0.00	0.00	0.00	0.00	21.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.00	0.00	0.36
Emission Subtotals																					**6.25**	**82.98**	**79.80**	**1.09**	**1.76**	**1.76**	**0.01**	**11,379.92**	**0.46**	**0.16**	**0.11**	**1.49**	**1.44**	**0.02**	**0.03**	**0.03**	**0.00**	**185.83**	**0.01**	**0.00**	**186.79**

Note:
The project would operate within the SBCAPCD jurisdiction for 34 nautical miles.

Marine Emission Estimates - Elizabeth C Day 4

											Emission Factors										Maximum Daily Emissions										Annual Emissions										
Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating	Engine Rating	Load Factor	Operation	Operation	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
						(hp)	(kW)		(hr/day)	(days/yr)	(g/kW-hr)										(lb/day)										(ton/year)							(MT/yr)			
Tugboat	Transit	Propulsion	3	0.1%S	2	1,300	969	0.50	9.50	36	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03	7.96	105.74	101.52	1.38	2.23	2.23	0.01	14,532.24	0.59	0.20	0.14	1.90	1.83	0.02	0.04	0.04	0.00	237.30	0.01	0.00	238.53
Tugboat	Transit	Auxiliary	3	0.1%S	2	99	74	0.31	9.50	36	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03	0.36	4.83	4.80	0.07	0.12	0.12	0.00	630.34	0.03	0.01	0.01	0.09	0.09	0.00	0.00	0.00	0.00	10.29	0.00	0.00	10.35
Emission Subtotals																					**8.32**	**110.56**	**106.32**	**1.45**	**2.35**	**2.35**	**0.01**	**15,162.58**	**0.62**	**0.21**	**0.15**	**1.99**	**1.91**	**0.03**	**0.04**	**0.04**	**0.00**	**247.60**	**0.01**	**0.00**	**248.88**

Note:
The project would operate within the SBCAPCD jurisdiction for 37.2 nautical miles.

Marine Emission Estimates - Bernardine C Day 1

											Emission Factors										Maximum Daily Emissions										Annual Emissions										
Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating	Engine Rating	Load Factor	Operation	Operation	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
						(hp)	(kW)		(hr/day)	(days/yr)	(g/kW-hr)										(lb/day)										(ton/year)							(MT/yr)			
Tugboat	Transit	Propulsion	3	0.1%S	2	500	373	0.50	24.00	36	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03	7.73	102.74	98.64	1.34	2.17	2.17	0.01	14,120.40	0.57	0.20	0.14	1.85	1.78	0.02	0.04	0.04	0.00	230.58	0.01	0.00	231.77
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	36	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03	0.46	6.10	6.07	0.08	0.15	0.15	0.00	796.22	0.04	0.01	0.01	0.11	0.11	0.00	0.00	0.00	0.00	13.00	0.00	0.00	13.08
Tugboat	Hoteling	Auxiliary	3	0.1%S	1	99	74	0.31	0.00	36	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03	-	-	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-
Emission Subtotals																					**8.19**	**108.84**	**104.71**	**1.42**	**2.32**	**2.32**	**0.01**	**14,916.62**	**0.61**	**0.21**	**0.15**	**1.96**	**1.88**	**0.03**	**0.04**	**0.04**	**0.00**	**243.58**	**0.01**	**0.00**	**244.85**

Note:
The project would operate within the SBCAPCD jurisdiction for 64 nautical miles from Port of Hueneme.

Marine Emission Estimates - Bernardine C Day 2 and 4

											Emission Factors										Maximum Daily Emissions										Annual Emissions										
Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating	Engine Rating	Load Factor	Operation	Operation	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
						(hp)	(kW)		(hr/day)	(days/yr)	(g/kW-hr)										(lb/day)										(ton/yr)							(MT/yr)			
Tugboat	Hoteling	Propulsion	3	0.1%S	2	500	373	0.50	0.00	72	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03	-	-	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	-	-	-	-	-
Tugboat	Hoteling	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	72	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03	0.46	6.10	6.07	0.08	0.15	0.15	0.00	796.22	0.04	0.01	0.02	0.22	0.22	0.00	0.01	0.01	0.00	28.66	0.00	0.00	28.83
Emission Subtotals																					**0.46**	**6.10**	**6.07**	**0.08**	**0.15**	**0.15**	**0.00**	**796.22**	**0.04**	**0.01**	**0.02**	**0.22**	**0.22**	**0.00**	**0.01**	**0.01**	**0.00**	**28.66**	**0.00**	**0.00**	**28.83**

Note: The project would be docked at VSFB harbor.

Marine Emission Estimates - Bernardine C Day 3

											Emission Factors										Maximum Daily Emissions										Annual Emissions										
Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating	Engine Rating	Load Factor	Operation	Operation	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
						(hp)	(kW)		(hr/day)	(days/yr)	(g/kW-hr)										(lb/day)										(ton/yr)							(MT/yr)			
Tugboat	Manuevering	Propulsion	3	0.1%S	2	500	373	0.50	4.50	36	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03	1.45	19.26	18.49	0.25	0.41	0.41	0.00	2,647.57	0.11	0.04	0.03	0.35	0.33	0.00	0.01	0.01	0.00	43.23	0.00	0.00	43.46
Tugboat	Manuevering	Auxiliary	3	0.1%S	1	99	74	0.31	4.50	36	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03	0.09	1.14	1.14	0.02	0.03	0.03	0.00	149.29	0.01	0.00	0.00	0.02	0.02	0.00	0.00	0.00	0.00	2.44	0.00	0.00	2.45
Tugboat	Contingency	Propulsion	3	0.1%S	2	500	373	0.50	0.33	36	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03	0.11	1.41	1.36	0.02	0.03	0.03	0.00	194.16	0.01	0.00	0.00	0.03	0.02	0.00	0.00	0.00	0.00	3.17	0.00	0.00	3.19
Tugboat	Contingency	Auxiliary	3	0.1%S	1	99	74	0.31	0.33	36	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03	0.01	0.08	0.08	0.00	0.00	0.00	0.00	10.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.18
Tugboat	Hoteling	Auxiliary	3	0.1%S	1	99	74	0.31	19.17	36	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03	0.37	4.87	4.85	0.07	0.12	0.12	0.00	635.98	0.03	0.01	0.01	0.09	0.09	0.00	0.00	0.00	0.00	10.39	0.00	0.00	10.44
Emission Subtotals																					**2.02**	**26.77**	**25.92**	**0.35**	**0.58**	**0.58**	**0.00**	**3,637.95**	**0.15**	**0.05**	**0.04**	**0.48**	**0.47**	**0.01**	**0.01**	**0.01**	**0.00**	**59.41**	**0.00**	**0.00**	**59.72**

Note:
The project would operate within the SBCAPCD jurisdiction for 61.7 nautical miles.

Marine Emission Estimates - Bernardine C Day 5

											Emission Factors										Maximum Daily Emissions										Annual Emissions										
Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating	Engine Rating	Load Factor	Operation	Operation	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
						(hp)	(kW)		(hr/day)	(days/yr)	(g/kW-hr)										(lb/day)										(ton/yr)							(MT/yr)			
Tugboat	Transit	Propulsion	3	0.1%S	2	500	373	0.50	24.00	36	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03	7.73	102.74	98.64	1.34	2.17	2.17	0.01	14,120.40	0.57	0.20	0.14	1.85	1.78	0.02	0.04	0.04	0.00	230.58	0.01	0.00	231.77
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	36	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03	0.46	6.10	6.07	0.08	0.15	0.15	0.00	796.22	0.04	0.01	0.01	0.11	0.11	0.00	0.00	0.00	0.00	13.00	0.00	0.00	13.08
Emission Subtotals																					**8.19**	**108.84**	**104.71**	**1.42**	**2.32**	**2.32**	**0.01**	**14,916.62**	**0.61**	**0.21**	**0.15**	**1.96**	**1.88**	**0.03**	**0.04**	**0.04**	**0.00**	**243.58**	**0.01**	**0.00**	**244.85**

Note: **1,256.24** **0.05** **0.02** **1,262.79**
The project would operate within the SBCAPCD jurisdiction for 64 nautical miles from Port of Hueneme.

Marine Propulsion

Engine Type	Engine Family	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
					(g/kW-hr)									
Slow Speed Diesel		<=1999	Tier 0	0.1%S	0.600	17.01	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		<=1999	Tier 0	0.1%S	0.500	13.16	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2000-2010	Tier 1	0.1%S	0.600	15.98	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2000-2010	Tier 1	0.1%S	0.500	12.22	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2011-2015	Tier 2	0.1%S	0.600	14.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029

Medium Speed Diesel		2011-2015	Tier 2	0.1%S	0.500	10.53	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2016+	Tier 3	0.1%S	0.600	3.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2016+	Tier 3	0.1%S	0.500	2.63	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
EPA Certification	HCEXN19.0AAA		Tier 3	0.1%S	0.392	5.21	5.0	0.07	0.11	0.11	0.0006067	716		

Notes:
Emission factors from Table 2.3 and 2.4 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
Load factors for propulsion engines based on Table 3.1 of the of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 1 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.

Marine Auxiliary

Engine Type	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
				(g/kW-hr)									
Aux High Speed Diesel	<=1999	Tier 0	0.1%S	0.600	10.9	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	<=1999	Tier 0	0.1%S	0.600	13.82	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	9.78	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	12.22	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	7.71	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	10.53	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	1.97	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	2.63	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux Med Speed Diesel Tier 3 Standard	2011-2015	Tier 3	0.1%S	0.378	5.022	5	0.068	0.12	0.12	0.0006067			

Notes:
Emission factors from Table 2.9 and 2.10 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
Load factors for propulsion engines based on Table 3.1 of the of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 5 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.

Marine exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\, EF_i \times Eng_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF	=	*Emission factor in grams per horse-power hour*
Eng	=	*Number of engines*
AvgHP	=	*Maximum rated average horsepower*
Load	=	*Load factor*
Activity	=	*Hours of operation*
i	=	*Equipment type*

SpaceX Marine Transport Project Baseline Santa Barbara County

Off-Road Emission Estimates

Day 2

Construction Equipment	OFFROAD Model Category	Engine Tier	Quantity	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (day/yr)
Crane-HTC-3140LB J8	Crane-transport	4	1	550	410	0.29	0.5	72
Crane-HTC-3140LB J8	Crane-lift	4	1	215	160	0.29	0	72
Generator-Barge	Generator Sets	4	1	49	37	0.74	7.8	72

Emission Factors (g/BHP-hr)	VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
Crane-HTC-3140LB J8 (Crane-transport)	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	470.5495	0.1522	0.0682
Crane-HTC-3140LB J8 (Crane-lift)	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	472.9057	0.1529	0.0690
Generator-Barge	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081

Daily Emissions (lb/day)	VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20
Crane-HTC-3140LB J8 (Crane-transport)	0.01	0.05	0.39	0.00	0.00	0.00	82.73	0.03	0.01
Crane-HTC-3140LB J8 (Crane-lift)	-	-	-	-	-	-	-	-	-
Generator-Barge	0.07	1.71	2.56	0.00	0.00	0.00	354	0.01	0.01
Emission Subtotals	**0.09**	**1.76**	**2.94**	**0.00**	**0.01**	**0.01**	**437.07**	**0.04**	**0.02**

Annual Emissions	VOC (ton/year)	NOx (ton/year)	CO (ton/year)	SOx (ton/year)	PM10 (ton/year)	PM2.5 (ton/year)	CO2 (MT/yr)	CH4 (MT/yr)	N2O (MT/yr)	CO2E (MT/yr)
Crane-HTC-3140LB J8 (Crane-transport)	0.00	0.00	0.01	0.00	0.00	0.00	2.70	0.00	0.00	2.84
Crane-HTC-3140LB J8 (Crane-lift)	-	-	-	-	-	-	-	-	-	-
Generator-Barge	0.00	0.06	0.09	0.00	0.00	0.00	11.57	0.00	0.00	11.63
Emission Subtotals	**0.00**	**0.06**	**0.11**	**0.00**	**0.00**	**0.00**	**14.27**	**0.00**	**0.00**	**14.47**

Notes:
Emission factors are default emission factors from CalEEMod 2016.3.2, which relies on OFFROAD 2011.
Load factor for generator are defaults from CalEEMod 2016.3.2.
Load factor for KMAG based on average speed over route compared to rated maximum travel speed.
Fugitive dust emissions from paved roads assumes the KMAG is loaded.
See Table D-12 of the Carl Moyer Program Guidelines. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/msprog/moyer/guidelines/2011/2011cmp_guidelinesVER4.pdf?_ga=2.218661721.1589730523.1723135078-1780396104.1706050686

Day 3

Construction Equipment	OFFROAD Model Category	Engine Tier	Quantity	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (day/yr)
KMAG	Off-Highway Truck	3	1	453	338	0.3	7.5	72
Crane-HTC-3140LB J8	Crane-transport	4	1	550	410	0.29	0.5	72
Crane-HTC-3140LB J8	Crane-lift	4	1	215	160	0.29	2	72
Generator-Barge	Generator Sets	4	1	49	37	0.74	21.5	72

Emission Factors (g/BHP-hr)	VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
KMAG	0.1200	2.3200	2.6000	0.0050	0.0088	0.0088	528.8080	0.1540	0.0690
Crane-HTC-3140LB J8 (Crane-transport)	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	470.5495	0.1522	0.0682
Crane-HTC-3140LB J8 (Crane-lift)	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	472.9057	0.1529	0.0690
Generator-Barge	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081

Daily Emissions (lb/day)	VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20
KMAG	0.27	5.22	5.85	0.01	0.50	0.14	1,189	0.35	0.16
Crane-HTC-3140LB J8 (Crane-transport)	0.01	0.05	0.39	0.00	0.00	0.00	82.73	0.03	0.01
Crane-HTC-3140LB J8 (Crane-lift)	0.02	0.07	0.60	0.00	0.00	0.00	130.01	0.04	0.02
Generator-Barge	0.21	4.73	7.05	0.01	0.01	0.01	977	0.03	0.01
Emission Subtotals	**0.50**	**10.06**	**13.88**	**0.02**	**0.51**	**0.15**	**2,378.38**	**0.45**	**0.20**

Annual Emissions	VOC (ton/year)	NOx (ton/year)	CO (ton/year)	SOx (ton/year)	PM10 (ton/year)	PM2.5 (ton/year)	CO2 (MT/yr)	CH4 (MT/yr)	N2O (MT/yr)	CO2E (MT/yr)
KMAG	0.01	0.19	0.21	0.00	0.02	0.00	38.83	0.01	0.01	40.62
Crane-HTC-3140LB J8 (Crane-transport)	0.00	0.00	0.01	0.00	0.00	0.00	2.70	0.00	0.00	2.84
Crane-HTC-3140LB J8 (Crane-lift)	0.00	0.00	0.02	0.00	0.00	0.00	4.25	0.00	0.00	4.46
Generator-Barge	0.01	0.17	0.25	0.00	0.00	0.00	31.90	0.00	0.00	32.06
Emission Subtotals	**0.02**	**0.36**	**0.50**	**0.00**	**0.02**	**0.01**	**77.67**	**0.01**	**0.01**	**79.99**
							91.95	0.02	0.01	94.46

Notes:
Emission factors are default emission factors from CalEEMod 2016.3.2, which relies on OFFROAD 2011.
Load factor for generator are defaults from CalEEMod 2016.3.2.
Load factor for KMAG based on average speed over route compared to rated maximum travel speed.
Fugitive dust emissions from paved roads assumes the KMAG is loaded.
See Table D-12 of the Carl Moyer Program Guidelines. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/msprog/moyer/guidelines/2011/2011cmp_guidelinesVER4.pdf?_ga=2.218661721.1589730523.1723135078-1780396104.1706050686

Emission Factors

Equipment Type	Year	Low HP	High HP	VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
				(g/BHP-hr)								
KMAG	Tier 3	300	599	0.1200	2.3200	2.6000	0.0050	0.0088	0.0088	528.8080	0.1540	0.0690
Crane-HTC-3140LB J8	Tier 4 Final	175	299	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	472.9057	0.1529	0.0690
Crane-HTC-3140LB J8	Tier 4 Final	300	599	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	470.5495	0.1522	0.0682
Generator Sets	Tier 4 Final	25	49	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081

Off-road mobile equipment exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\, EF_i \times Pop_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF	=	*Emission factor in grams per horse-power hour*
Pop	=	*Population, or the number of pieces of equipment*
AvgHP	=	*Maximum rated average horsepower*
Load	=	*Load factor*
Activity	=	*Hours of operation*
i	=	*Equipment type*

SpaceX Baseline - Ventura County

Marine Emission Estimates - Elizabeth C Day 2 and Day 4

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (days/yr)	Emission Factors VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
											(g/kW-hr)									
Tugboat	Transit	Propulsion	3	0.1%S	2	1,300	970	0.50	2.10	72	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03
Tugboat	Transit	Auxiliary	3	0.1%S	2	99	74	0.31	2.10	72	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03
											(g/hp-hr)									
Generator-Barge	Transit	Generator Sets	4	0.1%S	1	49	37	0.74	2.10	72	0.12	2.75	4.10	0.01	0.01	0.01	-	568.30	0.02	0.01
Emission Subtotals																				

Boat Classification	Maximum Daily Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
	(lb/day)									
Tugboat (Propulsion)	1.76	23.39	22.45	0.31	0.49	0.49	0.00	3,214.29	0.13	0.04
Tugboat (Auxiliary)	0.08	1.07	1.06	0.01	0.03	0.03	0.00	139.34	0.01	0.00
Generator-Barge	0.02	0.46	0.69	0.00	0.00	0.00	-	95.40	0.00	0.00
Emission Subtotals	**1.86**	**24.92**	**24.20**	**0.32**	**0.52**	**0.52**	**0.00**	**3,449.03**	**0.14**	**0.05**

Boat Classification	Annual Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
	(ton/yr)							(MT/yr)			
Tugboat (Propulsion)	0.06	0.84	0.81	0.01	0.02	0.02	0.00	104.97	0.00	0.00	105.52
Tugboat (Auxiliary)	0.00	0.04	0.04	0.00	0.00	0.00	0.00	4.55	0.00	0.00	4.58
Generator-Barge	0.00	0.02	0.02	0.00	0.00	0.00	-	3.12	0.00	0.00	3.15
Emission Subtotals	**0.07**	**0.90**	**0.87**	**0.01**	**0.02**	**0.02**	**0.00**	**112.64**	**0.00**	**0.00**	**113.24**

Note:
The project would operate within the VCAPCD jurisdiction for 16 nautical miles.

Marine Emission Estimates - Bernardine C Day 1 and 5

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (days/yr)	Emission Factors VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
											(g/kW-hr)									
Tugboat	Transit	Propulsion	3	0.1%S	2	500	373	0.50	5.50	72	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	5.50	72	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03
Emission Subtotals																				

Boat Classification	Maximum Daily Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
	(lb/day)									
Tugboat (Propulsion)	1.77	23.55	22.60	0.31	0.50	0.50	0.00	3,235.92	0.13	0.05
Tugboat (Auxiliary)	0.11	1.40	1.39	0.02	0.03	0.03	0.00	182.47	0.01	0.00
Emission Subtotals	**1.88**	**24.94**	**24.00**	**0.33**	**0.53**	**0.53**	**0.00**	**3,418.39**	**0.14**	**0.05**

Boat Classification	Annual Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
	(ton/yr)							(MT/yr)			
Tugboat (Propulsion)	0.06	0.85	0.81	0.01	0.02	0.02	0.00	105.68	0.00	0.00	106.23
Tugboat (Auxiliary)	0.00	0.05	0.05	0.00	0.00	0.00	0.00	5.96	0.00	0.00	5.99
Emission Subtotals	**0.07**	**0.90**	**0.86**	**0.01**	**0.02**	**0.02**	**0.00**	**111.64**	**0.00**	**0.00**	**112.22**

Note:
The project would operate within the VCAPCD jurisdiction for 13.6 nautical miles.

Emission Factors

Marine Propulsion

Engine Type	Engine Family	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
					(g/kW-hr)									
Slow Speed Diesel		<=1999	Tier 0	0.1%S	0.600	17.01	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		<=1999	Tier 0	0.1%S	0.500	13.16	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2000-2010	Tier 1	0.1%S	0.600	15.98	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2000-2010	Tier 1	0.1%S	0.500	12.22	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2011-2015	Tier 2	0.1%S	0.600	14.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2011-2015	Tier 2	0.1%S	0.500	10.53	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2016+	Tier 3	0.1%S	0.600	3.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2016+	Tier 3	0.1%S	0.500	2.63	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
EPA Certification	HCEXN19.0AAA		Tier 3	0.1%S	0.392	5.21	5.0	0.07	0.11	0.11	0.0006067	716		

Notes:
Emission factors from Table 2.3 and 2.4 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
Load factors for propulsion engines based on Table 3.1 of the of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 1 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.

Marine Auxiliary

Engine Type	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
				(g/kW-hr)									
Aux High Speed Diesel	<=1999	Tier 0	0.1%S	0.600	10.9	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	<=1999	Tier 0	0.1%S	0.600	13.82	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	9.78	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	12.22	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	7.71	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	10.53	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	1.97	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	2.63	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux Med Speed Diesel Tier 3 Standard	2011-2015	Tier 3	0.1%S	0.378	5.022	5	0.068	0.12	0.12	0.0006067			
				(g/hp-hr)									
Generator Sets		Tier 4 Final	0.1%S	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	-	568.2990	0.0180	0.0081

Notes:
Emission factors from Table 2.9 and 2.10 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
Load factors for propulsion engines based on Table 3.1 of the of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 5 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.
Emission factors for generator sets are default emission factors from CalEEMod 2016.3.2, which relies on OFFROAD 2011 and the Carl Moyer Progam Guidelines.
See Table D-12 of the Carl Moyer Program Guidelines. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/msprog/moyer/guidelines/2011/2011cmp_guidelinesVER4.pdf?_ga=2.218661721.1589730523.1723135078-1780396104.1706050686

Marine exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\, EF_i \times Eng_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF	=	*Emission factor in grams per horse-power hour*
Eng	=	*Number of engines*
AvgHP	=	*Maximum rated average horsepower*
Load	=	*Load factor*
Activity	=	*Hours of operation*
i	=	*Equipment type*

DETAIL AIR CONFORMITY APPLICABILITY MODEL REPORT

1. General Information

- Action Location
Base: VANDENBERG AFB
State: California
County(s): Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Action Title: Falcon Program at Vandenberg Space Force Base

- Project Number/s (if applicable):

- Projected Action Start Date: 1 / 2025

- Action Purpose and Need:
Space Exploration Technologies Corporation (SpaceX) has applied to the United States Space Force (USSF) to increase Falcon flight opportunities at Vandenberg Space Force Base (VSFB) in support of manifested and anticipated vehicle operations for Falcon 9. SpaceX currently launches commercial and government payloads from VSFB at SLC-4. SpaceX supports, and is under contract for, the full spectrum of U.S. Government space mission requirements, including crew and cargo transportation for the National Aeronautics and Space Administration (NASA) and spacecraft launches for NASA and the U.S. Department of Defense (DOD).

- Action Description:
The Proposed Action is to increase the annual Falcon launch cadence at VSFB through launches at SLC-4 to support future commercial and U.S. government launch service needs. SpaceX would launch Falcon 9 from SLC-4. Falcon 9 is approximately 229 feet tall and produces approximately 1.7 million pounds of thrust at liftoff. A discussion of Falcon 9 can be found in the 2016 EA and associated supplemental environmental documents. The number of launches would increase from 36 to 50 per year under the Proposed Action.

- Point of Contact
Name: Adam Poll
Title: Civilian/Senior Air Quality Specialist
Organization: Dudek
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Phone Number: 8053088516

- Activity List:

Activity Type		Activity Title
2.	Degreaser	Solvent use
3.	Emergency Generator	ES DICE1-3
4.	Emergency Generator	ES DICE4
5.	Emergency Generator	ES DICE 5
6.	Emergency Generator	Prime Engine
7.	Personnel	Worker Vehicles
8.	Personnel	Fleet Vehicle Use
9.	Personnel	Vendor-Contractor Vehicles
10.	Construction / Demolition	Operational Equipment Use

Emission factors and air emission estimating methods come from the United States Air Force's Air Emissions Guide for Air Force Stationary Sources, Air Emissions Guide for Air Force Mobile Sources, and Air Emissions Guide for Air Force Transitory Sources.

2. Degreaser

DETAIL AIR CONFORMITY APPLICABILITY MODEL REPORT

2.1 General Information & Timeline Assumptions

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: Solvent use

- Activity Description:
solvent use

- Activity Start Date
Start Month: 1
Start Year: 2025

- Activity End Date
Indefinite: Yes
End Month: N/A
End Year: N/A

- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	5.926830
SO_x	0.000000
NO_x	0.000000
CO	0.000000

Pollutant	Emissions Per Year (TONs)
PM 10	0.000000
PM 2.5	0.000000
Pb	0.000000
NH_3	0.000000

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)
CH_4	0.000000
N_2O	0.000000

Pollutant	Emissions Per Year (TONs)
CO_2	0.000000
CO_2e	0.000000

2.2 Degreaser Assumptions

- Degreaser
Net solvent usage (total less recycle) (gallons/year): 1820

- Default Settings Used: Yes

- Degreaser Consumption
Solvent used: Mineral Spirits CAS#64475-85-0 (default)
Specific gravity of solvent: 0.78 (default)
Solvent VOC content (%): 100 (default)
Efficiency of control device (%): 0 (default)

2.3 Degreaser Formula(s)

- Degreaser Emissions per Year
DE_{VOC}= (VOC / 100) * NS * SG * 8.35 * (1 - (CD / 100)) / 2000

DE_{VOC}: Degreaser VOC Emissions (TONs per Year)
VOC: Solvent VOC content (%)

(VOC / 100): Conversion Factor percent to decimal
NS: Net solvent usage (total less recycle) (gallons/year)
SG: Specific gravity of solvent
8.35: Conversion Factor the density of water
CD: Efficiency of control device (%)
(1 - (CD / 100)): Conversion Factor percent to decimal (Not effected by control device)
2000: Conversion Factor pounds to tons

3. Emergency Generator

3.1 General Information & Timeline Assumptions

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: ES DICE1-3

- Activity Description:
DICE1-3

- Activity Start Date
Start Month: 1
Start Year: 2025

- Activity End Date
Indefinite: Yes
End Month: N/A
End Year: N/A

- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	0.048804
SO_x	0.000852
NO_x	1.765409
CO	0.468958

Pollutant	Emissions Per Year (TONs)
PM 10	0.055143
PM 2.5	0.055143
Pb	0.000000
NH_3	0.000000

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)
CH_4	0.003156
N_2O	0.000631

Pollutant	Emissions Per Year (TONs)
CO_2	78.386875
CO_2e	90.656125

3.2 Emergency Generator Assumptions

- Emergency Generator
Type of Fuel used in Emergency Generator: Diesel
Number of Emergency Generators: 7

- Default Settings Used: No

- Emergency Generators Consumption

DETAIL AIR CONFORMITY APPLICABILITY MODEL REPORT

Emergency Generator's Horsepower: 779
Average Operating Hours Per Year (hours): 25

3.3 Emergency Generator Emission Factor(s)

- Emergency Generators Criteria Pollutant Emission Factor (lb/hp-hr)

VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3
0.000716	0.0000125	0.0259	0.00688	0.000809	0.000809		

- Emergency Generators Greenhouse Gasses Pollutant Emission Factor (lb/hp-hr)

CH_4	N_2O	CO_2	CO_2e
0.000046297	0.000009259	1.15	1.33

3.4 Emergency Generator Formula(s)

- Emergency Generator Emissions per Year

AE_{POL}= (NGEN * HP * OT * EF_{POL}) / 2000

AE_{POL}: Activity Emissions (TONs per Year)
NGEN: Number of Emergency Generators
HP: Emergency Generator's Horsepower (hp)
OT: Average Operating Hours Per Year (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hp-hr)

4. Emergency Generator

4.1 General Information & Timeline Assumptions

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: ES DICE4

- Activity Description:
ES DICE4

- Activity Start Date
Start Month: 1
Start Year: 2025

- Activity End Date
Indefinite: Yes
End Month: N/A
End Year: N/A

- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	0.012799
SO_x	0.010781
NO_x	0.052756

Pollutant	Emissions Per Year (TONs)
PM 10	0.011515
PM 2.5	0.011515
Pb	0.000000

DETAIL AIR CONFORMITY APPLICABILITY MODEL REPORT

CO	0.035232		NH_3	0.000000

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)		Pollutant	Emissions Per Year (TONs)
CH_4	0.000212		CO_2	5.275625
N_2O	0.000042		CO_2e	6.101375

4.2 Emergency Generator Assumptions

- Emergency Generator
Type of Fuel used in Emergency Generator: Diesel
Number of Emergency Generators: 1

- Default Settings Used: No

- Emergency Generators Consumption
Emergency Generator's Horsepower: 367
Average Operating Hours Per Year (hours): 25

4.3 Emergency Generator Emission Factor(s)

- Emergency Generators Criteria Pollutant Emission Factor (lb/hp-hr)

VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3
0.00279	0.00235	0.0115	0.00768	0.00251	0.00251		

- Emergency Generators Greenhouse Gasses Pollutant Emission Factor (lb/hp-hr)

CH_4	N_2O	CO_2	CO_2e
0.000046297	0.000009259	1.15	1.33

4.4 Emergency Generator Formula(s)

- Emergency Generator Emissions per Year
AE_{POL}= (NGEN * HP * OT * EF_{POL}) / 2000

AE_{POL}: Activity Emissions (TONs per Year)
NGEN: Number of Emergency Generators
HP: Emergency Generator's Horsepower (hp)
OT: Average Operating Hours Per Year (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hp-hr)

5. Emergency Generator

5.1 General Information & Timeline Assumptions

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: ES DICE 5

- Activity Description:

DETAIL AIR CONFORMITY APPLICABILITY MODEL REPORT

ES DICE 5

- Activity Start Date
Start Month: 1
Start Year: 2025

- Activity End Date
Indefinite: Yes
End Month: N/A
End Year: N/A

- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	0.011160
SO_x	0.009400
NO_x	0.046000
CO	0.030720

Pollutant	Emissions Per Year (TONs)
PM 10	0.010040
PM 2.5	0.010040
Pb	0.000000
NH_3	0.000000

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)
CH_4	0.000185
N_2O	0.000037

Pollutant	Emissions Per Year (TONs)
CO_2	4.600000
CO_2e	5.320000

5.2 Emergency Generator Assumptions

- Emergency Generator
Type of Fuel used in Emergency Generator: Diesel
Number of Emergency Generators: 1

- Default Settings Used: No

- Emergency Generators Consumption
Emergency Generator's Horsepower: 320
Average Operating Hours Per Year (hours): 25

5.3 Emergency Generator Emission Factor(s)

- Emergency Generators Criteria Pollutant Emission Factor (lb/hp-hr)

VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3
0.00279	0.00235	0.0115	0.00768	0.00251	0.00251		

- Emergency Generators Greenhouse Gasses Pollutant Emission Factor (lb/hp-hr)

CH_4	N_2O	CO_2	CO_2e
0.000046297	0.000009259	1.15	1.33

5.4 Emergency Generator Formula(s)

- Emergency Generator Emissions per Year

AE_{POL}= (NGEN * HP * OT * EF_{POL}) / 2000

AE_{POL}: Activity Emissions (TONs per Year)
NGEN: Number of Emergency Generators
HP: Emergency Generator's Horsepower (hp)
OT: Average Operating Hours Per Year (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hp-hr)

6. Emergency Generator

6.1 General Information & Timeline Assumptions

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: Prime Engine

- Activity Description:
Prime Engine

- Activity Start Date
Start Month: 1
Start Year: 2025

- Activity End Date
Indefinite: Yes
End Month: N/A
End Year: N/A

- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	1.009221
SO_x	0.850061
NO_x	4.159872
CO	2.778071

Pollutant	Emissions Per Year (TONs)
PM 10	0.907937
PM 2.5	0.907937
Pb	0.000000
NH_3	0.000000

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)
CH_4	0.016747
N_2O	0.003349

Pollutant	Emissions Per Year (TONs)
CO_2	415.987200
CO_2e	481.098240

6.2 Emergency Generator Assumptions

- Emergency Generator
Type of Fuel used in Emergency Generator: Diesel
Number of Emergency Generators: 4

- Default Settings Used: No

- Emergency Generators Consumption
Emergency Generator's Horsepower: 314
Average Operating Hours Per Year (hours): 576

6.3 Emergency Generator Emission Factor(s)

- Emergency Generators Criteria Pollutant Emission Factor (lb/hp-hr)

VOC	SO_x	NO_x	CO	PM 10	PM 2.5	Pb	NH_3

0.00279	0.00235	0.0115	0.00768	0.00251	0.00251		

- Emergency Generators Greenhouse Gasses Pollutant Emission Factor (lb/hp-hr)

CH_4	N_2O	CO_2	CO_2e
0.000046297	0.000009259	1.15	1.33

6.4 Emergency Generator Formula(s)

- Emergency Generator Emissions per Year

AE_{POL}= (NGEN * HP * OT * EF_{POL}) / 2000

AE_{POL}: Activity Emissions (TONs per Year)
NGEN: Number of Emergency Generators
HP: Emergency Generator's Horsepower (hp)
OT: Average Operating Hours Per Year (hours)
EF_{POL}: Emission Factor for Pollutant (lb/hp-hr)

7. Personnel

7.1 General Information & Timeline Assumptions

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: Worker Vehicles

- Activity Description:
Worker Vehicles

- Activity Start Date
Start Month: 1
Start Year: 2025

- Activity End Date
Indefinite: Yes
End Month: N/A
End Year: N/A

- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	1.130506
SO_x	0.012463
NO_x	0.552950
CO	6.932431

Pollutant	Emissions Per Year (TONs)
PM 10	0.070047
PM 2.5	0.025131
Pb	0.000000
NH_3	0.141851

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)
CH_4	0.077682
N_2O	0.049520

Pollutant	Emissions Per Year (TONs)
CO_2	1261.385763
CO_2e	1278.088142

7.2 Personnel Assumptions

- Number of Personnel

Active Duty Personnel:	0
Civilian Personnel:	0
Support Contractor Personnel:	700
Air National Guard (ANG) Personnel:	0
Reserve Personnel:	0

- Default Settings Used: Yes

- Average Personnel Round Trip Commute (mile): 20 (default)

- Personnel Work Schedule

Active Duty Personnel:	5 Days Per Week (default)
Civilian Personnel:	5 Days Per Week (default)
Support Contractor Personnel:	5 Days Per Week (default)
Air National Guard (ANG) Personnel:	4 Days Per Week (default)
Reserve Personnel:	4 Days Per Month (default)

7.3 Personnel On Road Vehicle Mixture

- On Road Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	37.55	60.32	0	0.03	0.2	0	1.9
GOVs	54.49	37.73	4.67	0	0	3.11	0

7.4 Personnel Emission Factor(s)

- On Road Vehicle Criteria Pollutant Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	NH_3
LDGV	0.15014	0.00272	0.08183	1.15414	0.01648	0.00579	0.03482
LDGT	0.19850	0.00338	0.15423	1.58574	0.01798	0.00647	0.03664
HDGV	0.25262	0.00518	0.25160	1.83327	0.02830	0.01002	0.03696
LDDV	0.02453	0.00212	0.21377	0.31526	0.03028	0.01896	0.00310
LDDT	0.01608	0.00283	0.07126	0.15320	0.02417	0.01248	0.00310
HDDV	0.10482	0.01080	2.21934	0.52071	0.11665	0.05708	0.18048
MC	5.55535	0.00206	0.72741	17.74481	0.01913	0.00815	0.00862

- On Road Vehicle Greenhouse Gasses Emission Factors (grams/mile)

	CH_4	N_2O	CO_2	CO_2e
LDGV	0.01196	0.00928	275.34289	278.40759
LDGT	0.01652	0.01302	342.02606	346.32025
HDGV	0.02149	0.01816	523.58650	529.53564
LDDV	0.00114	0.03522	223.57891	234.10442
LDDT	0.00075	0.04708	298.82532	312.87385
HDDV	0.00487	0.17970	1140.57202	1194.24362
MC	0.25786	0.04719	207.94492	228.45331

7.5 Personnel Formula(s)

- Personnel Vehicle Miles Travel for Work Days per Year

$VMT_P = NP * WD * AC$

VMT_P: Personnel Vehicle Miles Travel (miles/year)
NP: Number of Personnel
WD: Work Days per Year
AC: Average Commute (miles)

- Total Vehicle Miles Travel per Year
$VMT_{Total} = VMT_{AD} + VMT_C + VMT_{SC} + VMT_{ANG} + VMT_{AFRC}$

VMT_{Total}: Total Vehicle Miles Travel (miles)
VMT_{AD}: Active Duty Personnel Vehicle Miles Travel (miles)
VMT_C: Civilian Personnel Vehicle Miles Travel (miles)
VMT_{SC}: Support Contractor Personnel Vehicle Miles Travel (miles)
VMT_{ANG}: Air National Guard Personnel Vehicle Miles Travel (miles)
VMT_{AFRC}: Reserve Personnel Vehicle Miles Travel (miles)

- Vehicle Emissions per Year
$V_{POL} = (VMT_{Total} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{Total}: Total Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Personnel On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

8. Personnel

8.1 General Information & Timeline Assumptions

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: Fleet Vehicle Use

- Activity Description:
Fleet Vehicle Use

- Activity Start Date
Start Month: 1
Start Year: 2025

- Activity End Date
Indefinite: Yes
End Month: N/A
End Year: N/A

- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	0.080750
SO_x	0.000890
NO_x	0.039496

Pollutant	Emissions Per Year (TONs)
PM 10	0.005003
PM 2.5	0.001795
Pb	0.000000

CO	0.495174		NH_3	0.010132

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)		Pollutant	Emissions Per Year (TONs)
CH_4	0.005549		CO_2	90.098983
N_2O	0.003537		CO_2e	91.292010

8.2 Personnel Assumptions

- Number of Personnel
- **Active Duty Personnel:** 0
- **Civilian Personnel:** 0
- **Support Contractor Personnel:** 50
- **Air National Guard (ANG) Personnel:** 0
- **Reserve Personnel:** 0

- Default Settings Used: Yes

- Average Personnel Round Trip Commute (mile): 20 (default)

- Personnel Work Schedule
- **Active Duty Personnel:** 5 Days Per Week (default)
- **Civilian Personnel:** 5 Days Per Week (default)
- **Support Contractor Personnel:** 5 Days Per Week (default)
- **Air National Guard (ANG) Personnel:** 4 Days Per Week (default)
- **Reserve Personnel:** 4 Days Per Month (default)

8.3 Personnel On Road Vehicle Mixture

- On Road Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	37.55	60.32	0	0.03	0.2	0	1.9
GOVs	54.49	37.73	4.67	0	0	3.11	0

8.4 Personnel Emission Factor(s)

- On Road Vehicle Criteria Pollutant Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	NH_3
LDGV	0.15014	0.00272	0.08183	1.15414	0.01648	0.00579	0.03482
LDGT	0.19850	0.00338	0.15423	1.58574	0.01798	0.00647	0.03664
HDGV	0.25262	0.00518	0.25160	1.83327	0.02830	0.01002	0.03696
LDDV	0.02453	0.00212	0.21377	0.31526	0.03028	0.01896	0.00310
LDDT	0.01608	0.00283	0.07126	0.15320	0.02417	0.01248	0.00310
HDDV	0.10482	0.01080	2.21934	0.52071	0.11665	0.05708	0.18048
MC	5.55535	0.00206	0.72741	17.74481	0.01913	0.00815	0.00862

- On Road Vehicle Greenhouse Gasses Emission Factors (grams/mile)

	CH_4	N_2O	CO_2	CO_2e
LDGV	0.01196	0.00928	275.34289	278.40759
LDGT	0.01652	0.01302	342.02606	346.32025
HDGV	0.02149	0.01816	523.58650	529.53564
LDDV	0.00114	0.03522	223.57891	234.10442
LDDT	0.00075	0.04708	298.82532	312.87385
HDDV	0.00487	0.17970	1140.57202	1194.24362

MC	0.25786	0.04719	207.94492	228.45331

8.5 Personnel Formula(s)

- Personnel Vehicle Miles Travel for Work Days per Year
$VMT_P = NP * WD * AC$

VMT_P: Personnel Vehicle Miles Travel (miles/year)
NP: Number of Personnel
WD: Work Days per Year
AC: Average Commute (miles)

- Total Vehicle Miles Travel per Year
$VMT_{Total} = VMT_{AD} + VMT_C + VMT_{SC} + VMT_{ANG} + VMT_{AFRC}$

VMT_{Total}: Total Vehicle Miles Travel (miles)
VMT_{AD}: Active Duty Personnel Vehicle Miles Travel (miles)
VMT_C: Civilian Personnel Vehicle Miles Travel (miles)
VMT_{SC}: Support Contractor Personnel Vehicle Miles Travel (miles)
VMT_{ANG}: Air National Guard Personnel Vehicle Miles Travel (miles)
VMT_{AFRC}: Reserve Personnel Vehicle Miles Travel (miles)

- Vehicle Emissions per Year
$V_{POL} = (VMT_{Total} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{Total}: Total Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Personnel On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

9. Personnel

9.1 General Information & Timeline Assumptions

- Add or Remove Activity from Baseline? Add

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: Vendor-Contractor Vehicles

- Activity Description:
Vendor-Contractor Vehicles

- Activity Start Date
Start Month: 1
Start Year: 2025

- Activity End Date
Indefinite: Yes

End Month: N/A
End Year: N/A

- Activity Emissions of Criteria Pollutants:

Pollutant	Emissions Per Year (TONs)
VOC	0.108206
SO_x	0.001193
NO_x	0.052925
CO	0.663533

Pollutant	Emissions Per Year (TONs)
PM 10	0.006705
PM 2.5	0.002405
Pb	0.000000
NH_3	0.013577

- Global Scale Activity Emissions of Greenhouse Gasses:

Pollutant	Emissions Per Year (TONs)
CH_4	0.007435
N_2O	0.004740

Pollutant	Emissions Per Year (TONs)
CO_2	120.732637
CO_2e	122.331294

9.2 Personnel Assumptions

- Number of Personnel
Active Duty Personnel: 0
Civilian Personnel: 0
Support Contractor Personnel: 67
Air National Guard (ANG) Personnel: 0
Reserve Personnel: 0

- Default Settings Used: Yes

- Average Personnel Round Trip Commute (mile): 20 (default)

- Personnel Work Schedule
Active Duty Personnel: 5 Days Per Week (default)
Civilian Personnel: 5 Days Per Week (default)
Support Contractor Personnel: 5 Days Per Week (default)
Air National Guard (ANG) Personnel: 4 Days Per Week (default)
Reserve Personnel: 4 Days Per Month (default)

9.3 Personnel On Road Vehicle Mixture

- On Road Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	37.55	60.32	0	0.03	0.2	0	1.9
GOVs	54.49	37.73	4.67	0	0	3.11	0

9.4 Personnel Emission Factor(s)

- On Road Vehicle Criteria Pollutant Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	NH_3
LDGV	0.15014	0.00272	0.08183	1.15414	0.01648	0.00579	0.03482
LDGT	0.19850	0.00338	0.15423	1.58574	0.01798	0.00647	0.03664
HDGV	0.25262	0.00518	0.25160	1.83327	0.02830	0.01002	0.03696
LDDV	0.02453	0.00212	0.21377	0.31526	0.03028	0.01896	0.00310
LDDT	0.01608	0.00283	0.07126	0.15320	0.02417	0.01248	0.00310
HDDV	0.10482	0.01080	2.21934	0.52071	0.11665	0.05708	0.18048
MC	5.55535	0.00206	0.72741	17.74481	0.01913	0.00815	0.00862

DETAIL AIR CONFORMITY APPLICABILITY MODEL REPORT

- On Road Vehicle Greenhouse Gasses Emission Factors (grams/mile)

	CH_4	N_2O	CO_2	CO_2e
LDGV	0.01196	0.00928	275.34289	278.40759
LDGT	0.01652	0.01302	342.02606	346.32025
HDGV	0.02149	0.01816	523.58650	529.53564
LDDV	0.00114	0.03522	223.57891	234.10442
LDDT	0.00075	0.04708	298.82532	312.87385
HDDV	0.00487	0.17970	1140.57202	1194.24362
MC	0.25786	0.04719	207.94492	228.45331

9.5 Personnel Formula(s)

- Personnel Vehicle Miles Travel for Work Days per Year

$VMT_P = NP * WD * AC$

VMT_P: Personnel Vehicle Miles Travel (miles/year)
NP: Number of Personnel
WD: Work Days per Year
AC: Average Commute (miles)

- Total Vehicle Miles Travel per Year

$VMT_{Total} = VMT_{AD} + VMT_C + VMT_{SC} + VMT_{ANG} + VMT_{AFRC}$

VMT_{Total}: Total Vehicle Miles Travel (miles)
VMT_{AD}: Active Duty Personnel Vehicle Miles Travel (miles)
VMT_C: Civilian Personnel Vehicle Miles Travel (miles)
VMT_{SC}: Support Contractor Personnel Vehicle Miles Travel (miles)
VMT_{ANG}: Air National Guard Personnel Vehicle Miles Travel (miles)
VMT_{AFRC}: Reserve Personnel Vehicle Miles Travel (miles)

- Vehicle Emissions per Year

$V_{POL} = (VMT_{Total} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{Total}: Total Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Personnel On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

10. Construction / Demolition

10.1 General Information & Timeline Assumptions

- Activity Location
County: Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

- Activity Title: Operational Equipment Use

- Activity Description:
Operational Equipment Use

DETAIL AIR CONFORMITY APPLICABILITY MODEL REPORT

- Activity Start Date
Start Month: 1
Start Month: 2025

- Activity End Date
Indefinite: False
End Month: 0
End Month: 2055

- Activity Emissions:

Pollutant	Total Emissions (TONs)
VOC	1.485932
SO_x	0.042469
NO_x	13.329465
CO	17.975869

Pollutant	Total Emissions (TONs)
PM 10	0.409454
PM 2.5	0.376695
Pb	0.000000
NH_3	0.000000

- Activity Emissions of GHG:

Pollutant	Total Emissions (TONs)
CH_4	0.186498
N_2O	0.037312

Pollutant	Total Emissions (TONs)
CO_2	4597.670495
CO_2e	4613.448542

- Global Scale Activity Emissions for SCGHG:

Pollutant	Total Emissions (TONs)
CH_4	0.186498
N_2O	0.037312

Pollutant	Total Emissions (TONs)
CO_2	4597.670495
CO_2e	4613.448542

10.1 Site Grading Phase

10.1.1 Site Grading Phase Timeline Assumptions

- Phase Start Date
Start Month: 1
Start Quarter: 1
Start Year: 2025

- Phase Duration
Number of Month: 360
Number of Days: 0

10.1.2 Site Grading Phase Assumptions

- General Site Grading Information
Area of Site to be Graded (ft^2): 0
Amount of Material to be Hauled On-Site (yd^3): 0
Amount of Material to be Hauled Off-Site (yd^3): 0

- Site Grading Default Settings
Default Settings Used: No
Average Day(s) worked per week: 5

- Construction Exhaust

Equipment Name	Number Of Equipment	Hours Per Day
Aerial Lifts Composite	6	1

Forklifts Composite	7	1
Off-Highway Trucks Composite	4	1
Rough Terrain Forklifts Composite	6	1

- Vehicle Exhaust

Average Hauling Truck Capacity (yd^3): 20

Average Hauling Truck Round Trip Commute (mile): 0

- Vehicle Exhaust Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	0	0	0	0	0	100.00	0

- Worker Trips

Average Worker Round Trip Commute (mile): 0

- Worker Trips Vehicle Mixture (%)

	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
POVs	50.00	50.00	0	0	0	0	0

10.1.3 Site Grading Phase Emission Factor(s)

- Construction Exhaust Criteria Pollutant Emission Factors (g/hp-hour)

Aerial Lifts Composite [HP: 46] [LF: 0.31]						
	VOC	SO_x	NO_x	CO	PM 10	PM 2.5
Emission Factors	0.15354	0.00542	2.87672	3.08611	0.02068	0.01903
Forklifts Composite [HP: 82] [LF: 0.2]						
	VOC	SO_x	NO_x	CO	PM 10	PM 2.5
Emission Factors	0.26944	0.00487	2.55142	3.59881	0.13498	0.12418
Off-Highway Trucks Composite [HP: 376] [LF: 0.38]						
	VOC	SO_x	NO_x	CO	PM 10	PM 2.5
Emission Factors	0.17748	0.00488	1.08595	1.17415	0.03850	0.03542
Rough Terrain Forklifts Composite [HP: 96] [LF: 0.4]						
	VOC	SO_x	NO_x	CO	PM 10	PM 2.5
Emission Factors	0.11845	0.00489	1.69423	3.22091	0.03622	0.03332

- Construction Exhaust Greenhouse Gasses Pollutant Emission Factors (g/hp-hour)

Aerial Lifts Composite [HP: 46] [LF: 0.31]				
	CH_4	N_2O	CO_2	CO_2e
Emission Factors	0.02381	0.00476	586.90005	588.91415
Forklifts Composite [HP: 82] [LF: 0.2]				
	CH_4	N_2O	CO_2	CO_2e
Emission Factors	0.02138	0.00428	527.10822	528.91712
Off-Highway Trucks Composite [HP: 376] [LF: 0.38]				
	CH_4	N_2O	CO_2	CO_2e
Emission Factors	0.02144	0.00429	528.58735	530.40133
Rough Terrain Forklifts Composite [HP: 96] [LF: 0.4]				
	CH_4	N_2O	CO_2	CO_2e
Emission Factors	0.02145	0.00429	528.72612	530.54057

- Vehicle Exhaust & Worker Trips Criteria Pollutant Emission Factors (grams/mile)

	VOC	SO_x	NO_x	CO	PM 10	PM 2.5	NH_3
LDGV	0.15014	0.00272	0.08183	1.15414	0.01648	0.00579	0.03482
LDGT	0.19850	0.00338	0.15423	1.58574	0.01798	0.00647	0.03664
HDGV	0.25262	0.00518	0.25160	1.83327	0.02830	0.01002	0.03696

LDDV	0.02453	0.00212	0.21377	0.31526	0.03028	0.01896	0.00310
LDDT	0.01608	0.00283	0.07126	0.15320	0.02417	0.01248	0.00310
HDDV	0.10482	0.01080	2.21934	0.52071	0.11665	0.05708	0.18048
MC	5.55535	0.00206	0.72741	17.74481	0.01913	0.00815	0.00862

- Vehicle Exhaust & Worker Trips Greenhouse Gasses Emission Factors (grams/mile)

	CH_4	N_2O	CO_2	CO_2e
LDGV	0.01196	0.00928	275.34289	278.40759
LDGT	0.01652	0.01302	342.02606	346.32025
HDGV	0.02149	0.01816	523.58650	529.53564
LDDV	0.00114	0.03522	223.57891	234.10442
LDDT	0.00075	0.04708	298.82532	312.87385
HDDV	0.00487	0.17970	1140.57202	1194.24362
MC	0.25786	0.04719	207.94492	228.45331

10.1.4 Site Grading Phase Formula(s)

- Fugitive Dust Emissions per Phase

$PM10_{FD} = (20 * ACRE * WD) / 2000$

$PM10_{FD}$: Fugitive Dust PM 10 Emissions (TONs)
20: Conversion Factor Acre Day to pounds (20 lb / 1 Acre Day)
ACRE: Total acres (acres)
WD: Number of Total Work Days (days)
2000: Conversion Factor pounds to tons

- Construction Exhaust Emissions per Phase

$CEE_{POL} = (NE * WD * H * HP * LF * EF_{POL} * 0.002205) / 2000$

CEE_{POL}: Construction Exhaust Emissions (TONs)
NE: Number of Equipment
WD: Number of Total Work Days (days)
H: Hours Worked per Day (hours)
HP: Equipment Horsepower
LF: Equipment Load Factor
EF_{POL}: Emission Factor for Pollutant (g/hp-hour)
0.002205: Conversion Factor grams to pounds
2000: Conversion Factor pounds to tons

- Vehicle Exhaust Emissions per Phase

$VMT_{VE} = (HA_{OnSite} + HA_{OffSite}) * (1 / HC) * HT$

VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
HA_{OnSite}: Amount of Material to be Hauled On-Site (yd^3)
$HA_{OffSite}$: Amount of Material to be Hauled Off-Site (yd^3)
HC: Average Hauling Truck Capacity (yd^3)
(1 / HC): Conversion Factor cubic yards to trips (1 trip / HC yd^3)
HT: Average Hauling Truck Round Trip Commute (mile/trip)

$V_{POL} = (VMT_{VE} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{VE}: Vehicle Exhaust Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)

VM: Vehicle Exhaust On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

- Worker Trips Emissions per Phase
$VMT_{WT} = WD * WT * 1.25 * NE$

VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
WD: Number of Total Work Days (days)
WT: Average Worker Round Trip Commute (mile)
1.25: Conversion Factor Number of Construction Equipment to Number of Works
NE: Number of Construction Equipment

$V_{POL} = (VMT_{WT} * 0.002205 * EF_{POL} * VM) / 2000$

V_{POL}: Vehicle Emissions (TONs)
VMT_{WT}: Worker Trips Vehicle Miles Travel (miles)
0.002205: Conversion Factor grams to pounds
EF_{POL}: Emission Factor for Pollutant (grams/mile)
VM: Worker Trips On Road Vehicle Mixture (%)
2000: Conversion Factor pounds to tons

AIR CONFORMITY APPLICABILITY MODEL REPORT
RECORD OF AIR ANALYSIS (ROAA)

1. General Information: The Air Force's Air Conformity Applicability Model (ACAM) was used to perform a net change in emissions analysis to assess the potential air quality impact/s associated with the action. The analysis was performed in accordance with the Air Force Manual 32-7002, *Environmental Compliance and Pollution Prevention*; the *Environmental Impact Analysis Process* (EIAP, 32 CFR 989); the *General Conformity Rule* (GCR, 40 CFR 93 Subpart B); and the *USAF Air Quality Environmental Impact Analysis Process (EIAP) Guide*. This report provides a summary of the ACAM analysis.

a. Action Location:
Base: VANDENBERG AFB
State: California
County(s): Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

b. Action Title: Falcon Program at Vandenberg Space Force Base

c. Project Number/s (if applicable):

d. Projected Action Start Date: 1 / 2025

e. Action Description:

The Proposed Action is to increase the annual Falcon launch cadence at VSFB through launches at SLC-4 to support future commercial and U.S. government launch service needs. SpaceX would launch Falcon 9 from SLC-4. Falcon 9 is approximately 229 feet tall and produces approximately 1.7 million pounds of thrust at liftoff. A discussion of Falcon 9 can be found in the 2016 EA and associated supplemental environmental documents. The number of launches would increase from 36 to 50 per year under the Proposed Action.

f. Point of Contact:
Name: Adam Poll
Title: Civilian/Senior Air Quality Specialist
Organization: Dudek
Email: apoll@dudek.com
Phone Number: 8053088516

2. Air Impact Analysis: Based on the attainment status at the action location, the requirements of the GCR are:

____ applicable
_X_ not applicable

Total reasonably foreseeable net direct and indirect emissions associated with the action were estimated through ACAM on a calendar-year basis for the start of the action through achieving "steady state" (hsba.e., no net gain/loss in emission stabilized and the action is fully implemented) emissions. The ACAM analysis uses the latest and most accurate emission estimation techniques available; all algorithms, emission factors, and methodologies used are described in detail in the *USAF Air Emissions Guide for Air Force Stationary Sources*, the *USAF Air Emissions Guide for Air Force Mobile Sources*, and the *USAF Air Emissions Guide for Air Force Transitory Sources*.

"Insignificance Indicators" were used in the analysis to provide an indication of the significance of the proposed Action's potential impacts to local air quality. The insignificance indicators are trivial (de minimis) rate thresholds that have been demonstrated to have little to no impact to air quality. These insignificance indicators are the 250 ton/yr Prevention of Significant Deterioration (PSD) major source threshold and 25 ton/yr for lead for actions occurring in areas that are "Attainment" (hsba.e., not exceeding any National Ambient Air Quality Standard (NAAQS)). These indicators do not define a significant impact; however, they do provide a threshold to identify actions that are insignificant. Any action with net emissions below the insignificance indicators for all criteria pollutants is considered so insignificant that the action will not cause or contribute to an exceedance on one or more NAAQS. For further detail on insignificance indicators, refer to *Level II, Air Quality Quantitative Assessment, Insignificance Indicators*.

The action's net emissions for every year through achieving steady state were compared against the Insignificance Indicators and are summarized below.

Analysis Summary:

2025

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2026

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2027

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2028

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			

VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2029

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2030

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2031

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2032

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No

NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2033

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2034

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2035

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2036

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No

CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2037

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2038

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2039

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2040

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No

SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2041

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2042

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2043

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2044

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No

PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2045

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2046

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2047

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2048

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No

PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2049

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2050

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2051

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2052

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No

Pb	0.000	25	No
NH3	0.166	250	No

2053

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2054

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.378	250	No
NOx	7.114	250	No
CO	12.003	250	No
SOx	0.887	250	No
PM 10	1.080	250	No
PM 2.5	1.027	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2055

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.328	250	No
NOx	6.669	250	No
CO	11.404	250	No
SOx	0.886	250	No
PM 10	1.066	250	No
PM 2.5	1.014	250	No
Pb	0.000	25	No
NH3	0.166	250	No

2056 - (Steady State)

Pollutant	Action Emissions (ton/yr)	INSIGNIFICANCE INDICATOR	
		Indicator (ton/yr)	Exceedance (Yes or No)
NOT IN A REGULATORY AREA			
VOC	8.328	250	No
NOx	6.669	250	No
CO	11.404	250	No
SOx	0.886	250	No
PM 10	1.066	250	No
PM 2.5	1.014	250	No
Pb	0.000	25	No

AIR CONFORMITY APPLICABILITY MODEL REPORT
RECORD OF AIR ANALYSIS (ROAA)

NH3	0.166	250	No

None of the estimated annual net emissions associated with this action are above the insignificance indicators; therefore, the action will not cause or contribute to an exceedance of one or more NAAQSs and will have an insignificant impact on air quality. No further air assessment is needed.

Adam Poll, Civilian/Senior Air Quality Specialist — Jun 26 2024

Name, Title — **Date**

AIR CONFORMITY APPLICABILITY MODEL REPORT
GREENHOUSE GAS (GHG) EMISSIONS

1. General Information: The Air Force's Air Conformity Applicability Model (ACAM) was used to perform an analysis to estimate GHG emissions and assess the theoretical Social Cost of Greenhouse Gases (SC GHG) associated with the action. The analysis was performed in accordance with the Air Force Manual 32-7002, Environmental Compliance and Pollution Prevention; the Environmental Impact Analysis Process (EIAP, 32 CFR 989); and the USAF Air Quality Environmental Impact Analysis Process (EIAP) Guide. This report provides a summary of GHG emissions and SC GHG analysis.

a. Action Location:
Base: VANDENBERG AFB
State: California
County(s): Santa Barbara
Regulatory Area(s): NOT IN A REGULATORY AREA

b. Action Title: Falcon Program at Vandenberg Space Force Base

c. Project Number/s (if applicable):

d. Projected Action Start Date: 1 / 2025

e. Action Description:

The Proposed Action is to increase the annual Falcon launch cadence at VSFB through launches at SLC-4 to support future commercial and U.S. government launch service needs. SpaceX would launch Falcon 9 from SLC-4. Falcon 9 is approximately 229 feet tall and produces approximately 1.7 million pounds of thrust at liftoff. A discussion of Falcon 9 can be found in the 2016 EA and associated supplemental environmental documents. The number of launches would increase from 36 to 50 per year under the Proposed Action.

f. Point of Contact:
Name: Adam Poll
Title: Civilian/Senior Air Quality Specialist
Organization: Dudek
Email: apoll@dudek.com
Phone Number: 8053088516

2. Analysis: Total combined direct and indirect GHG emissions associated with the action were estimated through ACAM on a calendar-year basis from the action start through the expected life cycle of the action. The life cycle for Air Force actions with "steady state" emissions (SS, net gain/loss in emission stabilized and the action is fully implemented) is assumed to be 10 years beyond the SS emissions year or 20 years beyond SS emissions year for aircraft operations related actions.

GHG Emissions Analysis Summary:

GHGs produced by fossil-fuel combustion are primarily carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (NO_2). These three GHGs represent more than 97 percent of all U.S. GHG emissions. Emissions of GHGs are typically quantified and regulated in units of CO_2 equivalents (CO_2e). The CO_2e takes into account the global warming potential (GWP) of each GHG. The GWP is the measure of a particular GHG's ability to absorb solar radiation as well as its residence time within the atmosphere. The GWP allows comparison of global warming impacts between different gases; the higher the GWP, the more that gas contributes to climate change in comparison to CO_2. All GHG emissions estimates were derived from various emission sources using the methods, algorithms, emission factors, and GWPs from the most current Air Emissions Guide for Air Force Stationary Sources, Air Emissions Guide for Air Force Mobile Sources, and/or Air Emissions Guide for Air Force Transitory Sources.

AIR CONFORMITY APPLICABILITY MODEL REPORT
GREENHOUSE GAS (GHG) EMISSIONS

The Air Force has adopted the Prevention of Significant Deterioration (PSD) threshold for GHG of 75,000 ton per year (ton/yr) of CO2e (or 68,039 metric ton per year, mton/yr) as an indicator or "threshold of insignificance" for NEPA air quality impacts in all areas. This indicator does not define a significant impact; however, it provides a threshold to identify actions that are insignificant (de minimis, too trivial or minor to merit consideration). Actions with a net change in GHG (CO2e) emissions below the insignificance indicator (threshold) are considered too insignificant on a global scale to warrant any further analysis. Note that actions with a net change in GHG (CO2e) emissions above the insignificance indicator (threshold) are only considered potentially significant and require further assessment to determine if the action poses a significant impact. For further detail on insignificance indicators see Level II, Air Quality Quantitative Assessment, Insignificance Indicators (April 2023).

The following table summarizes the action-related GHG emissions on a calendar-year basis through the projected life cycle of the action.

Action-Related Annual GHG Emissions (mton/yr)						
YEAR	CO2	CH4	N2O	CO2e	Threshold	Exceedance
2025	1,932	0.10630615	0.05724406	2,022	68,039	No
2026	1,932	0.10630615	0.05724406	2,022	68,039	No
2027	1,932	0.10630615	0.05724406	2,022	68,039	No
2028	1,932	0.10630615	0.05724406	2,022	68,039	No
2029	1,932	0.10630615	0.05724406	2,022	68,039	No
2030	1,932	0.10630615	0.05724406	2,022	68,039	No
2031	1,932	0.10630615	0.05724406	2,022	68,039	No
2032	1,932	0.10630615	0.05724406	2,022	68,039	No
2033	1,932	0.10630615	0.05724406	2,022	68,039	No
2034	1,932	0.10630615	0.05724406	2,022	68,039	No
2035	1,932	0.10630615	0.05724406	2,022	68,039	No
2036	1,932	0.10630615	0.05724406	2,022	68,039	No
2037	1,932	0.10630615	0.05724406	2,022	68,039	No
2038	1,932	0.10630615	0.05724406	2,022	68,039	No
2039	1,932	0.10630615	0.05724406	2,022	68,039	No
2040	1,932	0.10630615	0.05724406	2,022	68,039	No
2041	1,932	0.10630615	0.05724406	2,022	68,039	No
2042	1,932	0.10630615	0.05724406	2,022	68,039	No
2043	1,932	0.10630615	0.05724406	2,022	68,039	No
2044	1,932	0.10630615	0.05724406	2,022	68,039	No
2045	1,932	0.10630615	0.05724406	2,022	68,039	No
2046	1,932	0.10630615	0.05724406	2,022	68,039	No
2047	1,932	0.10630615	0.05724406	2,022	68,039	No
2048	1,932	0.10630615	0.05724406	2,022	68,039	No
2049	1,932	0.10630615	0.05724406	2,022	68,039	No
2050	1,932	0.10630615	0.05724406	2,022	68,039	No
2051	1,932	0.10630615	0.05724406	2,022	68,039	No
2052	1,932	0.10630615	0.05724406	2,022	68,039	No
2053	1,932	0.10630615	0.05724406	2,022	68,039	No
2054	1,932	0.10630615	0.05724406	2,022	68,039	No
2055	1,793	0.10066654	0.05611577	1,882	68,039	No
2056 [SS Year]	1,793	0.10066654	0.05611577	1,882	68,039	No
2057	1,793	0.10066654	0.05611577	1,882	68,039	No
2058	1,793	0.10066654	0.05611577	1,882	68,039	No
2059	1,793	0.10066654	0.05611577	1,882	68,039	No
2060	1,793	0.10066654	0.05611577	1,882	68,039	No
2061	1,793	0.10066654	0.05611577	1,882	68,039	No
2062	1,793	0.10066654	0.05611577	1,882	68,039	No
2063	1,793	0.10066654	0.05611577	1,882	68,039	No

2064	1,793	0.10066654	0.05611577	1,882	68,039	No
2065	1,793	0.10066654	0.05611577	1,882	68,039	No
2066	1,793	0.10066654	0.05611577	1,882	68,039	No

The following U.S. and State's GHG emissions estimates (next two tables) are based on a five-year average (2016 through 2020) of individual state-reported GHG emissions (Reference: State Climate Summaries 2022, NOAA National Centers for Environmental Information, National Oceanic and Atmospheric Administration. https://statesummaries.ncics.org/downloads/).

State's Annual GHG Emissions (mton/yr)				
YEAR	**CO2**	**CH4**	**N2O**	**CO2e**
2025	336,950,322	1,567,526	55,459	338,573,307
2026	336,950,322	1,567,526	55,459	338,573,307
2027	336,950,322	1,567,526	55,459	338,573,307
2028	336,950,322	1,567,526	55,459	338,573,307
2029	336,950,322	1,567,526	55,459	338,573,307
2030	336,950,322	1,567,526	55,459	338,573,307
2031	336,950,322	1,567,526	55,459	338,573,307
2032	336,950,322	1,567,526	55,459	338,573,307
2033	336,950,322	1,567,526	55,459	338,573,307
2034	336,950,322	1,567,526	55,459	338,573,307
2035	336,950,322	1,567,526	55,459	338,573,307
2036	336,950,322	1,567,526	55,459	338,573,307
2037	336,950,322	1,567,526	55,459	338,573,307
2038	336,950,322	1,567,526	55,459	338,573,307
2039	336,950,322	1,567,526	55,459	338,573,307
2040	336,950,322	1,567,526	55,459	338,573,307
2041	336,950,322	1,567,526	55,459	338,573,307
2042	336,950,322	1,567,526	55,459	338,573,307
2043	336,950,322	1,567,526	55,459	338,573,307
2044	336,950,322	1,567,526	55,459	338,573,307
2045	336,950,322	1,567,526	55,459	338,573,307
2046	336,950,322	1,567,526	55,459	338,573,307
2047	336,950,322	1,567,526	55,459	338,573,307
2048	336,950,322	1,567,526	55,459	338,573,307
2049	336,950,322	1,567,526	55,459	338,573,307
2050	336,950,322	1,567,526	55,459	338,573,307
2051	336,950,322	1,567,526	55,459	338,573,307
2052	336,950,322	1,567,526	55,459	338,573,307
2053	336,950,322	1,567,526	55,459	338,573,307
2054	336,950,322	1,567,526	55,459	338,573,307
2055	336,950,322	1,567,526	55,459	338,573,307
2056 [SS Year]	336,950,322	1,567,526	55,459	338,573,307
2057	336,950,322	1,567,526	55,459	338,573,307
2058	336,950,322	1,567,526	55,459	338,573,307
2059	336,950,322	1,567,526	55,459	338,573,307
2060	336,950,322	1,567,526	55,459	338,573,307
2061	336,950,322	1,567,526	55,459	338,573,307
2062	336,950,322	1,567,526	55,459	338,573,307
2063	336,950,322	1,567,526	55,459	338,573,307
2064	336,950,322	1,567,526	55,459	338,573,307
2065	336,950,322	1,567,526	55,459	338,573,307
2066	336,950,322	1,567,526	55,459	338,573,307

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U.S. Annual GHG Emissions (mton/yr)				
YEAR	CO2	CH4	N2O	CO2e
2025	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2026	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2027	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2028	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2029	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2030	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2031	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2032	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2033	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2034	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2035	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2036	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2037	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2038	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2039	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2040	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2041	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2042	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2043	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2044	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2045	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2046	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2047	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2048	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2049	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2050	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2051	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2052	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2053	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2054	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2055	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2056 [SS Year]	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2057	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2058	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2059	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2060	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2061	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2062	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2063	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2064	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2065	5,136,454,179	25,626,912	1,500,708	5,163,581,798
2066	5,136,454,179	25,626,912	1,500,708	5,163,581,798

GHG Relative Significance Assessment:

A Relative Significance Assessment uses the rule of reason and the concept of proportionality along with the consideration of the affected area (yGba.e., global, national, and regional) and the degree (intensity) of the proposed action’s effects. The Relative Significance Assessment provides real-world context and allows for a reasoned choice against alternatives through a relative comparison analysis. The analysis weighs each alternative’s annual net change in GHG emissions proportionally against (or relative to) global, national, and regional emissions.

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The action's surroundings, circumstances, environment, and background (context associated with an action) provide the setting for evaluating the GHG intensity (impact significance). From an air quality perspective, context of an action is the local area's ambient air quality relative to meeting the NAAQSs, expressed as attainment, nonattainment, or maintenance areas (this designation is considered the attainment status). GHGs are non-hazardous to health at normal ambient concentrations and, at a cumulative global scale, action-related GHG emissions can only potentially cause warming of the climatic system. Therefore, the action-related GHGs generally have an insignificant impact to local air quality.

However, the affected area (context) of GHG/climate change is global. Therefore, the intensity or degree of the proposed action's GHG/climate change effects are gauged through the quantity of GHG associated with the action as compared to a baseline of the state, U.S., and global GHG inventories. Each action (or alternative) has significance, based on their annual net change in GHG emissions, in relation to or proportionally to the global, national, and regional annual GHG emissions.

To provide real-world context to the GHG and climate change effects on a global scale, an action's net change in GHG emissions is compared relative to the state (where action will occur) and U.S. annual emissions. The following table provides a relative comparison of an action's net change in GHG emissions vs. state and U.S. projected GHG emissions for the same time period.

Total GHG Relative Significance (mton)					
		CO2	CH4	N2O	CO2e
2025-2066	State Total	14,151,913,505	65,836,095	2,329,292	14,220,078,892
2025-2066	U.S. Total	215,731,075,518	1,076,330,291	63,029,721	216,870,435,529
2025-2066	Action	79,478	4.397183	2.390711	83,242
Percent of State Totals		0.00056160%	0.00000668%	0.00010264%	0.00058538%
Percent of U.S. Totals		0.00003684%	0.00000041%	0.00000379%	0.00003838%

Climate Change Assessment (as SC GHG):

On a global scale, the potential climate change effects of an action are indirectly addressed and put into context through providing the theoretical SC GHG associated with an action. The SC GHG is an administrative and theoretical tool intended to provide additional context to a GHG's potential impacts through approximating the long-term monetary damage that may result from GHG emissions affect on climate change. It is important to note that the SC GHG is a monetary quantification, in 2020 U.S. dollars, of the theoretical economic damages that could result from emitting GHGs into the atmosphere.

The SC GHG estimates are derived using the methodology and discount factors in the "Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990," released by the Interagency Working Group on Social Cost of Greenhouse Gases (IWG SC GHGs) in February 2021.

The speciated IWG Annual SC GHG Emission associated with an action (or alternative) are first estimated as annual unit cost (cost per metric ton, $/mton). Results of the annual IWG Annual SC GHG Emission Assessments are tabulated in the IWG Annual SC GHG Cost per Metric Ton Table below:

IWG SC GHG Discount Factor: 2.5%

IWG Annual SC GHG Cost per Metric Ton ($/mton [In 2020 $])			
YEAR	CO2	CH4	N2O
2025	$83.00	$2,200.00	$30,000.00
2026	$84.00	$2,300.00	$30,000.00
2027	$86.00	$2,300.00	$31,000.00

2028	$87.00	$2,400.00	$32,000.00
2029	$88.00	$2,500.00	$32,000.00
2030	$89.00	$2,500.00	$33,000.00
2031	$91.00	$2,600.00	$33,000.00
2032	$92.00	$2,600.00	$34,000.00
2033	$94.00	$2,700.00	$35,000.00
2034	$95.00	$2,800.00	$35,000.00
2035	$96.00	$2,800.00	$36,000.00
2036	$98.00	$2,900.00	$36,000.00
2037	$99.00	$3,000.00	$37,000.00
2038	$100.00	$3,000.00	$38,000.00
2039	$102.00	$3,100.00	$38,000.00
2040	$103.00	$3,100.00	$39,000.00
2041	$104.00	$3,200.00	$39,000.00
2042	$106.00	$3,300.00	$40,000.00
2043	$107.00	$3,300.00	$41,000.00
2044	$108.00	$3,400.00	$41,000.00
2045	$110.00	$3,500.00	$42,000.00
2046	$111.00	$3,500.00	$43,000.00
2047	$112.00	$3,600.00	$43,000.00
2048	$114.00	$3,700.00	$44,000.00
2049	$115.00	$3,700.00	$45,000.00
2050	$116.00	$3,800.00	$45,000.00
2051	$118.00	$3,827.00	$45,817.00
2052	$119.00	$3,888.00	$46,423.00
2053	$120.00	$3,950.00	$47,028.00
2054	$122.00	$4,011.00	$47,634.00
2055	$123.00	$4,072.00	$48,240.00
2056 [SS Year]	$124.00	$4,134.00	$48,845.00
2057	$126.00	$4,195.00	$49,451.00
2058	$127.00	$4,257.00	$50,057.00
2059	$128.00	$4,318.00	$50,662.00
2060	$130.00	$4,379.00	$51,268.00
2061	$131.00	$4,441.00	$51,874.00
2062	$132.00	$4,502.00	$52,479.00
2063	$134.00	$4,563.00	$53,085.00
2064	$135.00	$4,625.00	$53,691.00
2065	$136.00	$4,686.00	$54,296.00
2066	$138.00	$4,747.00	$54,902.00

Action-related SC GHG were estimated by calendar-year for the projected action's lifecycle. Annual estimates were found by multiplying the annual emission for a given year by the corresponding IWG Annual SC GHG Emission value (see table above).

Action-Related Annual SC GHG ($K/yr [In 2020 $])				
YEAR	**CO2**	**CH4**	**N2O**	**GHG**
2025	$160.36	$0.23	$1.72	$162.31
2026	$162.29	$0.24	$1.72	$164.25
2027	$166.16	$0.24	$1.77	$168.18
2028	$168.09	$0.26	$1.83	$170.18
2029	$170.02	$0.27	$1.83	$172.12
2030	$171.95	$0.27	$1.89	$174.11
2031	$175.82	$0.28	$1.89	$177.98
2032	$177.75	$0.28	$1.95	$179.97

2033	$181.61	$0.29	$2.00	$183.90
2034	$183.54	$0.30	$2.00	$185.85
2035	$185.48	$0.30	$2.06	$187.84
2036	$189.34	$0.31	$2.06	$191.71
2037	$191.27	$0.32	$2.12	$193.71
2038	$193.21	$0.32	$2.18	$195.70
2039	$197.07	$0.33	$2.18	$199.57
2040	$199.00	$0.33	$2.23	$201.56
2041	$200.93	$0.34	$2.23	$203.51
2042	$204.80	$0.35	$2.29	$207.44
2043	$206.73	$0.35	$2.35	$209.43
2044	$208.66	$0.36	$2.35	$211.37
2045	$212.53	$0.37	$2.40	$215.30
2046	$214.46	$0.37	$2.46	$217.29
2047	$216.39	$0.38	$2.46	$219.23
2048	$220.25	$0.39	$2.52	$223.17
2049	$222.19	$0.39	$2.58	$225.16
2050	$224.12	$0.40	$2.58	$227.10
2051	$227.98	$0.41	$2.62	$231.01
2052	$229.91	$0.41	$2.66	$232.99
2053	$231.85	$0.42	$2.69	$234.96
2054	$235.71	$0.43	$2.73	$238.86
2055	$220.54	$0.41	$2.71	$223.66
2056 [SS Year]	$222.33	$0.42	$2.74	$225.49
2057	$225.92	$0.42	$2.77	$229.12
2058	$227.71	$0.43	$2.81	$230.95
2059	$229.51	$0.43	$2.84	$232.78
2060	$233.09	$0.44	$2.88	$236.41
2061	$234.89	$0.45	$2.91	$238.24
2062	$236.68	$0.45	$2.94	$240.08
2063	$240.26	$0.46	$2.98	$243.70
2064	$242.06	$0.47	$3.01	$245.54
2065	$243.85	$0.47	$3.05	$247.37
2066	$247.44	$0.48	$3.08	$251.00

The following two tables summarize the U.S. and State’s Annual SC GHG by calendar-year. The U.S. and State’s Annual SC GHG are in 2020 dollars and were estimated by each year for the projected action lifecycle. Annual SC GHG estimates were found by multiplying the U.S. and State’s annual five-year average GHG emissions for a given year by the corresponding IWG Annual SC GHG Cost per Metric Ton value.

State’s Annual SC GHG ($K/yr [In 2020 $])				
YEAR	**CO2**	**CH4**	**N2O**	**GHG**
2025	$27,966,876.69	$3,448,557.38	$1,663,780.19	$33,079,214.26
2026	$28,303,827.01	$3,605,309.99	$1,663,780.19	$33,572,917.19
2027	$28,977,727.65	$3,605,309.99	$1,719,239.53	$34,302,277.18
2028	$29,314,677.97	$3,762,062.60	$1,774,698.87	$34,851,439.44
2029	$29,651,628.30	$3,918,815.21	$1,774,698.87	$35,345,142.37
2030	$29,988,578.62	$3,918,815.21	$1,830,158.21	$35,737,552.04
2031	$30,662,479.26	$4,075,567.81	$1,830,158.21	$36,568,205.29
2032	$30,999,429.58	$4,075,567.81	$1,885,617.55	$36,960,614.95
2033	$31,673,330.22	$4,232,320.42	$1,941,076.89	$37,846,727.54
2034	$32,010,280.55	$4,389,073.03	$1,941,076.89	$38,340,430.47
2035	$32,347,230.87	$4,389,073.03	$1,996,536.23	$38,732,840.13
2036	$33,021,131.51	$4,545,825.64	$1,996,536.23	$39,563,493.38

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2037	$33,358,081.83	$4,702,578.25	$2,051,995.57	$40,112,655.65
2038	$33,695,032.15	$4,702,578.25	$2,107,454.91	$40,505,065.31
2039	$34,368,932.80	$4,859,330.86	$2,107,454.91	$41,335,718.56
2040	$34,705,883.12	$4,859,330.86	$2,162,914.25	$41,728,128.23
2041	$35,042,833.44	$5,016,083.46	$2,162,914.25	$42,221,831.16
2042	$35,716,734.08	$5,172,836.07	$2,218,373.59	$43,107,943.75
2043	$36,053,684.40	$5,172,836.07	$2,273,832.93	$43,500,353.41
2044	$36,390,634.73	$5,329,588.68	$2,273,832.93	$43,994,056.34
2045	$37,064,535.37	$5,486,341.29	$2,329,292.27	$44,880,168.93
2046	$37,401,485.69	$5,486,341.29	$2,384,751.61	$45,272,578.59
2047	$37,738,436.01	$5,643,093.90	$2,384,751.61	$45,766,281.52
2048	$38,412,336.66	$5,799,846.51	$2,440,210.95	$46,652,394.11
2049	$38,749,286.98	$5,799,846.51	$2,495,670.29	$47,044,803.77
2050	$39,086,237.30	$5,956,599.11	$2,495,670.29	$47,538,506.70
2051	$39,760,137.94	$5,998,922.32	$2,540,980.57	$48,300,040.83
2052	$40,097,088.26	$6,094,541.41	$2,574,588.93	$48,766,218.60
2053	$40,434,038.58	$6,191,728.03	$2,608,141.83	$49,233,908.44
2054	$41,107,939.23	$6,287,347.12	$2,641,750.19	$50,037,036.54
2055	$41,444,889.55	$6,382,966.21	$2,675,358.55	$50,503,214.31
2056 [SS Year]	$41,781,839.87	$6,480,152.83	$2,708,911.45	$50,970,904.15
2057	$42,455,740.51	$6,575,771.92	$2,742,519.81	$51,774,032.24
2058	$42,792,690.84	$6,672,958.53	$2,776,128.17	$52,241,777.54
2059	$43,129,641.16	$6,768,577.62	$2,809,681.07	$52,707,899.85
2060	$43,803,541.80	$6,864,196.72	$2,843,289.43	$53,511,027.95
2061	$44,140,492.12	$6,961,383.33	$2,876,897.79	$53,978,773.25
2062	$44,477,442.44	$7,057,002.42	$2,910,450.69	$54,444,895.56
2063	$45,151,343.09	$7,152,621.51	$2,944,059.05	$55,248,023.65
2064	$45,488,293.41	$7,249,808.13	$2,977,667.41	$55,715,768.95
2065	$45,825,243.73	$7,345,427.22	$3,011,220.31	$56,181,891.26
2066	$46,499,144.37	$7,441,046.31	$3,044,828.67	$56,985,019.36

U.S. Annual SC GHG ($K/yr [In 2020 $])				
YEAR	**CO2**	**CH4**	**N2O**	**GHG**
2025	$426,325,696.86	$56,379,205.70	$45,021,229.08	$527,726,131.63
2026	$431,462,151.04	$58,941,896.86	$45,021,229.08	$535,425,276.98
2027	$441,735,059.39	$58,941,896.86	$46,521,936.72	$547,198,892.97
2028	$446,871,513.57	$61,504,588.03	$48,022,644.35	$556,398,745.96
2029	$452,007,967.75	$64,067,279.20	$48,022,644.35	$564,097,891.30
2030	$457,144,421.93	$64,067,279.20	$49,523,351.99	$570,735,053.12
2031	$467,417,330.29	$66,629,970.37	$49,523,351.99	$583,570,652.65
2032	$472,553,784.47	$66,629,970.37	$51,024,059.62	$590,207,814.46
2033	$482,826,692.83	$69,192,661.54	$52,524,767.26	$604,544,121.62
2034	$487,963,147.01	$71,755,352.70	$52,524,767.26	$612,243,266.97
2035	$493,099,601.18	$71,755,352.70	$54,025,474.90	$618,880,428.78
2036	$503,372,509.54	$74,318,043.87	$54,025,474.90	$631,716,028.31
2037	$508,508,963.72	$76,880,735.04	$55,526,182.53	$640,915,881.29
2038	$513,645,417.90	$76,880,735.04	$57,026,890.17	$647,553,043.11
2039	$523,918,326.26	$79,443,426.21	$57,026,890.17	$660,388,642.63
2040	$529,054,780.44	$79,443,426.21	$58,527,597.80	$667,025,804.45
2041	$534,191,234.62	$82,006,117.38	$58,527,597.80	$674,724,949.80
2042	$544,464,142.97	$84,568,808.54	$60,028,305.44	$689,061,256.96
2043	$549,600,597.15	$84,568,808.54	$61,529,013.08	$695,698,418.77
2044	$554,737,051.33	$87,131,499.71	$61,529,013.08	$703,397,564.12
2045	$565,009,959.69	$89,694,190.88	$63,029,720.71	$717,733,871.28

2046	$570,146,413.87	$89,694,190.88	$64,530,428.35	$724,371,033.10
2047	$575,282,868.05	$92,256,882.05	$64,530,428.35	$732,070,178.44
2048	$585,555,776.41	$94,819,573.22	$66,031,135.98	$746,406,485.61
2049	$590,692,230.59	$94,819,573.22	$67,531,843.62	$753,043,647.42
2050	$595,828,684.76	$97,382,264.38	$67,531,843.62	$760,742,792.77
2051	$606,101,593.12	$98,074,191.00	$68,757,921.76	$772,933,705.88
2052	$611,238,047.30	$99,637,432.61	$69,667,350.59	$780,542,830.50
2053	$616,374,501.48	$101,226,301.14	$70,575,278.71	$788,176,081.32
2054	$626,647,409.84	$102,789,542.75	$71,484,707.53	$800,921,660.12
2055	$631,783,864.02	$104,352,784.36	$72,394,136.36	$808,530,784.74
2056 [SS Year]	$636,920,318.20	$105,941,652.89	$73,302,064.48	$816,164,035.56
2057	$647,193,226.55	$107,504,894.50	$74,211,493.31	$828,909,614.36
2058	$652,329,680.73	$109,093,763.02	$75,120,922.14	$836,544,365.89
2059	$657,466,134.91	$110,657,004.63	$76,028,850.26	$844,151,989.80
2060	$667,739,043.27	$112,220,246.25	$76,938,279.08	$856,897,568.60
2061	$672,875,497.45	$113,809,114.77	$77,847,707.91	$864,532,320.13
2062	$678,011,951.63	$115,372,356.38	$78,755,636.03	$872,139,944.04
2063	$688,284,859.99	$116,935,598.00	$79,665,064.86	$884,885,522.84
2064	$693,421,314.17	$118,524,466.52	$80,574,493.68	$892,520,274.37
2065	$698,557,768.34	$120,087,708.13	$81,482,421.80	$900,127,898.28
2066	$708,830,676.70	$121,650,949.74	$82,391,850.63	$912,873,477.08

Relative Comparison of SC GHG:

To provide additional real-world context to the potential climate change impact associate with an action, a Relative Comparison of SC GHG Assessment is also performed. While the SC GHG estimates capture an indirect approximation of global climate damages, the Relative Comparison of SC GHG Assessment provides a better perspective from a regional and global scale.

The Relative Comparison of SC GHG Assessment uses the rule of reason and the concept of proportionality along with the consideration of the affected area (yGba.e., global, national, and regional) and the SC GHG as the degree (intensity) of the proposed action's effects. The Relative Comparison Assessment provides real-world context and allows for a reasoned choice among alternatives through a relative contrast analysis which weighs each alternative's SC GHG proportionally against (or relative to) existing global, national, and regional SC GHG. The below table provides a relative comparison between an action's SC GHG vs. state and U.S. projected SC GHG for the same time period:

Total SC-GHG ($K [In 2020 $])					
		CO2	**CH4**	**N2O**	**GHG**
2025-2066	State Total	$1,561,090,839.68	$229,477,980.85	$98,592,952.22	$1,889,161,772.76
2025-2066	U.S. Total	$23,797,192,211.31	$3,751,651,735.39	$2,667,886,001.31	$30,216,729,948.01
2025-2066	Action	$8,733.75	$15.26	$101.07	$8,850.09
Percent of State Totals		0.00055946%	0.00000665%	0.00010251%	0.00046847%
Percent of U.S. Totals		0.00003670%	0.00000041%	0.00000379%	0.00002929%

From a global context, the action alternative's total SC GHG percentage of total global SC GHG for the same time period is: 0.00000392%.*

* Global value based on the U.S. emits 13.4% of all global GHG annual emissions (2018 Emissions Data, Center for Climate and Energy Solutions, accessed 7-6-2023, https://www.c2es.org/content/international-emissions).

AIR CONFORMITY APPLICABILITY MODEL REPORT
GREENHOUSE GAS (GHG) EMISSIONS

Adam Poll, Civilian/Senior Air Quality Specialist	Jun 26 2024
Name, Title	**Date**

Launch, Landing, and Static Fire

						Emission Factors						Emissions							Emissions						
			<3,000ft			Pounds per burn second						Tons emitted per launch						Metric tons per Activity	Tons per year						Metric tons per year
Type	Stage	Fuel	Burn time (seconds)	Number of Engines	Annual Activities	VOC	NOx	CO	SOx	PM10	PM2.5	VOC	NOx	CO	SOx	PM10	PM2.5	CO2e	VOC	NOx	CO	SOx	PM10	PM2.5	CO2e
Launch Falcon 9	1	RP1/LOX	23	9	50	0.00	9.42	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	273.96	0.00	5.42	0.00	0.00	0.00	0.00	13,697.79
Landing (Offshore) Falcon 9	1	RP1/LOX	18	3	43	0.00	3.14	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	90.41	0.00	1.22	0.00	0.00	0.00	0.00	3,887.43
Landing (VSFB) Falcon 9	1	RP1/LOX	18	3	7	0.00	3.14	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	90.41	0.00	0.20	0.00	0.00	0.00	0.00	632.84
Static Fire Falcon 9	1	RP1/LOX	7	9	30	0.00	9.42	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	18.26	0.00	0.99	0.00	0.00	0.00	0.00	547.91
																		Total	0.00	7.82	0.00	0.00	0.00	0.00	18,765.97

Emission Factors Per Engine

	Emission Factors (pounds per second per engine)						
Propellant	VOC	NOx	CO	SOx	PM10	PM2.5	CO2
RP-1/LOX	0.00	1.05	0.00	0.00	0.00	0.00	639.12

Source: Exhaust Plume Calculations for SpaceX Merlin5 Booster Engine, Sierra Engineering & Software, Inc. (June 14, 2019)

Notes:

Launch emissions include fuel spent up to 3,000 ft AGL.

Landing emissions include all intermittent burns below 3,000 ft AGL.

Static fire assumes all 9 engines with a 7 second burn time.

Landing emissions assumed to be 33% of nominal power (only 3 engines used).

Launch GHG emissions include fuel spent up to 100,000ft MSL (approximately 105 seconds).

Landing GHG emissions include all intermittent burns below 100,000 ft MSL.

Booster Recovery Operations

																Emissions (<3 nm)											Emissions (3-12 nm)										
Vessel	Operations Per Year	Total Ship time on Range	Engines and Generators		Horsepower	Emission Factors (g/kWh)										Tons							Metric Tons				Tons							Metric Tons			
		Hours	No.	Load		VOCs	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O	VOCs	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O	CO2e	VOCs	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O	CO2e
Tugboat	43	68	2	0.5	850	0.53	2.60	1.10	0.41	0.19	0.19	0.00	656.12	0.01	0.03	0.01	0.04	0.02	0.01	0.00	0.00	0.00	8.46	0.00	0.00	8.58	0.02	0.11	0.05	0.02	0.01	0.01	0.00	25.39	0.00	0.00	25.74
	43	68	2	0.31	133	0.53	2.60	1.10	0.41	0.19	0.19	0.00	656.12	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.82	0.00	0.00	0.83	0.00	0.01	0.00	0.00	0.00	0.00	0.00	2.46	0.00	0.00	2.50
Support Boat	43	68	1	0.5	3,900	0.53	2.60	1.10	0.41	0.19	0.19	0.00	656.12	0.01	0.03	0.02	0.08	0.04	0.01	0.01	0.01	0.00	19.42	0.00	0.00	19.68	0.05	0.25	0.11	0.04	0.02	0.02	0.00	58.25	0.00	0.00	59.04
	43	68	2	0.31	114	0.53	2.60	1.10	0.41	0.19	0.19	0.00	656.12	0.01	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.71	0.00	0.01	0.00	0.00	0.00	0.00	0.00	2.11	0.00	0.00	2.14
Barge	43	12	1	0.6	2,600	0.53	2.60	1.10	0.41	0.19	0.19	0.00	656.12	0.01	0.03	0.00	0.01	0.01	0.00	0.00	0.00	0.00	2.74	0.00	0.00	2.78	0.01	0.04	0.02	0.01	0.00	0.00	0.00	8.22	0.00	0.00	8.34
	43	68	1	0.6	268	0.18	2.50	0.90	0.16	0.22	0.22	0.00	568.30	0.03	0.03	0.00	0.01	0.00	0.00	0.00	0.00	0.00	1.39	0.00	0.00	1.41	0.00	0.02	0.01	0.00	0.00	0.00	0.00	4.16	0.00	0.00	4.23
															Total	**0.03**	**0.15**	**0.06**	**0.02**	**0.01**	**0.01**	**0.00**	**33.53**	**0.00**	**0.00**	**33.99**	**0.09**	**0.44**	**0.19**	**0.07**	**0.03**	**0.03**	**0.00**	**100.60**	**0.00**	**0.00**	**101.98**

Notes:

Total ship time, engine specifics, and emission factors consistent with the 2023 SEA.

Fairing Recovery Operations

Vessel	Operations Per Year	Total Ship time on Range	Engines and Generators		Horsepower	Emission Factors (g/kWh)									
		Hours	No.	Load		VOCs	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
Support Boat	43	68	2	0.6	820	0.53	2.60	1.10	0.41	0.19	0.19	0.00	656.12	0.01	0.03

Vessel	Emissions (<3 nm)										
	Tons							Metric Tons			
	VOCs	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O	CO2e
Support Boat	0.01	0.04	0.02	0.01	0.00	0.00	0.00	9.80	0.00	0.00	9.93

Vessel	Emissions (3-12 nm)										
	Tons							Metric Tons			
	VOCs	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O	CO2e
Support Boat	0.03	0.13	0.05	0.02	0.01	0.01	0.00	29.39	0.00	0.00	29.79

Notes:

Total ship time, engine specifics, and emission factors consistent with the 2023 SEA.

Equipment	NO_x	ROC	CO	SO_x	PM	PM_{10}	$PM_{2.5}$
Falcon 9 RP-1							
lb/day		0.68					
TPY		0.01					
RSV Loading							
lb/day		95.81					
TPY		0.05					
Payload Fueling							
lb/day	14.84	0.15					
TPY	0.11	0.00					
Solvent Use							
lb/day		45.54					
TPY		5.93					
Total Emissions							
lb/day	**14.84**	**142.19**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
TPY	**0.11**	**5.99**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**

Falcon 9 Potential to Emit Calculations

Attachment: A-1
Permit Number: PTO 15069
Facility: SpaceX

RP-1 and System Input Data

Information	*Value*	*Units*	*Reference*
Specific Gravity at System Temp…………….	0.840	--	Material Specifications
Vapor Pressure @ 20 °F………………………..	0.00088	psi	Material Specifications
Vapor Molecular Weight……………………….	148.00	lb/lb-mol	Material Specifications
Gas Constant…………………………………….	10.73	scf-psi/°R-lb-mol	Ideal Gas Laws
System and RP-1 Temperature…….……...	474.67	°R	Permit Application
RP-1 Emission Factor………………………	0.00003	lb/ft^3	Calculated Value

Maximum Process Event Summary

Event Name	*Value*	*Units*	*Reference*
Events……………………………………………	50	events/year	Permit Application
Static Launch and Abort Events…………………	30	events/year	Permit Application
Events per day	2	events/day	Permit Application
Event Vehicle RP-1 Throughput Volume……….	48,500	gals/event	Permit Application
Event Fill Line Throughput Volume…………….	1,543	gals/event	Permit Application
Daily Launch Volume…………………………….	50,043	gals/day	Calculated Value
Daily Static Launch and Abort Volume……….	50,043	gals/day	Calculated Value
Daily Launch Volume…………………………….	6,690	ft^3/day	Calculated Value
Daily Static Launch and Abort Volume……….	13,380	ft^3/day	Calculated Value
Annual Launch Volume………………………….	2,502,150	gals/year	Calculated Value
Annual Static Launch and Abort Volume……….	2,502,150	gals/year	Calculated Value
Annual Launch Volume………………………….	334,490	ft^3/yr	Calculated Value
Annual Static Launch and Abort Volume………	334,490	ft^3/yr	Calculated Value

ROC Potential to Emit

Process	lb/day	TPY
Launches	0.34	0.00
Static Launches/Abort	0.68	0.00
Total PTE	**0.68**	**0.01**

Notes:
1. One Falcon 9 launch or static launch/abort permitted per day. PTE reflects the worst case scenario.

Processed By: KMB Date: 2/11/2020

RSV Loading Potential to Emit Calculations

Attachment: A-3
Permit Number: PTO 15069
Facility: SpaceX

RP-1 and System Input Data

Information	*Value*	*Units*	*Reference*
Specific Gravity at System Temp................	0.809	--	Material Specifications
Vapor Pressure @ 70 °F................................	0.011	psi	Material Specifications
Vapor Molecular Weight..............................	148.00	lb/lb-mol	Material Specifications
Gas Constant..	10.73	scf-psi/°R-lb-mol	Ideal Gas Laws
System and RP-1 Temperature.................	529.67	°R	Permit Application
RP-1 Emission Factor...........................	0.00029	lb/ft^3	Calculated Value

RP-1 Fuel Consumption

Consumption Operations	*Value*	*Units*	*Reference*
Worst Case Daily RP-1 Consumption............	378,000	gals/day	Equal to Total RP-1 Tank Calcs
Worst Case Annual RP-1 Consumption.......	2,502,150	gals	Falcon 9 Annual Launch Volume
Falcon 9 RP-1 Consumption.........................	334,490	ft^3	Calculated Values

ROC Potential to Emit

lb/day	TPY
95.81	0.05

Processed By: KMB

Date: 2/11/2020

Payload Fueling Potential to Emit Calculations

Attachment: A-4
Permit Number: PTO 15069
Facility: SpaceX

Payload/Unloading Input Data

Information	*Value*	*Units*	*Reference*
Flow Rate (loading/unloading).............	5.00	scf/min	Permit Application
MMH Molecular Weight.....................	60.10	lb/lb-mol	Permit Application
N_2O_4 Molecular Weight..................	92.01	lb/lb-mol	Permit Application
Molar Denisty...........................	0.00264	lb-mole/scf	Permit Application
Processing Time........................	4	hours	Permit Application
Loading Annual Operations................	10	events/year	Permit Application
Unloading Annual Operations.............	5	events/year	Permit Application
Loading Control Efficiency...........	99.95	%	Permit Application
Unloading Control Efficiency..........	95.70	%	Permit Application
NO_x Fugitives Per Event..................	2.31	lb/event	Permit Application
ROC Fugitives Per Event..................	0.058	lb/event	Permit Application

Payload Loading Controlled Potential to Emit

Propellant	Pollutant	lb/day	TPY
N_2O_4	NO_x	12.53	0.06
MMH	ROC	0.10	0.00
N_2O_4	NO_x (Fugitives)	2.31	0.01
MMH	ROC (Fugitives)	0.06	0.00

Payload Unloading Controlled Potential to Emit

Propellant	Pollutant	lb/day	TPY
N_2O_4	NO_x	12.53	0.03
MMH	ROC	0.10	0.00
N_2O_4	NO_x (Fugitives)	2.31	0.01
MMH	ROC (Fugitives)	0.06	0.00

Total Potential to Emit

Propellant	Pollutant	lb/day	TPY
N_2O_4	NO_x	14.84	0.11
MMH	ROC	0.15	0.00

Notes:
1. One payload loading or unloading event permitted per day.
   PTE reflects the worst case scenario.

Processed By: KMB

Date: 2/11/2020

SpaceX Marine Transport Project
Emissions Summary

Project Emissions

Source Category	**VOC**	**NO_x**	**CO**	**SO_x**	**PM_{10}**	**$PM_{2.5}$**	**CO_2e**
	(ton/yr)						**MT/yr**
Marine	1.04	9.98	26.96	0.37	0.22	0.22	3,515.09
Offroad	0.02	0.36	0.54	0.00	0.00	0.00	68.59
Total	1.06	10.34	27.51	0.37	0.22	0.22	3,583.68
general conformity de minimis threshold	100	100	100	100	100	100	NA
Significant?	**No**	**No**	**No**	**No**	**No**	**No**	**NA**

SpaceX Marine Transport Project

185 days contingency

Marine Emission Estimates Day 2 - Elizabeth C

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (days/yr)	Emission Factors VOC (g/kW-hr)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20
Tugboat	Transit	Propulsion	4	0.1%S	2	1,300	969	0.75	24.00	23	0.19	1.80	5.00	0.07	0.04	0.04	715.76	0.01	0.03
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	23	0.38	5.02	5.00	0.07	0.12	0.12	656.00	0.01	0.03
Emission Subtotals																			

Boat Classification	Maximum Daily Emissions VOC (lb/day)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	Annual Emissions VOC (ton/yr)	NOx	CO	SOx	PM10	PM2.5	CO2 (MT/yr)	CH4	N20	CO2E
Tugboat	14.62	138.49	384.69	5.23	3.08	3.08	55,069.54	2.23	0.77	0.17	1.59	4.42	0.06	0.04	0.04	574.52	0.02	0.01	577.49
Tugboat	0.46	6.10	6.07	0.08	0.15	0.15	796.22	0.04	0.01	0.01	0.07	0.07	0.00	0.00	0.00	8.31	0.00	0.00	8.35
Emission Subtotals	**15.08**	**144.58**	**390.76**	**5.31**	**3.22**	**3.22**	**55,865.76**	**2.27**	**0.78**	**0.17**	**1.66**	**4.49**	**0.06**	**0.04**	**0.04**	**582.83**	**0.02**	**0.01**	**585.85**

Note:
The project would operate in federal waters 53 nautical miles one-way.

Marine Emission Estimates Day 3 - Elizabeth C

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (days/yr)	Emission Factors VOC (g/kW-hr)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20
Tugboat	Transit	Propulsion	4	0.1%S	2	1,300	969	0.75	24.00	92	0.19	1.80	5.00	0.07	0.04	0.04	715.76	0.01	0.03
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	92	0.38	5.02	5.00	0.07	0.12	0.12	656.00	0.01	0.03
Emission Subtotals																			

Boat Classification	Maximum Daily Emissions VOC (lb/day)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	Annual Emissions VOC (ton/yr)	NOx	CO	SOx	PM10	PM2.5	CO2 (MT/yr)	CH4	N20	CO2E
Tugboat	14.62	138.49	384.69	5.23	3.08	3.08	55,069.54	2.23	0.77	0.67	6.37	17.70	0.24	0.14	0.14	2,298.08	0.09	0.03	2,309.98
Tugboat	0.46	6.10	6.07	0.08	0.15	0.15	796.22	0.04	0.01	0.02	0.28	0.28	0.00	0.01	0.01	33.23	0.00	0.00	33.41
Emission Subtotals	**15.08**	**144.58**	**390.76**	**5.31**	**3.22**	**3.22**	**55,865.76**	**2.27**	**0.78**	**0.69**	**6.65**	**17.98**	**0.24**	**0.15**	**0.15**	**2,331.31**	**0.09**	**0.03**	**2,343.39**

Note:
The project would operate in federal waters 147 nautical miles one-way.

Marine Emission Estimates Day 4 - Elizabeth C

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (days/yr)	Emission Factors VOC (g/kW-hr)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20
Tugboat	Transit	Propulsion	4	0.1%S	2	1,300	969	0.75	24.00	23	0.19	1.80	5.00	0.07	0.04	0.04	715.76	0.01	0.03
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	23	0.38	5.02	5.00	0.07	0.12	0.12	656.00	0.01	0.03
Emission Subtotals																			

Boat Classification	Maximum Daily Emissions VOC (lb/day)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	Annual Emissions VOC (ton/yr)	NOx	CO	SOx	PM10	PM2.5	CO2 (MT/yr)	CH4	N20	CO2E
Tugboat	14.62	138.49	384.69	5.23	3.08	3.08	55,069.54	2.23	0.77	0.17	1.59	4.42	0.06	0.04	0.04	574.52	0.02	0.01	577.49
Tugboat	0.46	6.10	6.07	0.08	0.15	0.15	796.22	0.04	0.01	0.01	0.07	0.07	0.00	0.00	0.00	8.31	0.00	0.00	8.35
Emission Subtotals	**15.08**	**144.58**	**390.76**	**5.31**	**3.22**	**3.22**	**55,865.76**	**2.27**	**0.78**	**0.17**	**1.66**	**4.49**	**0.06**	**0.04**	**0.04**	**582.83**	**0.02**	**0.01**	**585.85**

Note:
The project would operate in federal waters 147 nautical miles one-way.

	VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	CO2E
Total	**1.04**	**9.98**	**26.96**	**0.37**	**0.22**	**0.22**	**3,496.96**	**0.14**	**0.05**	**3,515.09**

Emission Factors

Marine Propulsion

Engine Type	Engine Family	Model	Tier	Fuel	VOC (g/kW-hr)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
Slow Speed Diesel		<=1999	Tier 0	0.1%S	0.600	17.01	1.4	0.39	0.26	0.24	589	0.012	0.029
Medium Speed Diesel		<=1999	Tier 0	0.1%S	0.500	13.16	1.1	0.43	0.26	0.24	649	0.010	0.029
Slow Speed Diesel		2000-2010	Tier 1	0.1%S	0.600	15.98	1.4	0.39	0.26	0.24	589	0.012	0.029
Medium Speed Diesel		2000-2010	Tier 1	0.1%S	0.500	12.22	1.1	0.43	0.26	0.24	649	0.010	0.029
Slow Speed Diesel		2011-2015	Tier 2	0.1%S	0.600	14.38	1.4	0.39	0.26	0.24	589	0.012	0.029
Medium Speed Diesel		2011-2015	Tier 2	0.1%S	0.500	10.53	1.1	0.43	0.26	0.24	649	0.010	0.029
Slow Speed Diesel		2016+	Tier 3	0.1%S	0.600	3.38	1.4	0.39	0.26	0.24	589	0.012	0.029
Medium Speed Diesel		2016+	Tier 3	0.1%S	0.500	2.63	1.1	0.43	0.26	0.24	649	0.010	0.029
EPA Certification	HCEXN19.0AAA		Tier 3	0.1%S	0.392	5.21	5.0	0.07	0.11	0.11	716		
EPA Certification	D233051MX03		Tier 4	0.1%S	0.190	1.80	5.0	0.07	0.04	0.04	716		

Notes:
Emission factors from Table 2.3 and 2.4 of the 2019 Port of Los Angeles Emission Inventory Methodology Report
Load factors for propulsion engines based on Table 3.1 of the of the 2019 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 1 to CFR §1042.101.

Marine Auxiliary

Engine Type	Model	Tier	Fuel	VOC (g/kW-hr)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
Aux High Speed Diesel	<=1999	Tier 0	0.1%S	0.600	10.9	1.1	0.455	0.26	0.24	656	0.010	0.029
Aux Med Speed Diesel	<=1999	Tier 0	0.1%S	0.600	13.82	1.4	0.455	0.26	0.24	686	0.012	0.029
Aux High Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	9.78	1.1	0.455	0.26	0.24	656	0.010	0.029
Aux Med Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	12.22	1.4	0.455	0.26	0.24	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	7.71	1.1	0.455	0.26	0.24	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	10.53	1.4	0.455	0.26	0.24	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	1.97	1.1	0.455	0.26	0.24	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	2.63	1.4	0.455	0.26	0.24	686	0.012	0.029
Aux Med Speed Diesel Tier 3 Standard	2011-2015	Tier 3	0.1%S	0.378	5.022	5	0.068	0.12	0.12			

Notes:
Emission factors from Table 2.9 and 2.10 of the 2019 Port of Los Angeles Emission Inventory Methodology Report
Load factors for propulsion engines based on Table 3.1 of the of the 2019 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 5 to CFR §1042.101.

Marine exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\ EF_i \times Eng_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF	=	*Emission factor in grams per horse-power hour*
Eng	=	*Number of engines*
AvgHP	=	*Maximum rated average horsepower*
Load	=	*Load factor*
Activity	=	*Hours of operation*
i	=	*Equipment type*

SpaceX Marine Transport Project

Off-Road Emission Estimates

Day 2									Emission Factors									Daily Emissions									Annual Emissions									
Construction Equipment	OFFROAD Model Category	Engine Tier	Quantity	Engine Rating	Engine Rating	Load Factor	Operation	Operation	VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O	VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O	CO2E
				(hp)	(kW)		(hr/day)	(day/yr)	(g/BHP-hr)									(lb/day)									(ton/yr)						(MT/yr)			
Generator-Barge	Generator Sets	4	1	49	37	0.74	24.00	23	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081	0.23	5.28	7.87	0.01	0.02	0.02	1,090	0.03	0.02	0.00	0.06	0.09	0.00	0.00	0.00	11.37	0.00	0.00	11.43
Emission Subtotals																		**0.23**	**5.28**	**7.87**	**0.01**	**0.02**	**0.02**	**1,090.29**	**0.03**	**0.02**	**0.00**	**0.06**	**0.09**	**0.00**	**0.00**	**0.00**	**11.37**	**0.00**	**0.00**	**11.43**

Day 3									Emission Factors									Daily Emissions									Annual Emissions									
Construction Equipment	OFFROAD Model Category	Engine Tier	Quantity	Engine Rating	Engine Rating	Load Factor	Operation	Operation	VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O	VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O	CO2E
				(hp)	(kW)		(hr/day)	(day/yr)	(g/BHP-hr)									(lb/day)									(ton/yr)						(MT/yr)			
Generator-Barge	Generator Sets	4	1	49	37	0.74	24.00	92	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081	0.23	5.28	7.87	0.01	0.02	0.02	1,090	0.03	0.02	0.01	0.24	0.36	0.00	0.00	0.00	45.50	0.00	0.00	45.73
Emission Subtotals																		**0.23**	**5.28**	**7.87**	**0.01**	**0.02**	**0.02**	**1,090.29**	**0.03**	**0.02**	**0.01**	**0.24**	**0.36**	**0.00**	**0.00**	**0.00**	**45.50**	**0.00**	**0.00**	**45.73**

Day 4									Emission Factors									Daily Emissions									Annual Emissions									
Construction Equipment	OFFROAD Model Category	Engine Tier	Quantity	Engine Rating	Engine Rating	Load Factor	Operation	Operation	VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O	VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O	CO2E
				(hp)	(kW)		(hr/day)	(day/yr)	(g/BHP-hr)									(lb/day)									(ton/yr)						(MT/yr)			
Generator-Barge	Generator Sets	4	1	49	37	0.74	24.00	23	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081	0.23	5.28	7.87	0.01	0.02	0.02	1,090	0.03	0.02	0.00	0.06	0.09	0.00	0.00	0.00	11.37	0.00	0.00	11.43
Emission Subtotals																		**0.23**	**5.28**	**7.87**	**0.01**	**0.02**	**0.02**	**1,090.29**	**0.03**	**0.02**	**0.00**	**0.06**	**0.09**	**0.00**	**0.00**	**0.00**	**11.37**	**0.00**	**0.00**	**11.43**

Notes:

Load factor for generator are defaults from CalEEMod 2016.3.2.

0.02	0.36	0.54	0.00	0.00	0.00	68.25	0.00	0.00	68.59

Emission Factors

Equipment Type	Year	Low HP	High HP	VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
				(g/BHP-hr)								
Generator Sets	Tier 4 Final	25	49	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081

Off-road mobile equipment exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\, EF_i \times Pop_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF	=	*Emission factor in grams per horse-power hour*
Pop	=	*Population, or the number of pieces of equipment*
AvgHP	=	*Maximum rated average horsepower*
Load	=	*Load factor*
Activity	=	*Hours of operation*
i	=	*Equipment type*

Roll-On Roll-Off Emissions - Los Angeles County Elizabeth C

Source Category	VOC	NO_x	CO	SO_x	PM_{10}	$PM_{2.5}$	Pb	CO2	CH4	N2O	CO2e
	ton/yr							MT/yr			
Marine Vessel	0.23	2.64	4.73	0.06	0.06	0.06	0.00	613.82	0.01	0.02	621.43
Off-Road	0.02	0.31	0.41	0.00	0.01	0.01	0.00	70.22	0.02	0.01	73.53
Total	**0.25**	**2.95**	**5.15**	**0.06**	**0.07**	**0.07**	**0.00**	**684.04**	**0.03**	**0.03**	**694.95**

Roll-On Roll-Off Emissions - Los Angeles County Elizabeth C

Marine Emission Estimates - Elizabeth C

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (hours/yr)	Emission Factors VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
											(g/kW-hr)									
Tugboat	Transit	Propulsion	4	0.1%S	2	1,300	969	1.00	24.00	312	0.19	1.80	5.00	0.07	0.04	0.04	0.00	715.76	0.01	0.03
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	312	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03
											(g/hp-hr)									
Generator-Barge	Transit	Generator Sets	4	0.1%S	1	49	37	0.74	24.00	312	0.12	2.75	4.10	0.01	0.01	0.01	-	568.30	0.02	0.01
Emission Subtotals																				

Boat Classification	Engine	Maximum Daily Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
		(lb/day)									
Tugboat	Propulsion	19.49	184.65	512.92	6.98	4.10	4.10	0.06	73,426.05	2.97	1.03
Tugboat	Auxiliary	0.46	6.10	6.07	0.08	0.15	0.15	0.00	796.22	0.04	0.01
Generator-Barge	Generator Sets	0.23	5.28	7.87	0.01	0.02	0.02	-	1,090.29	0.02	0.03
Emission Subtotals		**20.18**	**196.02**	**526.86**	**7.07**	**4.26**	**4.26**	**0.06**	**75,312.57**	**3.03**	**1.07**

Boat Classification	Engine	Annual Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
		(ton/yr)							(MT/yr)			
Tugboat	Propulsion	0.13	1.20	3.34	0.05	0.03	0.03	0.00	433.58	0.01	0.02	438.97
Tugboat	Auxiliary	0.00	0.04	0.04	0.00	0.00	0.00	0.00	4.70	0.00	0.00	4.77
Generator-Barge	Generator Sets	0.00	0.02	0.03	0.00	0.00	0.00	-	4.07	0.00	0.00	4.09
Emission Subtotals		**0.13**	**1.26**	**3.41**	**0.05**	**0.03**	**0.03**	**0.00**	**442.36**	**0.01**	**0.02**	**447.83**

Note:

Marine Emission Estimates - Bernardine C

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (hours/yr)	Emission Factors VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
											(g/kW-hr)									
Tugboat	Transit	Propulsion	3	0.1%S	2	500	373	1.00	24.00	312	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	312	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03
Emission Subtotals																				

Boat Classification	Engine	Maximum Daily Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
		(lb/day)									
Tugboat	Propulsion	15.47	205.49	197.28	2.68	4.34	4.34	0.02	28,240.79	1.14	0.39
Tugboat	Auxiliary	0.46	6.10	6.07	0.08	0.15	0.15	0.00	796.22	0.04	0.01
Emission Subtotals		**15.93**	**211.58**	**203.35**	**2.77**	**4.49**	**4.49**	**0.02**	**29,037.01**	**1.18**	**0.41**

Boat Classification	Engine	Annual Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
		(ton/yr)							(MT/yr)			
Tugboat	Propulsion	0.10	1.34	1.28	0.02	0.03	0.03	0.00	166.76	0.00	0.01	168.83
Tugboat	Auxiliary	0.00	0.04	0.04	0.00	0.00	0.00	0.00	4.70	0.00	0.00	4.77
Emission Subtotals		**0.10**	**1.38**	**1.32**	**0.02**	**0.03**	**0.03**	**0.00**	**171.46**	**0.00**	**0.01**	**173.60**

Note:

Emission Factors

Marine Propulsion

Engine Type	Engine Family	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
					(g/kW-hr)									
Slow Speed Diesel		<=1999	Tier 0	0.1%S	0.600	17.01	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		<=1999	Tier 0	0.1%S	0.500	13.16	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2000-2010	Tier 1	0.1%S	0.600	15.98	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2000-2010	Tier 1	0.1%S	0.500	12.22	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2011-2015	Tier 2	0.1%S	0.600	14.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2011-2015	Tier 2	0.1%S	0.500	10.53	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2016+	Tier 3	0.1%S	0.600	3.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2016+	Tier 3	0.1%S	0.500	2.63	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
EPA Certification	HCEXN19.0AAA		Tier 3	0.1%S	0.392	5.21	5.0	0.07	0.11	0.11	0.0006067	716		
EPA Certification	D233051MX03		Tier 4	0.1%S	0.190	1.80	5.0	0.07	0.04	0.04	0.0006067	716		

Notes:
Emission factors from Table 2.3 and 2.4 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 1 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.

Marine Auxiliary

Engine Type	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
				(g/kW-hr)									
Aux High Speed Diesel	<=1999	Tier 0	0.1%S	0.600	10.9	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	<=1999	Tier 0	0.1%S	0.600	13.82	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	9.78	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	12.22	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	7.71	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	10.53	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	1.97	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	2.63	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux Med Speed Diesel Tier 3 Standard	2011-2015	Tier 3	0.1%S	0.378	5.022	5	0.068	0.12	0.12	0.0006067			
				(g/hp-hr)									
Generator Sets		Tier 4 Final	0.1%S	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	-	568.2990	0.0180	0.0081

Notes:
Emission factors from Table 2.9 and 2.10 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
Load factors for auxiliary engines based on Table 3.1 of the of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 5 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.
Emission factors for generator sets are default emission factors from CalEEMod 2016.3.2, which relies on OFFROAD 2011.
See Table D-12 of the Carl Moyer Program Guidelines. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/msprog/moyer/guidelines/2011/2011cmp_guidelinesVER4.pdf?_ga=2.218661721.1589730523.1723135078-1780396104.1706050686

Marine exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\, EF_i \times Eng_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF	=	*Emission factor in grams per horse-power hour*
Eng	=	*Number of engines*
AvgHP	=	*Maximum rated average horsepower*
Load	=	*Load factor*
Activity	=	*Hours of operation*
i	=	*Equipment type*

Roll-On Roll-Off Emissions - Los Angeles County Elizabeth C

Off-Road Emission Estimates

Construction Equipment	OFFROAD Model Category	Engine Tier	Quantity	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (day/yr)
Crane-LR 1300	Crane	3	1	603	450	0.29	16	36
Crane-Tadano ATF 220G	Crane	4	1	197	147	0.29	8	36
KMAG	Off-Highway Truck	3	1	453	338	0.3	4.0	36
Emission Subtotals								

Construction Equipment	Emission Factors VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
	(g/BHP-hr)								
Crane-LR 1300	0.12	2.32	2.6	0.005	0.088	0.088	510.334	0.152	0.068138
Crane-Tadano ATF 220G	0.0600	0.2600	3.7000	0.0050	0.0080	0.0080	514.2600	0.1540	0.0690
KMAG	0.1200	2.3200	2.6000	0.0050	0.0088	0.0088	528.8080	0.1540	0.0690
Emission Subtotals									

Construction Equipment	Daily Emissions VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	Annual Emissions CO2	CH4	N2O	CO2E
	(lb/day)									(MT/yr)			
Crane-LR 1300	0.74	14.31	16.04	0.03	0.54	0.54	3,147.87	0.94	0.42	51.40	0.02	0.01	53.83
Crane-Tadano ATF 220G	0.06	0.26	3.73	0.01	0.01	0.01	518.16	0.16	0.07	8.46	0.00	0.00	8.86
KMAG	0.14	2.78	3.12	0.01	0.01	0.01	634	0.18	0.08	10.35	0.00	0.00	10.83
Emission Subtotals	**0.94**	**17.35**	**22.88**	**0.04**	**0.56**	**0.56**	**4,300.12**	**1.28**	**0.57**	**70.22**	**0.02**	**0.01**	**73.53**

Notes:

Emission factors are default emission factors from CalEEMod 2016.3.2, which relies on OFFROAD 2011.

Load factor for generator and cranes are defaults from CalEEMod 2016.3.2.

Load factor for KMAG based on average speed over route compared to rated maximum travel speed.

See Table D-12 of the Carl Moyer Program Guidelines. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/msprog/moyer/guidelines/2011/2011cmp_guidelinesVER4.pdf?_ga=2.218661721.1589730523.1723135078-1780396104.1706050686

Emission Factors

Equipment Type	Year	Low HP	High HP	VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
								(g/BHP-hr)				
KMAG	Tier 3	300	599	0.1200	2.3200	2.6000	0.0050	0.0088	0.0088	528.8080	0.1540	0.0690
Generator Sets	Tier 4 Final	25	49	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081
Crane-LR 1300	Tier 3	600	750	0.1200	2.3200	2.6000	0.0050	0.0880	0.0880	510.3340	0.1520	0.0681
Crane-Tadano ATF 220G	Tier 4 Final	120	174	0.0600	0.2600	3.7000	0.0050	0.0080	0.0080	514.2600	0.1540	0.0690

Off-road mobile equipment exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\ EF_i \times Pop_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF	=	*Emission factor in grams per horse-power hour*
Pop	=	*Population, or the number of pieces of equipment*
AvgHP	=	*Maximum rated average horsepower*
Load	=	*Load factor*
Activity	=	*Hours of operation*
i	=	*Equipment type*

Roll-On Roll-Off Emissions Kelly C - Los Angeles County

Source Category	VOC	NO_x	CO	SO_x	PM_{10}	$PM_{2.5}$	Pb	CO2	CH4	N2O	CO2e
	ton/yr							MT/yr			
Marine Vessel	0.11	1.52	1.47	0.02	0.03	0.03	0.00	190.50	0.00	0.01	192.85
Off-Road	0.01	0.12	0.16	0.00	0.00	0.00	0.00	27.31	0.01	0.00	28.59
Total	**0.12**	**1.64**	**1.63**	**0.02**	**0.04**	**0.04**	**0.00**	**217.80**	**0.01**	**0.01**	**221.45**

Roll-On Roll-Off Emissions Kelly C - Los Angeles County

Marine Emission Estimates - Kelly C

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (hours/yr)	Emission Factors VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
											(g/kW-hr)									
Tugboat	Transit	Propulsion	3	0.1%S	2	1,000	746	1.00	24.00	116	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	116	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03
											(g/hp-hr)									
Generator-Barge	Transit	Generator Sets	4	0.1%S	1	49	37	0.74	24.00	116	0.12	2.75	4.10	0.01	0.01	0.01	-	568.30	0.02	0.01
Emission Subtotals																				

Boat Classification	Engine	Maximum Daily Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
		(lb/day)									
Tugboat	Propulsion	30.93	410.97	394.56	5.37	8.68	8.68	0.05	56,481.58	2.29	0.79
Tugboat	Auxiliary	0.46	6.10	6.07	0.08	0.15	0.15	0.00	796.22	0.04	0.01
Generator-Barge	Generator Sets	0.23	5.28	7.87	0.01	0.02	0.02	-	1,090.29	0.02	0.03
Emission Subtotals		**31.62**	**422.34**	**408.49**	**5.46**	**8.84**	**8.84**	**0.05**	**58,368.10**	**2.34**	**0.84**

Boat Classification	Engine	Annual Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
		(ton/yr)							(MT/yr)			
Tugboat	Propulsion	0.07	0.99	0.95	0.01	0.02	0.02	0.00	123.36	0.00	0.00	124.89
Tugboat	Auxiliary	0.00	0.01	0.01	0.00	0.00	0.00	0.00	1.74	0.00	0.00	1.76
Generator-Barge	Generator Sets	0.00	0.01	0.01	0.00	0.00	0.00	-	1.98	0.00	0.00	1.99
Emission Subtotals		**0.08**	**1.01**	**0.98**	**0.01**	**0.02**	**0.02**	**0.00**	**127.08**	**0.00**	**0.01**	**128.65**

Note:

Marine Emission Estimates - Bernardine C

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (hours/yr)	Emission Factors VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
											(g/kW-hr)									
Tugboat	Transit	Propulsion	3	0.1%S	2	500	373	1.00	24.00	116	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	116	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03
Emission Subtotals																				

Boat Classification	Engine	Maximum Daily Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
		(lb/day)									
Tugboat	Propulsion	15.47	205.49	197.28	2.68	4.34	4.34	0.02	28,240.79	1.14	0.39
Tugboat	Auxiliary	0.46	6.10	6.07	0.08	0.15	0.15	0.00	796.22	0.04	0.01
Emission Subtotals		**15.93**	**211.58**	**203.35**	**2.77**	**4.49**	**4.49**	**0.02**	**29,037.01**	**1.18**	**0.41**

Boat Classification	Engine	Annual Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
		(ton/yr)							(MT/yr)			
Tugboat	Propulsion	0.04	0.49	0.47	0.01	0.01	0.01	0.00	61.68	0.00	0.00	62.45
Tugboat	Auxiliary	0.00	0.01	0.01	0.00	0.00	0.00	0.00	1.74	0.00	0.00	1.76
Emission Subtotals		**0.04**	**0.51**	**0.49**	**0.01**	**0.01**	**0.01**	**0.00**	**63.42**	**0.00**	**0.00**	**64.21**

Note:

Emission Factors

Marine Propulsion

Engine Type	Engine Family	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
					(g/kW-hr)									
Slow Speed Diesel		<=1999	Tier 0	0.1%S	0.600	17.01	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		<=1999	Tier 0	0.1%S	0.500	13.16	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2000-2010	Tier 1	0.1%S	0.600	15.98	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2000-2010	Tier 1	0.1%S	0.500	12.22	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2011-2015	Tier 2	0.1%S	0.600	14.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2011-2015	Tier 2	0.1%S	0.500	10.53	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2016+	Tier 3	0.1%S	0.600	3.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2016+	Tier 3	0.1%S	0.500	2.63	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
EPA Certification	HCEXN19.0AAA		Tier 3	0.1%S	0.392	5.21	5.0	0.07	0.11	0.11	0.0006067	716		
EPA Certification	D233051MX03		Tier 4	0.1%S	0.190	1.80	5.0	0.07	0.04	0.04	0.0006067	716		

Notes:
Emission factors from Table 2.3 and 2.4 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 1 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.

Marine Auxiliary

Engine Type	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
				(g/kW-hr)									
Aux High Speed Diesel	<=1999	Tier 0	0.1%S	0.600	10.9	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	<=1999	Tier 0	0.1%S	0.600	13.82	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	9.78	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	12.22	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	7.71	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	10.53	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	1.97	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	2.63	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux Med Speed Diesel Tier 3 Standard	2011-2015	Tier 3	0.1%S	0.378	5.022	5	0.068	0.12	0.12	0.0006067			
				(g/hp-hr)									
Generator Sets		Tier 4 Final	0.1%S	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	-	568.2990	0.0180	0.0081

Notes:
Emission factors from Table 2.9 and 2.10 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
Load factors for auxiliary engines based on Table 3.1 of the of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 5 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.
Emission factors for generator sets are default emission factors from CalEEMod 2016.3.2, which relies on OFFROAD 2011 and the Carl Moyer Progam Guidelines.
See Table D-12 of the Carl Moyer Program Guidelines. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/msprog/moyer/guidelines/2011/2011cmp_guidelinesVER4.pdf?_ga=2.218661721.1589730523.1723135078-1780396104.1706050686

Marine exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\, EF_i \times Eng_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF	=	*Emission factor in grams per horse-power hour*
Eng	=	*Number of engines*
AvgHP	=	*Maximum rated average horsepower*
Load	=	*Load factor*
Activity	=	*Hours of operation*
i	=	*Equipment type*

Roll-On Roll-Off Emissions Kelly C - Los Angeles County

Off-Road Emission Estimates

									Emission Factors									Daily Emissions									Annual Emissions			
Construction Equipment	**OFFROAD Model Category**	**Engine Tier**	**Quantity**	**Engine Rating**	**Engine Rating**	**Load Factor**	**Operation**	**Operation**	**VOC**	**NOx**	**CO**	**SOx**	**PM10**	**PM2.5**	**CO2**	**CH4**	**N2O**	**VOC**	**NOx**	**CO**	**SOx**	**PM10**	**PM2.5**	**CO2**	**CH4**	**N20**	**CO2**	**CH4**	**N2O**	**CO2E**
				(hp)	(kW)		(hr/day)	(day/yr)	(g/BHP-hr)									(lb/day)									(MT/yr)			
Crane-LR 1300	Crane	3	1	603	450	0.29	16	14	0.12	2.32	2.6	0.005	0.088	0.088	510.334	0.152	0.068138	0.74	14.31	16.04	0.03	0.54	0.54	3,147.87	0.94	0.42	19.99	0.01	0.00	20.93
Crane-Tadano ATF 220G	Crane	4	1	197	147	0.29	8	14	0.0600	0.2600	3.7000	0.0050	0.0080	0.0080	514.2600	0.1540	0.0690	0.06	0.26	3.73	0.01	0.01	0.01	518.16	0.16	0.07	3.29	0.00	0.00	3.45
KMAG	Off-Highway Truck	3	1	453	338	0.3	4.0	14	0.1200	2.3200	2.6000	0.0050	0.0088	0.0088	528.8080	0.1540	0.0690	0.14	2.78	3.12	0.01	0.01	0.01	634	0.18	0.08	4.03	0.00	0.00	4.21
Emission Subtotals																		**0.94**	**17.35**	**22.88**	**0.04**	**0.56**	**0.56**	**4,300.12**	**1.28**	**0.57**	**27.31**	**0.01**	**0.00**	**28.59**

Notes:

Emission factors are default emission factors from CalEEMod 2016.3.2, which relies on OFFROAD 2011.

Load factor for generator and cranes are defaults from CalEEMod 2016.3.2.

Load factor for KMAG based on average speed over route compared to rated maximum travel speed.

See Table D-12 of the Carl Moyer Program Guidelines. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/msprog/moyer/guidelines/2011/2011cmp_guidelinesVER4.pdf?_ga=2.218661721.1589730523.1723135078-1780396104.1706050686

Emission Factors

Equipment Type	**Year**	**Low HP**	**High HP**	**VOC**	**NOx**	**CO**	**SOx**	**PM10**	**PM2.5**	**CO2**	**CH4**	**N2O**
				(g/BHP-hr)								
KMAG	Tier 3	300	599	0.1200	2.3200	2.6000	0.0050	0.0088	0.0088	528.8080	0.1540	0.0690
Generator Sets	Tier 4 Final	25	49	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081
Crane-LR 1300	Tier 3	600	750	0.1200	2.3200	2.6000	0.0050	0.0880	0.0880	510.3340	0.1520	0.0681
Crane-Tadano ATF 220G	Tier 4 Final	120	174	0.0600	0.2600	3.7000	0.0050	0.0080	0.0080	514.2600	0.1540	0.0690

Off-road mobile equipment exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\, EF_i \times Pop_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF	=	*Emission factor in grams per horse-power hour*
Pop	=	*Population, or the number of pieces of equipment*
AvgHP	=	*Maximum rated average horsepower*
Load	=	*Load factor*
Activity	=	*Hours of operation*
i	=	*Equipment type*

SpaceX Marine Transport Project
Emissions Summary

SpaceX Marine Transport Project

Marine Emission Estimates - Elizabeth C Day 1 and 4

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (days/yr)	Emission Factors VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20
											(g/kW-hr)								
Tugboat	Transit	Propulsion	4	0.1%S	2	1,300	969	1.00	6.00	46	0.19	1.80	5.00	0.07	0.04	0.04	715.76	0.01	0.03
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	6.00	46	0.38	5.02	5.00	0.07	0.12	0.12	656.00	0.01	0.03
Tugboat	Maneuvering	Propulsion	4	0.1%S	2	1,300	969	1.00	0.50	46	0.19	1.80	5.00	0.07	0.04	0.04	715.76	0.01	0.03
Tugboat	Maneuvering	Auxiliary	3	0.1%S	1	99	74	0.31	0.50	46	0.38	5.02	5.00	0.07	0.12	0.12	656.00	0.01	0.03
											(g/hp-hr)								
Generator-Barge	Transit	Generator Sets	4	0.1%S	1	49	37	0.74	6.50	46	0.12	2.75	4.10	0.01	0.01	0.01	568.30	0.02	0.01
Emission Subtotals																			

Boat Classification	Phase	Engine	Maximum Daily Emissions VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	Annual Emissions VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	CO2E
			(lb/day)									(ton/yr)						(MT/yr)			
Tugboat	Transit	Propulsion	4.87	46.16	128.23	1.74	1.03	1.03	18,356.51	0.74	0.26	0.11	1.06	2.95	0.04	0.02	0.02	383.01	0.02	0.01	385.00
Tugboat	Transit	Auxiliary	0.11	1.52	1.52	0.02	0.04	0.04	199.06	0.01	0.00	0.00	0.04	0.03	0.00	0.00	0.00	4.15	0.00	0.00	4.18
Tugboat	Maneuvering	Propulsion	0.41	3.85	10.69	0.15	0.09	0.09	1,529.71	0.06	0.02	0.01	0.09	0.25	0.00	0.00	0.00	31.92	0.00	0.00	32.08
Tugboat	Maneuvering	Auxiliary	0.01	0.13	0.13	0.00	0.00	0.00	16.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.35
Generator-Barge	Transit	Generator Sets	0.06	1.43	2.13	0.00	0.00	0.00	295.29	0.00	0.01	0.00	0.03	0.05	0.00	0.00	0.00	6.16	0.00	0.00	6.22
Emission Subtotals			**5.47**	**53.09**	**142.69**	**1.91**	**1.15**	**1.15**	**20,397.15**	**0.82**	**0.29**	**0.13**	**1.22**	**3.28**	**0.04**	**0.03**	**0.03**	**425.59**	**0.02**	**0.01**	**427.83**

Note:
The project would operate from the Port of Long Beach within SCAQMD waters up to 30 nautical miles, assuming average transit speed of 7.5 knots.

Marine Emission Estimates - Elizabeth C Day 2 and 5

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (days/yr)	Emission Factors VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20
											(g/kW-hr)								
Tugboat	Transit	Propulsion	4	0.1%S	2	1,300	969	1.00	6.50	46	0.19	1.80	5.00	0.07	0.04	0.04	715.76	0.01	0.03
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	6.50	46	0.38	5.02	5.00	0.07	0.12	0.12	656.00	0.01	0.03
											(g/hp-hr)								
Generator-Barge	Transit	Generator Sets	4	0.1%S	1	49	37	0.74	6.50	46	0.12	2.75	4.10	0.01	0.01	0.01	568.30	0.02	0.01
Emission Subtotals																			

Boat Classification	Phase	Engine	Maximum Daily Emissions VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	Annual Emissions VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	CO2E
			(lb/day)									(ton/yr)						(MT/yr)			
Tugboat	Transit	Propulsion	5.28	50.01	138.92	1.89	1.11	1.11	19,886.22	0.81	0.28	0.12	1.15	3.20	0.04	0.03	0.03	414.93	0.02	0.01	417.08
Tugboat	Transit	Auxiliary	0.12	1.65	1.64	0.02	0.04	0.04	215.64	0.01	0.00	0.00	0.04	0.04	0.00	0.00	0.00	4.50	0.00	0.00	4.52
Generator-Barge	Transit	Generator Sets	0.06	1.43	2.13	0.00	0.00	0.00	295.29	0.00	0.01	0.00	0.03	0.05	0.00	0.00	0.00	6.16	0.00	0.00	6.22
Emission Subtotals			**5.47**	**53.09**	**142.69**	**1.91**	**1.15**	**1.15**	**20,397.15**	**0.82**	**0.29**	**0.13**	**1.22**	**3.28**	**0.04**	**0.03**	**0.03**	**425.59**	**0.02**	**0.01**	**427.83**

Note:
The project would operate within SCAQMD waters up to 33.75 nautical miles, assuming average transit speed of 7.5 knots.

Emission Factors

Marine Propulsion

Engine Type	Engine Family	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
					(g/kW-hr)								
Slow Speed Diesel		<=1999	Tier 0	0.1%S	0.600	17.01	1.4	0.39	0.26	0.24	589	0.012	0.029
Medium Speed Diesel		<=1999	Tier 0	0.1%S	0.500	13.16	1.1	0.43	0.26	0.24	649	0.010	0.029
Slow Speed Diesel		2000-2010	Tier 1	0.1%S	0.600	15.98	1.4	0.39	0.26	0.24	589	0.012	0.029
Medium Speed Diesel		2000-2010	Tier 1	0.1%S	0.500	12.22	1.1	0.43	0.26	0.24	649	0.010	0.029
Slow Speed Diesel		2011-2015	Tier 2	0.1%S	0.600	14.38	1.4	0.39	0.26	0.24	589	0.012	0.029
Medium Speed Diesel		2011-2015	Tier 2	0.1%S	0.500	10.53	1.1	0.43	0.26	0.24	649	0.010	0.029
Slow Speed Diesel		2016+	Tier 3	0.1%S	0.600	3.38	1.4	0.39	0.26	0.24	589	0.012	0.029
Medium Speed Diesel		2016+	Tier 3	0.1%S	0.500	2.63	1.1	0.43	0.26	0.24	649	0.010	0.029
EPA Certification	HCEXN19.0AAA		Tier 3	0.1%S	0.392	5.21	5.0	0.07	0.11	0.11	716		
EPA Certification	D233051MX03		Tier 4	0.1%S	0.190	1.80	5.0	0.07	0.04	0.04	716		

Notes:
Emission factors from Table 2.3 and 2.4 of the 2019 Port of Los Angeles Emission Inventory Methodology Report
Load factors for propulsion engines based on Table 3.1 of the of the 2019 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 1 to CFR §1042.101.

Marine Auxiliary

Engine Type	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
				(g/kW-hr)								
Aux High Speed Diesel	<=1999	Tier 0	0.1%S	0.600	10.9	1.1	0.455	0.26	0.24	656	0.010	0.029
Aux Med Speed Diesel	<=1999	Tier 0	0.1%S	0.600	13.82	1.4	0.455	0.26	0.24	686	0.012	0.029
Aux High Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	9.78	1.1	0.455	0.26	0.24	656	0.010	0.029
Aux Med Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	12.22	1.4	0.455	0.26	0.24	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	7.71	1.1	0.455	0.26	0.24	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	10.53	1.4	0.455	0.26	0.24	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	1.97	1.1	0.455	0.26	0.24	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	2.63	1.4	0.455	0.26	0.24	686	0.012	0.029
Aux Med Speed Diesel Tier 3 Standard	2011-2015	Tier 3	0.1%S	0.378	5.022	5	0.068	0.12	0.12			
				(g/hp-hr)								
Generator Sets		Tier 4 Final	0.1%S	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081

Notes:
Emission factors from Table 2.9 and 2.10 of the 2019 Port of Los Angeles Emission Inventory Methodology Report
Load factors for propulsion engines based on Table 3.1 of the of the 2019 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 5 to CFR §1042.101.

Marine exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma EF_i \times Eng_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF = *Emission factor in grams per horse-power hour*
Eng = *Number of engines*
AvgHP = *Maximum rated average horsepower*
Load = *Load factor*
Activity = *Hours of operation*
i = *Equipment type*

SpaceX Marine Transport Project

Off-Road Emission Estimates

Construction Equipment	OFFROAD Model Category	Engine Tier	Quantity	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (day/yr)	Emission Factors (g/BHP-hr) VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
Crane-LR 1300	Crane	3	1	603	450	0.29	16	23	0.12	2.32	2.6	0.005	0.088	0.088	510.334	0.152	0.068138
Crane-Tadano ATF 220G	Crane	4	1	197	147	0.29	8	23	0.0600	0.2600	3.7000	0.0050	0.0080	0.0080	514.2600	0.1540	0.0690
KMAG	NA	3	1	453	338	0.3	4.0	23	0.1200	2.3200	2.6000	0.0050	0.0088	0.0088	528.8080	0.1540	0.0690
Emission Subtotals																	

Construction Equipment	Daily Emissions (lb/day) VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	Annual Emissions (MT/yr) CO2	CH4	N2O	CO2E
Crane-LR 1300	0.74	14.31	16.04	0.03	0.54	0.54	3,147.87	0.94	0.42	32.84	0.01	0.00	34.39
Crane-Tadano ATF 220G	0.06	0.26	3.73	0.01	0.01	0.01	518.16	0.16	0.07	5.41	0.00	0.00	5.66
KMAG	0.14	2.78	3.12	0.01	0.01	0.01	634	0.18	0.08	6.62	0.00	0.00	6.92
Emission Subtotals	**0.94**	**17.35**	**22.88**	**0.04**	**0.56**	**0.56**	**4,300.12**	**1.28**	**0.57**	**44.86**	**0.01**	**0.01**	**46.98**

Notes:

Emission factors are default emission factors from CalEEMod 2016.3.2, which relies on OFFROAD 2011.

Load factor for generator and cranes are defaults from CalEEMod 2016.3.2.

Load factor for KMAG based on average speed over route compared to rated maximum travel speed.

Emission Factors

Equipment Type	Year	Low HP	High HP	VOC (g/BHP-hr)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
KMAG	Tier 3	300	599	0.1200	2.3200	2.6000	0.0050	0.0088	0.0088	528.8080	0.1540	0.0690
Generator Sets	Tier 4 Final	25	49	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081
Crane-LR 1300	Tier 3	600	750	0.1200	2.3200	2.6000	0.0050	0.0880	0.0880	510.3340	0.1520	0.0681
Crane-Tadano ATF 220G	Tier 4 Final	120	174	0.0600	0.2600	3.7000	0.0050	0.0080	0.0080	514.2600	0.1540	0.0690

Off-road mobile equipment exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\, EF_i \times Pop_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF	=	*Emission factor in grams per horse-power hour*
Pop	=	*Population, or the number of pieces of equipment*
AvgHP	=	*Maximum rated average horsepower*
Load	=	*Load factor*
Activity	=	*Hours of operation*
i	=	*Equipment type*

Roll-On Roll-Off Emissions Elizabeth C - Santa Barbara County

Source Category	VOC	NO_x	CO	SO_x	PM_{10}	$PM_{2.5}$	Pb	CO2	CH4	N20	CO2e
	ton/yr							MT/yr			
Marine Vessel	0.52	5.87	10.55	0.14	0.13	0.13	0.00	1,367.66	0.02	0.06	1384.67
Off-Road	0.04	0.80	1.10	0.00	0.00	0.00	0.00	169.50	0.03	0.01	174.36
Total	**0.56**	**6.67**	**11.65**	**0.15**	**0.13**	**0.13**	**0.00**	**1,537.16**	**0.05**	**0.07**	**1,559.03**

Roll-On Roll-Off Emissions Elizabeth C - Santa Barbara County

Marine Emission Estimates - Elizabeth C

											Emission Factors										Maximum Daily Emissions										Annual Emissions										
Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating	Engine Rating	Load Factor	Operation	Operation	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
						(hp)	(kW)		(hr/day)	(hours/yr)	(g/kW-hr)										(lb/day)										(ton/year)							(MT/yr)			
Tugboat	Transit	Propulsion	4	0.1%S	2	1,300	969	1.00	24.00	701	0.19	1.80	5.00	0.07	0.04	0.04	0.00	715.76	0.01	0.03	19.49	184.65	512.92	6.98	4.10	4.10	0.06	73,426.05	2.97	1.03	0.28	2.70	7.49	0.10	0.06	0.06	0.00	972.52	0.01	0.04	984.60
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	701	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03	0.46	6.10	6.07	0.08	0.15	0.15	0.00	796.22	0.04	0.01	0.01	0.09	0.09	0.00	0.00	0.00	0.00	10.55	0.00	0.00	10.69
Emission Subtotals																					**19.95**	**190.75**	**518.99**	**7.06**	**4.25**	**4.25**	**0.06**	**74,222.28**	**3.01**	**1.04**	**0.29**	**2.78**	**7.58**	**0.10**	**0.06**	**0.06**	**0.00**	**983.07**	**0.01**	**0.04**	**995.29**

Note:

Marine Emission Estimates - Bernardine C

											Emission Factors										Maximum Daily Emissions										Annual Emissions										
Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating	Engine Rating	Load Factor	Operation	Operation	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
						(hp)	(kW)		(hr/day)	(hours/yr)	(g/kW-hr)										(lb/day)										(ton/yr)							(MT/yr)			
Tugboat	Transit	Propulsion	3	0.1%S	2	500	373	1.00	24.00	701	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03	15.47	205.49	197.28	2.68	4.34	4.34	0.02	28,240.79	1.14	0.39	0.23	3.00	2.88	0.04	0.06	0.06	0.00	374.05	0.01	0.02	378.69
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	701	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03	0.46	6.10	6.07	0.08	0.15	0.15	0.00	796.22	0.04	0.01	0.01	0.09	0.09	0.00	0.00	0.00	0.00	10.55	0.00	0.00	10.69
Emission Subtotals																					**15.93**	**211.58**	**203.35**	**2.77**	**4.49**	**4.49**	**0.02**	**29,037.01**	**1.18**	**0.41**	**0.23**	**3.09**	**2.97**	**0.04**	**0.07**	**0.07**	**0.00**	**384.59**	**0.01**	**0.02**	**389.38**

Note:

Marine Propulsion

Engine Type	Engine Family	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
					(g/kW-hr)									
Slow Speed Diesel		<=1999	Tier 0	0.1%S	0.600	17.01	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		<=1999	Tier 0	0.1%S	0.500	13.16	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2000-2010	Tier 1	0.1%S	0.600	15.98	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2000-2010	Tier 1	0.1%S	0.500	12.22	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2011-2015	Tier 2	0.1%S	0.600	14.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2011-2015	Tier 2	0.1%S	0.500	10.53	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2016+	Tier 3	0.1%S	0.600	3.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2016+	Tier 3	0.1%S	0.500	2.63	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
EPA Certification	HCEXN19.0AAA		Tier 3	0.1%S	0.392	5.21	5.0	0.07	0.11	0.11	0.0006067	716		
EPA Certification	D233051MX03		Tier 4	0.1%S	0.190	1.80	5.0	0.07	0.04	0.04	0.0006067	716		

Notes:

Emission factors from Table 2.3 and 2.4 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 1 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.

Marine Auxiliary

Engine Type	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
				(g/kW-hr)									
Aux High Speed Diesel	<=1999	Tier 0	0.1%S	0.600	10.9	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	<=1999	Tier 0	0.1%S	0.600	13.82	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	9.78	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	12.22	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	7.71	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	10.53	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	1.97	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	2.63	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux Med Speed Diesel Tier 3 Standard	2011-2015	Tier 3	0.1%S	0.378	5.022	5	0.068	0.12	0.12	0.0006067			

Notes:

Emission factors from Table 2.9 and 2.10 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
Load factors for auxiliary engines based on Table 3.1 of the of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 5 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.

Marine exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\, EF_i \times Eng_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF = *Emission factor in grams per horse-power hour*
Eng = *Number of engines*
AvgHP = *Maximum rated average horsepower*
Load = *Load factor*
Activity = *Hours of operation*
i = *Equipment type*

Roll-On Roll-Off Emissions Elizabeth C - Santa Barbara County

Off-Road Emission Estimates

Construction Equipment	OFFROAD Model Category	Engine Tier	Quantity	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (hours/yr)	Emission Factors VOC (g/BHP-hr)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
Crane-HTC-3140LB J8	Crane-transport	4	1	550	410	0.29	0.5	75	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	470.5495	0.1522	0.0682
Crane-HTC-3140LB J8	Crane-lift	4	1	215	160	0.29	2	300	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	472.9057	0.1529	0.0690
KMAG	Off-Highway Truck	3	1	453	338	0.30	8	1125	0.1200	2.3200	2.6000	0.0050	0.0088	0.0088	528.8080	0.1540	0.0690
Generator-Barge	Generator Sets	4	1	49	37	0.74	24.0	3600	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081
Emission Subtotals																	

Construction Equipment	Daily Emissions VOC (lb/day)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20
Crane-HTC-3140LB J8	0.01	0.05	0.39	0.00	0.00	0.00	82.73	0.03	0.01
Crane-HTC-3140LB J8	0.02	0.07	0.60	0.00	0.00	0.00	130.01	0.04	0.02
KMAG	0.27	5.21	5.84	0.01	0.02	0.02	1,188.24	0.35	0.16
Generator-Barge	0.23	5.28	7.87	0.01	0.02	0.02	1,090	0.03	0.02
Emission Subtotals	**0.53**	**10.61**	**14.70**	**0.02**	**0.04**	**0.04**	**2,491.27**	**0.45**	**0.20**

Construction Equipment	Annual Emissions VOC (ton/year)	NOx	CO	SOx	PM10	PM2.5	CO2 (MT/yr)	CH4	N2O	CO2E
Crane-HTC-3140LB J8	0.00	0.00	0.03	0.00	0.00	0.00	5.63	0.00	0.00	5.92
Crane-HTC-3140LB J8	0.00	0.01	0.05	0.00	0.00	0.00	8.85	0.00	0.00	9.30
KMAG	0.02	0.39	0.44	0.00	0.00	0.00	80.85	0.02	0.01	84.58
Generator-Barge	0.02	0.40	0.59	0.00	0.00	0.00	74.18	0.00	0.00	74.55
Emission Subtotals	**0.04**	**0.80**	**1.10**	**0.00**	**0.00**	**0.00**	**169.50**	**0.03**	**0.01**	**174.36**

Notes:

Emission factors are default emission factors from CalEEMod 2016.3.2, which relies on OFFROAD 2011.

Load factor for generator are defaults from CalEEMod 2016.3.2.

Load factor for KMAG based on average speed over route compared to rated maximum travel speed.

Fugitive dust emissions from paved roads assumes the KMAG is loaded.

See Table D-12 of the Carl Moyer Program Guidelines. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/msprog/moyer/guidelines/2011/2011cmp_guidelinesVER4.pdf?_ga=2.218661721.1589730523.1723135078-1780396104.1706050686

Emission Factors

Equipment Type	Year	Low HP	High HP	VOC (g/BHP-hr)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
KMAG	Tier 3	300	599	0.1200	2.3200	2.6000	0.0050	0.0088	0.0088	528.8080	0.1540	0.0690
Crane-HTC-3140LB J8	Tier 4 Final	175	299	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	472.9057	0.1529	0.0690
Crane-HTC-3140LB J8	Tier 4 Final	300	599	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	470.5495	0.1522	0.0682
Generator Sets	Tier 4 Final	25	49	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081

Off-road mobile equipment exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\, EF_i \times Pop_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF = *Emission factor in grams per horse-power hour*

Pop = *Population, or the number of pieces of equipment*

AvgHP = *Maximum rated average horsepower*

Load = *Load factor*

Activity = *Hours of operation*

i = *Equipment type*

Roll-On Roll-Off Emissions Kelly C - Santa Barbara County

Source Category	VOC	NO_x	CO	SO_x	PM_{10}	$PM_{2.5}$	Pb	CO2	CH4	N20	CO2e
	ton/yr							MT/yr			
Marine Vessel	0.26	3.39	3.26	0.04	0.07	0.07	0.00	422.84	0.01	0.02	428.10
Off-Road	0.00	0.05	0.07	0.00	0.00	0.00	0.00	11.30	0.00	0.00	11.62
Total	**0.26**	**3.45**	**3.33**	**0.04**	**0.07**	**0.07**	**0.00**	**434.14**	**0.01**	**0.02**	**439.72**

Roll-On Roll-Off Emissions Kelly C - Santa Barbara County

Marine Emission Estimates - Kelly C

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (hours/yr)
Tugboat	Transit	Propulsion	3	0.1%S	2	1,000	746	1.00	24.00	259
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	259
Emission Subtotals										

Emission Factors (g/kW-hr)	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
Tugboat – Propulsion	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03
Tugboat – Auxiliary	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03

Maximum Daily Emissions (lb/day)	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
Tugboat – Propulsion	30.93	410.97	394.56	5.37	8.68	8.68	0.05	56,481.58	2.29	0.79
Tugboat – Auxiliary	0.46	6.10	6.07	0.08	0.15	0.15	0.00	796.22	0.04	0.01
Emission Subtotals	**31.39**	**417.07**	**400.63**	**5.45**	**8.83**	**8.83**	**0.05**	**57,277.80**	**2.32**	**0.80**

Annual Emissions	VOC (ton/year)	NOx (ton/year)	CO (ton/year)	SOx (ton/year)	PM10 (ton/year)	PM2.5 (ton/year)	Pb (ton/year)	CO2 (MT/yr)	CH4 (MT/yr)	N20 (MT/yr)	CO2E (MT/yr)
Tugboat – Propulsion	0.17	2.22	2.13	0.03	0.05	0.05	0.00	276.69	0.00	0.01	280.13
Tugboat – Auxiliary	0.00	0.03	0.03	0.00	0.00	0.00	0.00	3.90	0.00	0.00	3.95
Emission Subtotals	**0.17**	**2.25**	**2.16**	**0.03**	**0.05**	**0.05**	**0.00**	**280.59**	**0.00**	**0.01**	**284.08**

Note:

Marine Emission Estimates - Bernardine C

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (hours/yr)
Tugboat	Transit	Propulsion	3	0.1%S	2	500	373	1.00	24.00	259
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	259
Emission Subtotals										

Emission Factors (g/kW-hr)	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
Tugboat – Propulsion	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03
Tugboat – Auxiliary	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03

Maximum Daily Emissions (lb/day)	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
Tugboat – Propulsion	15.47	205.49	197.28	2.68	4.34	4.34	0.02	28,240.79	1.14	0.39
Tugboat – Auxiliary	0.46	6.10	6.07	0.08	0.15	0.15	0.00	796.22	0.04	0.01
Emission Subtotals	**15.93**	**211.58**	**203.35**	**2.77**	**4.49**	**4.49**	**0.02**	**29,037.01**	**1.18**	**0.41**

Annual Emissions	VOC (ton/yr)	NOx (ton/yr)	CO (ton/yr)	SOx (ton/yr)	PM10 (ton/yr)	PM2.5 (ton/yr)	Pb (ton/yr)	CO2 (MT/yr)	CH4 (MT/yr)	N20 (MT/yr)	CO2E (MT/yr)
Tugboat – Propulsion	0.08	1.11	1.07	0.01	0.02	0.02	0.00	138.35	0.00	0.01	140.06
Tugboat – Auxiliary	0.00	0.03	0.03	0.00	0.00	0.00	0.00	3.90	0.00	0.00	3.95
Emission Subtotals	**0.09**	**1.14**	**1.10**	**0.01**	**0.02**	**0.02**	**0.00**	**142.25**	**0.00**	**0.01**	**144.02**

Note:

Marine Propulsion

Engine Type	Engine Family	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
					(g/kW-hr)									
Slow Speed Diesel		<=1999	Tier 0	0.1%S	0.600	17.01	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		<=1999	Tier 0	0.1%S	0.500	13.16	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2000-2010	Tier 1	0.1%S	0.600	15.98	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2000-2010	Tier 1	0.1%S	0.500	12.22	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2011-2015	Tier 2	0.1%S	0.600	14.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2011-2015	Tier 2	0.1%S	0.500	10.53	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2016+	Tier 3	0.1%S	0.600	3.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2016+	Tier 3	0.1%S	0.500	2.63	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
EPA Certification	HCEXN19.0AAA		Tier 3	0.1%S	0.392	5.21	5.0	0.07	0.11	0.11	0.0006067	716		
EPA Certification	D233051MX03		Tier 4	0.1%S	0.190	1.80	5.0	0.07	0.04	0.04	0.0006067	716		

Notes:
Emission factors from Table 2.3 and 2.4 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 1 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.

Marine Auxiliary

Engine Type	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
				(g/kW-hr)									
Aux High Speed Diesel	<=1999	Tier 0	0.1%S	0.600	10.9	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	<=1999	Tier 0	0.1%S	0.600	13.82	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	9.78	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	12.22	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	7.71	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	10.53	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	1.97	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	2.63	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux Med Speed Diesel Tier 3 Standard	2011-2015	Tier 3	0.1%S	0.378	5.022	5	0.068	0.12	0.12	0.0006067			
				(g/hp-hr)									
Generator Sets		Tier 4 Final	0.1%S	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	-	568.2990	0.0180	0.0081

Notes:
Emission factors from Table 2.9 and 2.10 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
Load factors for auxiliary engines based on Table 3.1 of the of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 5 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.

Marine exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\, EF_i \times Eng_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF	=	*Emission factor in grams per horse-power hour*
Eng	=	*Number of engines*
AvgHP	=	*Maximum rated average horsepower*
Load	=	*Load factor*
Activity	=	*Hours of operation*
i	=	*Equipment type*

Roll-On Roll-Off Emissions Kelly C - Santa Barbara County

Off-Road Emission Estimates

Construction Equipment	OFFROAD Model Category	Engine Tier	Quantity	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (hours/yr)	Emission Factors VOC (g/BHP-hr)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
Crane-HTC-3140LB J8	Crane-transport	4	1	550	410	0.29	0.5	5	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	470.5495	0.1522	0.0682
Crane-HTC-3140LB J8	Crane-lift	4	1	215	160	0.29	2	20	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	472.9057	0.1529	0.0690
KMAG	Off-Highway Truck	3	1	453	338	0.30	8	75	0.1200	2.3200	2.6000	0.0050	0.0088	0.0088	528.8080	0.1540	0.0690
Generator-Barge	Generator Sets	4	1	49	37	0.74	24.0	240	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081
Emission Subtotals																	

Construction Equipment	Daily Emissions VOC (lb/day)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20
Crane-HTC-3140LB J8	0.01	0.05	0.39	0.00	0.00	0.00	82.73	0.03	0.01
Crane-HTC-3140LB J8	0.02	0.07	0.60	0.00	0.00	0.00	130.01	0.04	0.02
KMAG	0.27	5.21	5.84	0.01	0.02	0.02	1,188.24	0.35	0.16
Generator-Barge	0.23	5.28	7.87	0.01	0.02	0.02	1,090	0.03	0.02
Emission Subtotals	**0.53**	**10.61**	**14.70**	**0.02**	**0.04**	**0.04**	**2,491.27**	**0.45**	**0.20**

Construction Equipment	Annual Emissions VOC (ton/year)	NOx	CO	SOx	PM10	PM2.5	CO2 (MT/yr)	CH4	N2O	CO2E
Crane-HTC-3140LB J8	0.00	0.00	0.00	0.00	0.00	0.00	0.38	0.00	0.00	0.39
Crane-HTC-3140LB J8	0.00	0.00	0.00	0.00	0.00	0.00	0.59	0.00	0.00	0.62
KMAG	0.00	0.03	0.03	0.00	0.00	0.00	5.39	0.00	0.00	5.64
Generator-Barge	0.00	0.03	0.04	0.00	0.00	0.00	4.95	0.00	0.00	4.97
Emission Subtotals	**0.00**	**0.05**	**0.07**	**0.00**	**0.00**	**0.00**	**11.30**	**0.00**	**0.00**	**11.62**

Notes:

Emission factors are default emission factors from CalEEMod 2016.3.2, which relies on OFFROAD 2011.

Load factor for generator are defaults from CalEEMod 2016.3.2.

Load factor for KMAG based on average speed over route compared to rated maximum travel speed.

Fugitive dust emissions from paved roads assumes the KMAG is loaded.

See Table D-12 of the Carl Moyer Program Guidelines. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/msprog/moyer/guidelines/2011/2011cmp_guidelinesVER4.pdf?_ga=2.218661721.1589730523.1723135078-1780396104.1706050686

Emission Factors

Equipment Type	Year	Low HP	High HP	VOC (g/BHP-hr)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
KMAG	Tier 3	300	599	0.1200	2.3200	2.6000	0.0050	0.0088	0.0088	528.8080	0.1540	0.0690
Crane-HTC-3140LB J8	Tier 4 Final	175	299	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	472.9057	0.1529	0.0690
Crane-HTC-3140LB J8	Tier 4 Final	300	599	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	470.5495	0.1522	0.0682
Generator Sets	Tier 4 Final	25	49	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081

Off-road mobile equipment exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\, EF_i \times Pop_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF	=	*Emission factor in grams per horse-power hour*
Pop	=	*Population, or the number of pieces of equipment*
AvgHP	=	*Maximum rated average horsepower*
Load	=	*Load factor*
Activity	=	*Hours of operation*
i	=	*Equipment type*

SpaceX Marine Transport Project
Emissions Summary

Existing Emissions

Source Category	VOC	NO_x	CO	SO_x	PM_{10}	$PM_{2.5}$	PM_{10}
	(lb/day)						ton/yr
Mobile	0.09	1.66	2.96	0.01	2.43	0.37	0.01
Off-Road	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	**0.09**	**1.66**	**2.96**	**0.01**	**2.43**	**0.37**	**0.01**
SBCAPCD CEQA Significance Threshold	240	240	240	240	-	240	25
Significant?	**No**	**No**	**No**	**No**	**-**	**No**	**No**
SBCAPCD AQIA Threshold	120	120	500	120	80	55	-
Exceeded?	**No**	**No**	**No**	**No**	**No**	**No**	**-**

Project Emissions - Gross - Day 2

Source Category	VOC	NO_x	CO	SO_x	PM_{10}	$PM_{2.5}$	PM_{10}
	(lb/day)						ton/yr

Marine Vessel	11.68	113.39	298.00	4.05	2.54	2.54	0.03
Off-Road	0.09	1.76	2.94	0.00	0.01	0.01	0.00
Total	**11.77**	**115.15**	**300.95**	**4.06**	**2.54**	**2.54**	**0.03**
SBCAPCD CEQA Significance Threshold	240	240	NA	240	80	80	25
Significant?	**No**	**No**	**No**	**No**	**No**	**No**	**No**

SpaceX Marine Transport Project

Marine Emission Estimates - Elizabeth C Day 2

											Emission Factors									Maximum Daily Emissions									Annual Emissions									
Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (days/yr)	VOC (g/kW-hr)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	VOC (lb/day)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	VOC (ton/year)	NOx	CO	SOx	PM10	PM2.5	CO2 (MT/yr)	CH4	N20	CO2E
Tugboat	Transit	Propulsion	4	0.1%S	2	1,300	969	1.00	13.50	23	0.19	1.80	5.00	0.07	0.04	0.04	715.76	0.01	0.03	10.96	103.87	288.52	3.92	2.31	2.31	41,302.16	1.67	0.58	0.13	1.19	3.32	0.05	0.03	0.03	430.89	0.02	0.01	433.12
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	13.50	23	0.38	5.02	5.00	0.07	0.12	0.12	656.00	0.01	0.03	0.26	3.43	3.41	0.05	0.08	0.08	447.88	0.02	0.01	0.00	0.04	0.04	0.00	0.00	0.00	4.67	0.00	0.00	4.70
Emission Subtotals																				**11.22**	**107.30**	**291.93**	**3.97**	**2.39**	**2.39**	**41,750.03**	**1.69**	**0.58**	**0.13**	**1.23**	**3.36**	**0.05**	**0.03**	**0.03**	**435.56**	**0.02**	**0.01**	**437.82**

Note:
The project would operate within the SBCAPCD jurisdiction for 37.2 nautical miles.

Marine Emission Estimates - Elizabeth C Day 3

											Emission Factors									Maximum Daily Emissions									Annual Emissions									
Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (days/yr)	VOC (g/kW-hr)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	VOC (lb/day)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	VOC (ton/year)	NOx	CO	SOx	PM10	PM2.5	CO2 (MT/yr)	CH4	N20	CO2E
Tugboat	Transit	Propulsion	4	0.1%S	2	1,300	969	1.00	2.00	23	0.19	1.80	5.00	0.07	0.04	0.04	715.76	0.01	0.03	1.62	15.39	42.74	0.58	0.34	0.34	6,118.84	0.25	0.09	0.02	0.18	0.49	0.01	0.00	0.00	63.84	0.00	0.00	64.17
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	2.00	23	0.38	5.02	5.00	0.07	0.12	0.12	656.00	0.01	0.03	0.04	0.51	0.51	0.01	0.01	0.01	66.35	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.69	0.00	0.00	0.70
Tugboat	Maneuvering	Propulsion	4	0.1%S	2	1,300	969	1.00	6.00	23	0.19	1.80	5.00	0.07	0.04	0.04	715.76	0.01	0.03	4.87	46.16	128.23	1.74	1.03	1.03	18,356.51	0.74	0.26	0.06	0.53	1.47	0.02	0.01	0.01	191.51	0.01	0.00	192.50
Tugboat	Maneuvering	Auxiliary	3	0.1%S	1	99	74	0.31	6.00	23	0.38	5.02	5.00	0.07	0.12	0.12	656.00	0.01	0.03	0.11	1.52	1.52	0.02	0.04	0.04	199.06	0.01	0.00	0.00	0.02	0.02	0.00	0.00	0.00	2.08	0.00	0.00	2.09
Tugboat	Contingency	Propulsion	4	0.1%S	2	1,300	969	1.00	2.00	23	0.19	1.80	5.00	0.07	0.04	0.04	715.76	0.01	0.03	1.62	15.39	42.74	0.58	0.34	0.34	6,118.84	0.25	0.09	0.02	0.18	0.49	0.01	0.00	0.00	63.84	0.00	0.00	64.17
Tugboat	Contingency	Auxiliary	3	0.1%S	1	99	74	0.31	2.00	23	0.38	5.02	5.00	0.07	0.12	0.12	656.00	0.01	0.03	0.04	0.51	0.51	0.01	0.01	0.01	66.35	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.69	0.00	0.00	0.70
Emission Subtotals																				**8.31**	**79.48**	**216.25**	**2.94**	**1.77**	**1.77**	**30,925.95**	**1.25**	**0.43**	**0.10**	**0.91**	**2.49**	**0.03**	**0.02**	**0.02**	**322.64**	**0.01**	**0.00**	**324.31**

Note:
The project would operate within the SBCAPCD jurisdiction for 34 nautical miles.

Marine Emission Estimates - Elizabeth C Day 4

											Emission Factors									Maximum Daily Emissions									Annual Emissions									
Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (days/yr)	VOC (g/kW-hr)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	VOC (lb/day)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	VOC (ton/year)	NOx	CO	SOx	PM10	PM2.5	CO2 (MT/yr)	CH4	N20	CO2E
Tugboat	Transit	Propulsion	4	0.1%S	2	1,300	969	1.00	13.50	23	0.19	1.80	5.00	0.07	0.04	0.04	715.76	0.01	0.03	10.96	103.87	288.52	3.92	2.31	2.31	41,302.16	1.67	0.58	0.13	1.19	3.32	0.05	0.03	0.03	430.89	0.02	0.01	433.12
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	13.50	23	0.38	5.02	5.00	0.07	0.12	0.12	656.00	0.01	0.03	0.26	3.43	3.41	0.05	0.08	0.08	447.88	0.02	0.01	0.00	0.04	0.04	0.00	0.00	0.00	4.67	0.00	0.00	4.70
Emission Subtotals																				**11.22**	**107.30**	**291.93**	**3.97**	**2.39**	**2.39**	**41,750.03**	**1.69**	**0.58**	**0.13**	**1.23**	**3.36**	**0.05**	**0.03**	**0.03**	**435.56**	**0.02**	**0.01**	**437.82**

Note:
The project would operate within the SBCAPCD jurisdiction for 37.2 nautical miles.

Marine Emission Estimates - Bernardine C Day 1

											Emission Factors									Maximum Daily Emissions									Annual Emissions									
Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (days/yr)	VOC (g/kW-hr)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	VOC (lb/day)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	VOC (ton/yr)	NOx	CO	SOx	PM10	PM2.5	CO2 (MT/yr)	CH4	N20	CO2E
Tugboat	Transit	Propulsion	3	0.1%S	2	500	373	0.50	24.00	23	0.39	5.21	5.00	0.07	0.11	0.11	715.76	0.01	0.03	7.73	102.74	98.64	1.34	2.17	2.17	14,120.40	0.57	0.20	0.09	1.18	1.13	0.02	0.02	0.02	147.31	0.01	0.00	148.08
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	23	0.38	5.02	5.00	0.07	0.12	0.12	656.00	0.01	0.03	0.46	6.10	6.07	0.08	0.15	0.15	796.22	0.04	0.01	0.01	0.07	0.07	0.00	0.00	0.00	8.31	0.00	0.00	8.35
Tugboat	Hoteling	Auxiliary	3	0.1%S	1	99	74	0.31	0.00	23	0.38	5.02	5.00	0.07	0.12	0.12	656.00	0.01	0.03	-	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	-	-	-	-
Emission Subtotals																				**8.19**	**108.84**	**104.71**	**1.42**	**2.32**	**2.32**	**14,916.62**	**0.61**	**0.21**	**0.09**	**1.25**	**1.20**	**0.02**	**0.03**	**0.03**	**155.62**	**0.01**	**0.00**	**156.43**

Note:
The project would operate within the SBCAPCD jurisdiction for 64 nautical miles from Port of Hueneme.

Marine Emission Estimates - Bernardine C Day 2 and 4

											Emission Factors									Maximum Daily Emissions									Annual Emissions									
Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (days/yr)	VOC (g/kW-hr)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	VOC (lb/day)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	VOC (ton/yr)	NOx	CO	SOx	PM10	PM2.5	CO2 (MT/yr)	CH4	N20	CO2E
Tugboat	Hoteling	Propulsion	3	0.1%S	2	500	373	0.50	0.00	46	0.39	5.21	5.00	0.07	0.11	0.11	715.76	0.01	0.03	-	-	-	-	-	-	0.00	-	-	-	-	-	-	-	-	-	-	-	-
Tugboat	Hoteling	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	46	0.38	5.02	5.00	0.07	0.12	0.12	656.00	0.01	0.03	0.46	6.10	6.07	0.08	0.15	0.15	796.22	0.04	0.01	0.01	0.14	0.14	0.00	0.00	0.00	18.31	0.00	0.00	18.42
Emission Subtotals																				**0.46**	**6.10**	**6.07**	**0.08**	**0.15**	**0.15**	**796.22**	**0.04**	**0.01**	**0.01**	**0.14**	**0.14**	**0.00**	**0.00**	**0.00**	**18.31**	**0.00**	**0.00**	**18.42**

Note: The project would be docked at VSFB harbor.

Marine Emission Estimates - Bernardine C Day 3

											Emission Factors									Maximum Daily Emissions									Annual Emissions									
Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (days/yr)	VOC (g/kW-hr)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	VOC (lb/day)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	VOC (ton/yr)	NOx	CO	SOx	PM10	PM2.5	CO2 (MT/yr)	CH4	N20	CO2E
Tugboat	Manuevering	Propulsion	3	0.1%S	2	500	373	0.50	4.50	23	0.39	5.21	5.00	0.07	0.11	0.11	715.76	0.01	0.03	1.45	19.26	18.49	0.25	0.41	0.41	2,647.57	0.11	0.04	0.02	0.22	0.21	0.00	0.00	0.00	27.62	0.00	0.00	27.76
Tugboat	Manuevering	Auxiliary	3	0.1%S	1	99	74	0.31	4.50	23	0.38	5.02	5.00	0.07	0.12	0.12	656.00	0.01	0.03	0.09	1.14	1.14	0.02	0.03	0.03	149.29	0.01	0.00	0.00	0.01	0.01	0.00	0.00	0.00	1.56	0.00	0.00	1.57
Tugboat	Contingency	Propulsion	3	0.1%S	2	500	373	0.50	0.33	23	0.39	5.21	5.00	0.07	0.11	0.11	715.76	0.01	0.03	0.11	1.41	1.36	0.02	0.03	0.03	194.16	0.01	0.00	0.00	0.02	0.02	0.00	0.00	0.00	2.03	0.00	0.00	2.04
Tugboat	Contingency	Auxiliary	3	0.1%S	1	99	74	0.31	0.33	23	0.38	5.02	5.00	0.07	0.12	0.12	656.00	0.01	0.03	0.01	0.08	0.08	0.00	0.00	0.00	10.95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.11
Tugboat	Hoteling	Auxiliary	3	0.1%S	1	99	74	0.31	19.17	23	0.38	5.02	5.00	0.07	0.12	0.12	656.00	0.01	0.03	0.37	4.87	4.85	0.07	0.12	0.12	635.98	0.03	0.01	0.00	0.06	0.06	0.00	0.00	0.00	6.63	0.00	0.00	6.67
Emission Subtotals																				**2.02**	**26.77**	**25.92**	**0.35**	**0.58**	**0.58**	**3,637.95**	**0.15**	**0.05**	**0.02**	**0.31**	**0.30**	**0.00**	**0.01**	**0.01**	**37.95**	**0.00**	**0.00**	**38.15**

Note:
The project would operate within the SBCAPCD jurisdiction for 61.7 nautical miles.

Marine Emission Estimates - Bernardine C Day 5

											Emission Factors									Maximum Daily Emissions									Annual Emissions									
Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (days/yr)	VOC (g/kW-hr)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	VOC (lb/day)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	VOC (ton/yr)	NOx	CO	SOx	PM10	PM2.5	CO2 (MT/yr)	CH4	N20	CO2E
Tugboat	Transit	Propulsion	3	0.1%S	2	500	373	0.50	24.00	23	0.39	5.21	5.00	0.07	0.11	0.11	715.76	0.01	0.03	7.73	102.74	98.64	1.34	2.17	2.17	14,120.40	0.57	0.20	0.09	1.18	1.13	0.02	0.02	0.02	147.31	0.01	0.00	148.08
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	23	0.38	5.02	5.00	0.07	0.12	0.12	656.00	0.01	0.03	0.46	6.10	6.07	0.08	0.15	0.15	796.22	0.04	0.01	0.01	0.07	0.07	0.00	0.00	0.00	8.31	0.00	0.00	8.35
Emission Subtotals																				**8.19**	**108.84**	**104.71**	**1.42**	**2.32**	**2.32**	**14,916.62**	**0.61**	**0.21**	**0.09**	**1.25**	**1.20**	**0.02**	**0.03**	**0.03**	**155.62**	**0.01**	**0.00**	**156.43**
																																			1,561.27	**0.06**	**0.02**	**1,569.38**

Note:
The project would operate within the SBCAPCD jurisdiction for 64 nautical miles from Port of Hueneme.

Marine Propulsion

Engine Type	Engine Family	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
									(g/kW-hr)				
Slow Speed Diesel		<=1999	Tier 0	0.1%S	0.600	17.01	1.4	0.39	0.26	0.24	589	0.012	0.029
Medium Speed Diesel		<=1999	Tier 0	0.1%S	0.500	13.16	1.1	0.43	0.26	0.24	649	0.010	0.029
Slow Speed Diesel		2000-2010	Tier 1	0.1%S	0.600	15.98	1.4	0.39	0.26	0.24	589	0.012	0.029
Medium Speed Diesel		2000-2010	Tier 1	0.1%S	0.500	12.22	1.1	0.43	0.26	0.24	649	0.010	0.029
Slow Speed Diesel		2011-2015	Tier 2	0.1%S	0.600	14.38	1.4	0.39	0.26	0.24	589	0.012	0.029
Medium Speed Diesel		2011-2015	Tier 2	0.1%S	0.500	10.53	1.1	0.43	0.26	0.24	649	0.010	0.029
Slow Speed Diesel		2016+	Tier 3	0.1%S	0.600	3.38	1.4	0.39	0.26	0.24	589	0.012	0.029
Medium Speed Diesel		2016+	Tier 3	0.1%S	0.500	2.63	1.1	0.43	0.26	0.24	649	0.010	0.029
EPA Certification	HCEXN19.0AAA		Tier 3	0.1%S	0.392	5.21	5.0	0.07	0.11	0.11	716		
EPA Certification	D233051MX03		Tier 4	0.1%S	0.190	1.80	5.0	0.07	0.04	0.04	716		

Notes:

Emission factors from Table 2.3 and 2.4 of the 2019 Port of Los Angeles Emission Inventory Methodology Report

Load factors for propulsion engines based on Table 3.1 of the of the 2019 Port of Los Angeles Emission Inventory Methodology Report

EPA certification based on Tier 3 rating for the engine family from Table 1 to CFR §1042.101.

Marine Auxiliary

Engine Type		Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
									(g/kW-hr)				
Aux High Speed Diesel		<=1999	Tier 0	0.1%S	0.600	10.9	1.1	0.455	0.26	0.24	656	0.010	0.029
Aux Med Speed Diesel		<=1999	Tier 0	0.1%S	0.600	13.82	1.4	0.455	0.26	0.24	686	0.012	0.029
Aux High Speed Diesel		2000-2010	Tier 1	0.1%S	0.600	9.78	1.1	0.455	0.26	0.24	656	0.010	0.029
Aux Med Speed Diesel		2000-2010	Tier 1	0.1%S	0.600	12.22	1.4	0.455	0.26	0.24	686	0.012	0.029
Aux High Speed Diesel		2011-2015	Tier 2	0.1%S	0.600	7.71	1.1	0.455	0.26	0.24	656	0.010	0.029
Aux Med Speed Diesel		2011-2015	Tier 2	0.1%S	0.600	10.53	1.4	0.455	0.26	0.24	686	0.012	0.029
Aux High Speed Diesel		2011-2015	Tier 3	0.1%S	0.600	1.97	1.1	0.455	0.26	0.24	656	0.010	0.029
Aux Med Speed Diesel		2011-2015	Tier 3	0.1%S	0.600	2.63	1.4	0.455	0.26	0.24	686	0.012	0.029
Aux Med Speed Diesel	Tier 3 Standard	2011-2015	Tier 3	0.1%S	0.378	5.022	5	0.068	0.12	0.12			

Notes:

Emission factors from Table 2.9 and 2.10 of the 2019 Port of Los Angeles Emission Inventory Methodology Report

Load factors for propulsion engines based on Table 3.1 of the of the 2019 Port of Los Angeles Emission Inventory Methodology Report

EPA certification based on Tier 3 rating for the engine family from Table 5 to CFR §1042.101.

Marine exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma EF_i \times Eng_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF	=	*Emission factor in grams per horse-power hour*
Eng	=	*Number of engines*
AvgHP	=	*Maximum rated average horsepower*
Load	=	*Load factor*
Activity	=	*Hours of operation*
i	=	*Equipment type*

SpaceX Marine Transport Project

Off-Road Emission Estimates

Day 2

Construction Equipment	OFFROAD Model Category	Engine Tier	Quantity	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (day/yr)
Crane-HTC-3140LB J8	Crane-transport	4	1	550	410	0.29	0.5	46
Crane-HTC-3140LB J8	Crane-lift	4	1	215	160	0.29	0	46
Generator-Barge	Generator Sets	4	1	49	37	0.74	7.8	46

Construction Equipment	Emission Factors (g/BHP-hr) VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
Crane-HTC-3140LB J8	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	470.5495	0.1522	0.0682
Crane-HTC-3140LB J8	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	472.9057	0.1529	0.0690
Generator-Barge	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081

Construction Equipment	Daily Emissions (lb/day) VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20
Crane-HTC-3140LB J8	0.01	0.05	0.39	0.00	0.00	0.00	82.73	0.03	0.01
Crane-HTC-3140LB J8	-	-	-	-	-	-	-	-	-
Generator-Barge	0.07	1.71	2.56	0.00	0.00	0.00	354	0.01	0.01
Emission Subtotals	**0.09**	**1.76**	**2.94**	**0.00**	**0.01**	**0.01**	**437.07**	**0.04**	**0.02**

Construction Equipment	Annual Emissions (ton/year) VOC	NOx	CO	SOx	PM10	PM2.5	(MT/yr) CO2	CH4	N2O	CO2E
Crane-HTC-3140LB J8	0.00	0.00	0.01	0.00	0.00	0.00	1.73	0.00	0.00	1.81
Crane-HTC-3140LB J8	-	-	-	-	-	-	-	-	-	-
Generator-Barge	0.00	0.04	0.06	0.00	0.00	0.00	7.39	0.00	0.00	7.43
Emission Subtotals	**0.00**	**0.04**	**0.07**	**0.00**	**0.00**	**0.00**	**9.12**	**0.00**	**0.00**	**9.25**

Notes:

Emission factors are default emission factors from CalEEMod 2016.3.2, which relies on OFFROAD 2011.

Load factor for generator are defaults from CalEEMod 2016.3.2.

Load factor for KMAG based on average speed over route compared to rated maximum travel speed.

Fugitive dust emissions from paved roads assumes the KMAG is loaded.

Day 3

Construction Equipment	OFFROAD Model Category	Engine Tier	Quantity	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (day/yr)
KMAG	NA	3	1	453	338	0.3	7.5	46
Crane-HTC-3140LB J8	Crane-transport	4	1	550	410	0.29	0.5	46
Crane-HTC-3140LB J8	Crane-lift	4	1	215	160	0.29	2	46
Generator-Barge	Generator Sets	4	1	49	37	0.74	21.5	46

Construction Equipment	Emission Factors (g/BHP-hr) VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
KMAG	0.1200	2.3200	2.6000	0.0050	0.0088	0.0088	528.8080	0.1540	0.0690
Crane-HTC-3140LB J8	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	470.5495	0.1522	0.0682
Crane-HTC-3140LB J8	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	472.9057	0.1529	0.0690
Generator-Barge	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081

Construction Equipment	Daily Emissions (lb/day) VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20
KMAG	0.27	5.22	5.85	0.01	0.50	0.14	1,189	0.35	0.16
Crane-HTC-3140LB J8	0.01	0.05	0.39	0.00	0.00	0.00	82.73	0.03	0.01
Crane-HTC-3140LB J8	0.02	0.07	0.60	0.00	0.00	0.00	130.01	0.04	0.02
Generator-Barge	0.21	4.73	7.05	0.01	0.01	0.01	977	0.03	0.01
Emission Subtotals	**0.50**	**10.06**	**13.88**	**0.02**	**0.51**	**0.15**	**2,378.38**	**0.45**	**0.20**

Construction Equipment	Annual Emissions (ton/year) VOC	NOx	CO	SOx	PM10	PM2.5	(MT/yr) CO2	CH4	N2O	CO2E
KMAG	0.01	0.12	0.13	0.00	0.01	0.00	24.81	0.01	0.00	25.95
Crane-HTC-3140LB J8	0.00	0.00	0.01	0.00	0.00	0.00	1.73	0.00	0.00	1.81
Crane-HTC-3140LB J8	0.00	0.00	0.01	0.00	0.00	0.00	2.71	0.00	0.00	2.85
Generator-Barge	0.00	0.11	0.16	0.00	0.00	0.00	20.38	0.00	0.00	20.48
Emission Subtotals	**0.01**	**0.23**	**0.32**	**0.00**	**0.01**	**0.00**	**49.63**	**0.01**	**0.00**	**51.10**
							58.75	0.01	0.00	60.35

Notes:

Emission factors are default emission factors from CalEEMod 2016.3.2, which relies on OFFROAD 2011.

Load factor for generator are defaults from CalEEMod 2016.3.2.

Load factor for KMAG based on average speed over route compared to rated maximum travel speed.

Fugitive dust emissions from paved roads assumes the KMAG is loaded.

Emission Factors

Equipment Type	Year	Low HP	High HP	VOC (g/BHP-hr)	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
KMAG	Tier 3	300	599	0.1200	2.3200	2.6000	0.0050	0.0088	0.0088	528.8080	0.1540	0.0690
Crane-HTC-3140LB J8	Tier 4 Final	175	299	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	472.9057	0.1529	0.0690
Crane-HTC-3140LB J8	Tier 4 Final	300	599	0.0600	0.2600	2.2000	0.0050	0.0080	0.0080	470.5495	0.1522	0.0682
Generator Sets	Tier 4 Final	25	49	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081

Off-road mobile equipment exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma EF_i \times Pop_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF	=	*Emission factor in grams per horse-power hour*
Pop	=	*Population, or the number of pieces of equipment*
AvgHP	=	*Maximum rated average horsepower*
Load	=	*Load factor*
Activity	=	*Hours of operation*
i	=	*Equipment type*

SpaceX Roll-On Roll-Off Proposed Action Elizabeth C Ventura County

Marine Emission Estimates - Elizabeth C

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (hours/yr)
Tugboat	Transit	Propulsion	4	0.1%S	2	1,300	969	1.00	24.00	701
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	701
Generator-Barge	Transit	Generator Sets	4	0.1%S	1	49	37	0.74	24.00	701
Emission Subtotals										

Boat Classification	Emission Factors VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
	(g/kW-hr)									
Tugboat (Propulsion)	0.19	1.80	5.00	0.07	0.04	0.04	0.00	715.76	0.01	0.03
Tugboat (Auxiliary)	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03
	(g/hp-hr)									
Generator-Barge	0.12	2.75	4.10	0.01	0.01	0.01	-	568.30	0.02	0.01

Boat Classification	Maximum Daily Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
	(lb/day)									
Tugboat (Propulsion)	19.49	184.65	512.92	6.98	4.10	4.10	0.06	73,426.05	2.97	1.03
Tugboat (Auxiliary)	0.46	6.10	6.07	0.08	0.15	0.15	0.00	796.22	0.04	0.01
Generator-Barge	0.23	5.28	7.87	0.01	0.02	0.02	-	1,090.29	0.02	0.03
Emission Subtotals	**20.18**	**196.02**	**526.86**	**7.07**	**4.26**	**4.26**	**0.06**	**75,312.57**	**3.03**	**1.07**

Boat Classification	Annual Emissions VOC (ton/yr)	NOx (ton/yr)	CO (ton/yr)	SOx (ton/yr)	PM10 (ton/yr)	PM2.5 (ton/yr)	Pb (ton/yr)	CO2 (MT/yr)	CH4 (MT/yr)	N20 (MT/yr)	CO2E (MT/yr)
Tugboat (Propulsion)	0.28	2.70	7.49	0.10	0.06	0.06	0.00	972.52	0.01	0.04	984.60
Tugboat (Auxiliary)	0.01	0.09	0.09	0.00	0.00	0.00	0.00	10.55	0.00	0.00	10.69
Generator-Barge	0.00	0.06	0.09	0.00	0.00	0.00	-	10.90	0.00	0.00	10.96
Emission Subtotals	**0.29**	**2.84**	**7.66**	**0.10**	**0.06**	**0.06**	**0.00**	**993.97**	**0.01**	**0.04**	**1,006.25**

Note:

Marine Emission Estimates - Bernardine C

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (hours/yr)
Tugboat	Transit	Propulsion	3	0.1%S	2	500	373	1.00	24.00	701
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	701
Emission Subtotals										

Boat Classification	Emission Factors VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
	(g/kW-hr)									
Tugboat (Propulsion)	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03
Tugboat (Auxiliary)	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03

Boat Classification	Maximum Daily Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
	(lb/day)									
Tugboat (Propulsion)	15.47	205.49	197.28	2.68	4.34	4.34	0.02	28,240.79	1.14	0.39
Tugboat (Auxiliary)	0.46	6.10	6.07	0.08	0.15	0.15	0.00	796.22	0.04	0.01
Emission Subtotals	**15.93**	**211.58**	**203.35**	**2.77**	**4.49**	**4.49**	**0.02**	**29,037.01**	**1.18**	**0.41**

Boat Classification	Annual Emissions VOC (ton/yr)	NOx (ton/yr)	CO (ton/yr)	SOx (ton/yr)	PM10 (ton/yr)	PM2.5 (ton/yr)	Pb (ton/yr)	CO2 (MT/yr)	CH4 (MT/yr)	N20 (MT/yr)	CO2E (MT/yr)
Tugboat (Propulsion)	0.23	3.00	2.88	0.04	0.06	0.06	0.00	374.05	0.01	0.02	378.69
Tugboat (Auxiliary)	0.01	0.09	0.09	0.00	0.00	0.00	0.00	10.55	0.00	0.00	10.69
Emission Subtotals	**0.23**	**3.09**	**2.97**	**0.04**	**0.07**	**0.07**	**0.00**	**384.59**	**0.01**	**0.02**	**389.38**

Note:

Emission Factors

Marine Propulsion

Engine Type	Engine Family	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
					(g/kW-hr)									
Slow Speed Diesel		<=1999	Tier 0	0.1%S	0.600	17.01	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		<=1999	Tier 0	0.1%S	0.500	13.16	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2000-2010	Tier 1	0.1%S	0.600	15.98	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2000-2010	Tier 1	0.1%S	0.500	12.22	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2011-2015	Tier 2	0.1%S	0.600	14.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2011-2015	Tier 2	0.1%S	0.500	10.53	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2016+	Tier 3	0.1%S	0.600	3.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2016+	Tier 3	0.1%S	0.500	2.63	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
EPA Certification	HCEXN19.0AAA		Tier 3	0.1%S	0.392	5.21	5.0	0.07	0.11	0.11	0.0006067	716		
EPA Certification	D233051MX03		Tier 4	0.1%S	0.190	1.80	5.0	0.07	0.04	0.04	0.0006067	716		

Notes:
Emission factors from Table 2.3 and 2.4 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 1 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.

Marine Auxiliary

Engine Type	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
				(g/kW-hr)									
Aux High Speed Diesel	<=1999	Tier 0	0.1%S	0.600	10.9	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	<=1999	Tier 0	0.1%S	0.600	13.82	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	9.78	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	12.22	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	7.71	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	10.53	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	1.97	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	2.63	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux Med Speed Diesel Tier 3 Standard	2011-2015	Tier 3	0.1%S	0.378	5.022	5	0.068	0.12	0.12	0.0006067			
				(g/hp-hr)									
Generator Sets		Tier 4 Final	0.1%S	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	-	568.2990	0.0180	0.0081

Notes:
Emission factors from Table 2.9 and 2.10 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
Load factors for auxiliary engines based on Table 3.1 of the of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 5 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.
Emission factors for generator sets are default emission factors from CalEEMod 2016.3.2, which relies on OFFROAD 2011 and the Carl Moyer Progam Guidelines.
See Table D-12 of the Carl Moyer Program Guidelines. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/msprog/moyer/guidelines/2011/2011cmp_guidelinesVER4.pdf?_ga=2.218661721.1589730523.1723135078-1780396104.1706050686

Marine exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\, EF_i \times Eng_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF	=	*Emission factor in grams per horse-power hour*
Eng	=	*Number of engines*
AvgHP	=	*Maximum rated average horsepower*
Load	=	*Load factor*
Activity	=	*Hours of operation*
i	=	*Equipment type*

SpaceX Roll-On Roll-Off Emissions Proposed Action Kelly C Ventura County

Marine Emission Estimates - Kelly C

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (hours/yr)	Emission Factors VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
											(g/kW-hr)									
Tugboat	Transit	Propulsion	3	0.1%S	2	1,000	746	1.00	24.00	259	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	259	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03
											(g/hp-hr)									
Generator-Barge	Transit	Generator Sets	4	0.1%S	1	49	37	0.74	24.00	259	0.12	2.75	4.10	0.01	0.01	0.01	-	568.30	0.02	0.01
Emission Subtotals																				

Boat Classification	Engine	Maximum Daily Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
		(lb/day)									
Tugboat	Propulsion	30.93	410.97	394.56	5.37	8.68	8.68	0.05	56,481.58	2.29	0.79
Tugboat	Auxiliary	0.46	6.10	6.07	0.08	0.15	0.15	0.00	796.22	0.04	0.01
Generator-Barge	Generator Sets	0.23	5.28	7.87	0.01	0.02	0.02	0	1,090.29	0.02	0.03
Emission Subtotals		**31.62**	**422.34**	**408.49**	**5.46**	**8.84**	**8.84**	**0.05**	**58,368.10**	**2.34**	**0.84**

Boat Classification	Engine	Annual Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
		(ton/yr)							(MT/yr)			
Tugboat	Propulsion	0.17	2.22	2.13	0.03	0.05	0.05	0.00	276.69	0.00	0.01	280.13
Tugboat	Auxiliary	0.00	0.03	0.03	0.00	0.00	0.00	0.00	3.90	0.00	0.00	3.95
Generator-Barge	Generator Sets	0.00	0.02	0.03	0.00	0.00	0.00	-	4.03	0.00	0.00	4.05
Emission Subtotals		**0.17**	**2.27**	**2.20**	**0.03**	**0.05**	**0.05**	**0.00**	**284.63**	**0.00**	**0.01**	**288.14**

Note:

Marine Emission Estimates - Bernardine C

Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (hours/yr)	Emission Factors VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
											(g/kW-hr)									
Tugboat	Transit	Propulsion	3	0.1%S	2	500	373	1.00	24.00	259	0.39	5.21	5.00	0.07	0.11	0.11	0.00	715.76	0.01	0.03
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	24.00	259	0.38	5.02	5.00	0.07	0.12	0.12	0.00	656.00	0.01	0.03
Emission Subtotals																				

Boat Classification	Engine	Maximum Daily Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20
		(lb/day)									
Tugboat	Propulsion	15.47	205.49	197.28	2.68	4.34	4.34	0.02	28,240.79	1.14	0.39
Tugboat	Auxiliary	0.46	6.10	6.07	0.08	0.15	0.15	0.00	796.22	0.04	0.01
Emission Subtotals		**15.93**	**211.58**	**203.35**	**2.77**	**4.49**	**4.49**	**0.02**	**29,037.01**	**1.18**	**0.41**

Boat Classification	Engine	Annual Emissions VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N20	CO2E
		(ton/yr)							(MT/yr)			
Tugboat	Propulsion	0.08	1.11	1.07	0.01	0.02	0.02	0.00	138.35	0.00	0.01	140.06
Tugboat	Auxiliary	0.00	0.03	0.03	0.00	0.00	0.00	0.00	3.90	0.00	0.00	3.95
Emission Subtotals		**0.09**	**1.14**	**1.10**	**0.01**	**0.02**	**0.02**	**0.00**	**142.25**	**0.00**	**0.01**	**144.02**

Note:

Emission Factors

Marine Propulsion

Engine Type	Engine Family	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
					(g/kW-hr)									
Slow Speed Diesel		<=1999	Tier 0	0.1%S	0.600	17.01	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		<=1999	Tier 0	0.1%S	0.500	13.16	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2000-2010	Tier 1	0.1%S	0.600	15.98	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2000-2010	Tier 1	0.1%S	0.500	12.22	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2011-2015	Tier 2	0.1%S	0.600	14.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2011-2015	Tier 2	0.1%S	0.500	10.53	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
Slow Speed Diesel		2016+	Tier 3	0.1%S	0.600	3.38	1.4	0.39	0.26	0.24	0.0006067	589	0.012	0.029
Medium Speed Diesel		2016+	Tier 3	0.1%S	0.500	2.63	1.1	0.43	0.26	0.24	0.0006067	649	0.010	0.029
EPA Certification	HCEXN19.0AAA		Tier 3	0.1%S	0.392	5.21	5.0	0.07	0.11	0.11	0.0006067	716		
EPA Certification	D233051MX03		Tier 4	0.1%S	0.190	1.80	5.0	0.07	0.04	0.04	0.0006067	716		

Notes:
Emission factors from Table 2.3 and 2.4 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 1 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.

Marine Auxiliary

Engine Type		Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	Pb	CO2	CH4	N2O
					(g/kW-hr)									
Aux High Speed Diesel		<=1999	Tier 0	0.1%S	0.600	10.9	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel		<=1999	Tier 0	0.1%S	0.600	13.82	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel		2000-2010	Tier 1	0.1%S	0.600	9.78	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel		2000-2010	Tier 1	0.1%S	0.600	12.22	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel		2011-2015	Tier 2	0.1%S	0.600	7.71	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel		2011-2015	Tier 2	0.1%S	0.600	10.53	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux High Speed Diesel		2011-2015	Tier 3	0.1%S	0.600	1.97	1.1	0.455	0.26	0.24	0.0006067	656	0.010	0.029
Aux Med Speed Diesel		2011-2015	Tier 3	0.1%S	0.600	2.63	1.4	0.455	0.26	0.24	0.0006067	686	0.012	0.029
Aux Med Speed Diesel	Tier 3 Standard	2011-2015	Tier 3	0.1%S	0.378	5.022	5	0.068	0.12	0.12	0.0006067			
					(g/hp-hr)									
Generator Sets			Tier 4 Final	0.1%S	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	-	568.2990	0.0180	0.0081

Notes:
Emission factors from Table 2.9 and 2.10 of the 2023 Port of Los Angeles Emission Inventory Methodology Report
Load factors for auxiliary engines based on Table 3.1 of the of the 2023 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 5 to CFR §1042.101.
Emission factor for Pb from the Santa Barbara Air Pollution Control District Approved TAC Emission Factors, December 2023.
Emission factors for generator sets are default emission factors from CalEEMod 2016.3.2, which relies on OFFROAD 2011 and the Carl Moyer Progam Guidelines.
See Table D-12 of the Carl Moyer Program Guidelines. Available at: https://ww2.arb.ca.gov/sites/default/files/classic/msprog/moyer/guidelines/2011/2011cmp_guidelinesVER4.pdf?_ga=2.218661721.1589730523.1723135078-1780396104.1706050686

Marine exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma EF_i \times Eng_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF	=	*Emission factor in grams per horse-power hour*
Eng	=	*Number of engines*
AvgHP	=	*Maximum rated average horsepower*
Load	=	*Load factor*
Activity	=	*Hours of operation*
i	=	*Equipment type*

SpaceX Marine Transport Project
Emissions Summary

Existing Emissions

Source Category	VOC	NO_x	CO	SO_x	PM_{10}
	(lb/day)				
Mobile	0.06	0.99	1.74	0.01	1.32
VCAPCD Significance Threshold	25	25	-	-	-
Significant?	**No**	**No**	**-**	**-**	**-**

Project Emissions - Gross Day 2

Source Category	VOC	NO_x	CO	SO_x	PM_{10}
	(lb/day)				
Marine Vessel	2.52	24.50	65.86	0.88	0.53
Total	**2.52**	**24.50**	**65.86**	**0.88**	**0.53**
VCAPCD Significance Threshold	25	25	-	-	-
Significant?	**No**	**No**	**-**	**-**	**-**

Project Emissions - Net Day 2

Source Category	VOC	NO_x	CO	SO_x	PM_{10}
	(lb/day)				
Total	**2.46**	**23.51**	**64.12**	**0.88**	**-0.79**
VCAPCD Significance Threshold	25	25	-	-	-
Significant?	**No**	**No**	**-**	**-**	**-**

Project Emissions - Total Annual

Source Category	VOC	NO_x	CO	SO_x	PM_{10}
	ton/yr				
Marine Vessel	0.10	1.14	2.07	0.03	0.02
Total	**0.10**	**1.14**	**2.07**	**0.03**	**0.02**
VCAPCD Significance Threshold	-	-	-	-	-
Significant?	**-**	**-**	**-**	**-**	**-**

$PM_{2.5}$	CO_2e
	MT/yr
0.20	4.31
-	-
-	**-**

$PM_{2.5}$	CO_2e
	MT/yr
0.53	98.73
0.53	**98.73**
-	-
-	**-**

Project Emission

Source Category	VOC	NO_x
Marine Vessel	2.52	24.50
Total	**2.52**	**24.50**
VCAPCD Significance Threshold	25	25
Significant?	**No**	**No**

$PM_{2.5}$	CO_2e
	MT/yr
0.33	**94.42**
-	-
-	**-**

$PM_{2.5}$	CO2e
	MT/yr
0.02	269.15
0.02	**269.15**
-	3,000
-	**No**

s - Gross Day 4

CO	SO_x	PM_{10}	$PM_{2.5}$	CO_2e
(lb/day)				MT/yr
65.86	0.88	0.53	0.53	98.73
65.86	**0.88**	**0.53**	**0.53**	**98.73**
-	-	-	-	-
-	**-**	**-**	**-**	**-**

SpaceX Marine Transport Project

Marine Emission Estimates - Elizabeth C Day 2 and Day 4

											Emission Factors									Maximum Daily Emissions									Annual Emissions									
Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (days/yr)	VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	CO2E
															(g/kW-hr)									(lb/day)								(ton/yr)				(MT/yr)		
Tugboat	Transit	Propulsion	4	0.1%S	2	1,300	969	1.00	3.00	46	0.19	1.80	5.00	0.07	0.04	0.04	715.76	0.01	0.03	2.44	23.08	64.12	0.87	0.51	0.51	9,178.26	0.37	0.13	0.06	0.53	1.47	0.02	0.01	0.01	191.51	0.01	0.00	192.50
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	3.00	46	0.38	5.02	5.00	0.07	0.12	0.12	656.00	0.01	0.03	0.06	0.76	0.76	0.01	0.02	0.02	99.53	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.00	2.08	0.00	0.00	2.09
															(g/hp-hr)																							
Generator-Barge	Transit	Generator Sets	4	0.1%S	1	49	37	0.74	3.00	46	0.12	2.75	4.10	0.01	0.01	0.01	568.30	0.02	0.01	0.03	0.66	0.98	0.00	0.00	0.00	136.29	0.00	0.00	0.00	0.02	0.02	0.00	0.00	0.00	2.84	0.00	0.00	2.87
Emission Subtotals																				**2.52**	**24.50**	**65.86**	**0.88**	**0.53**	**0.53**	**9,414.07**	**0.38**	**0.13**	**0.06**	**0.56**	**1.51**	**0.02**	**0.01**	**0.01**	**196.43**	**0.01**	**0.00**	**197.46**

Note:
The project would operate within the VCAPCD jurisdiction for 16 nautical miles.

Marine Emission Estimates - Bernardine C Day 1 and 5

											Emission Factors									Maximum Daily Emissions									Annual Emissions									
Boat Classification	Phase	Engine	Engine Tier	Fuel	# Engines	Engine Rating (hp)	Engine Rating (kW)	Load Factor	Operation (hr/day)	Operation (days/yr)	VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N20	CO2E
															(g/kW-hr)									(lb/day)								(ton/yr)				(MT/yr)		
Tugboat	Transit	Propulsion	3	0.1%S	2	500	373	0.50	5.50	46	0.39	5.21	5.00	0.07	0.11	0.11	715.76	0.01	0.03	1.77	23.55	22.60	0.31	0.50	0.50	3,235.92	0.13	0.05	0.04	0.54	0.52	0.01	0.01	0.01	67.52	0.00	0.00	67.87
Tugboat	Transit	Auxiliary	3	0.1%S	1	99	74	0.31	5.50	46	0.38	5.02	5.00	0.07	0.12	0.12	656.00	0.01	0.03	0.11	1.40	1.39	0.02	0.03	0.03	182.47	0.01	0.00	0.00	0.03	0.03	0.00	0.00	0.00	3.81	0.00	0.00	3.83
Emission Subtotals																				**1.88**	**24.94**	**24.00**	**0.33**	**0.53**	**0.53**	**3,418.39**	**0.14**	**0.05**	**0.04**	**0.57**	**0.55**	**0.01**	**0.01**	**0.01**	**71.33**	**0.00**	**0.00**	**71.70**

Note:
The project would operate within the VCAPCD jurisdiction for 13.6 nautical miles.

Emission Factors

Marine Propulsion

Engine Type	Engine Family	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
									(g/kW-hr)				
Slow Speed Diesel		<=1999	Tier 0	0.1%S	0.600	17.01	1.4	0.39	0.26	0.24	589	0.012	0.029
Medium Speed Diesel		<=1999	Tier 0	0.1%S	0.500	13.16	1.1	0.43	0.26	0.24	649	0.010	0.029
Slow Speed Diesel		2000-2010	Tier 1	0.1%S	0.600	15.98	1.4	0.39	0.26	0.24	589	0.012	0.029
Medium Speed Diesel		2000-2010	Tier 1	0.1%S	0.500	12.22	1.1	0.43	0.26	0.24	649	0.010	0.029
Slow Speed Diesel		2011-2015	Tier 2	0.1%S	0.600	14.38	1.4	0.39	0.26	0.24	589	0.012	0.029
Medium Speed Diesel		2011-2015	Tier 2	0.1%S	0.500	10.53	1.1	0.43	0.26	0.24	649	0.010	0.029
Slow Speed Diesel		2016+	Tier 3	0.1%S	0.600	3.38	1.4	0.39	0.26	0.24	589	0.012	0.029
Medium Speed Diesel		2016+	Tier 3	0.1%S	0.500	2.63	1.1	0.43	0.26	0.24	649	0.010	0.029
EPA Certification	HCEXN19.0AAA		Tier 3	0.1%S	0.392	5.21	5.0	0.07	0.11	0.11	716		
EPA Certification	D233051MX03		Tier 4	0.1%S	0.190	1.80	5.0	0.07	0.04	0.04	716		

Notes:
Emission factors from Table 2.3 and 2.4 of the 2019 Port of Los Angeles Emission Inventory Methodology Report
Load factors for propulsion engines based on Table 3.1 of the of the 2019 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 1 to CFR §1042.101.

Marine Auxiliary

Engine Type	Model	Tier	Fuel	VOC	NOx	CO	SOx	PM10	PM2.5	CO2	CH4	N2O
								(g/kW-hr)				
Aux High Speed Diesel	<=1999	Tier 0	0.1%S	0.600	10.9	1.1	0.455	0.26	0.24	656	0.010	0.029
Aux Med Speed Diesel	<=1999	Tier 0	0.1%S	0.600	13.82	1.4	0.455	0.26	0.24	686	0.012	0.029
Aux High Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	9.78	1.1	0.455	0.26	0.24	656	0.010	0.029
Aux Med Speed Diesel	2000-2010	Tier 1	0.1%S	0.600	12.22	1.4	0.455	0.26	0.24	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	7.71	1.1	0.455	0.26	0.24	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 2	0.1%S	0.600	10.53	1.4	0.455	0.26	0.24	686	0.012	0.029
Aux High Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	1.97	1.1	0.455	0.26	0.24	656	0.010	0.029
Aux Med Speed Diesel	2011-2015	Tier 3	0.1%S	0.600	2.63	1.4	0.455	0.26	0.24	686	0.012	0.029
Aux Med Speed Diesel Tier 3 Standard	2011-2015	Tier 3	0.1%S	0.378	5.022	5	0.068	0.12	0.12			
								(g/hp-hr)				
Generator Sets		Tier 4 Final	0.1%S	0.1200	2.7500	4.1000	0.0050	0.0080	0.0080	568.2990	0.0180	0.0081

Notes:
Emission factors from Table 2.9 and 2.10 of the 2019 Port of Los Angeles Emission Inventory Methodology Report
Load factors for propulsion engines based on Table 3.1 of the of the 2019 Port of Los Angeles Emission Inventory Methodology Report
EPA certification based on Tier 3 rating for the engine family from Table 5 to CFR §1042.101.

Marine exhaust emissions were calculated using the following equation:

$$Emissions_{diesel} = \Sigma\, EF_i \times Eng_i \times AvgHP \times Load_i \times Activity_i$$

Where:

EF	=	*Emission factor in grams per horse-power hour*
Eng	=	*Number of engines*
AvgHP	=	*Maximum rated average horsepower*
Load	=	*Load factor*
Activity	=	*Hours of operation*
i	=	*Equipment type*

SpaceX SLC-4 Operations Detailed Report

Table of Contents

1. Basic Project Information

1.1. Basic Project Information

Data Field	Value
Project Name	SpaceX SLC-4 Operations
Construction Start Date	1/1/2024
Operational Year	2025
Lead Agency	—
Land Use Scale	Project/site
Analysis Level for Defaults	County
Windspeed (m/s)	3.10
Precipitation (days)	27.8
Location	34.58233161250706, -120.6276097945451
County	Santa Barbara
City	Unincorporated
Air District	Santa Barbara County APCD
Air Basin	South Central Coast
TAZ	3342
EDFZ	6
Electric Utility	Pacific Gas & Electric Company
Gas Utility	Southern California Gas
App Version	2022.1.1.24

1.2. Land Use Types

Land Use Subtype	Size	Unit	Lot Acreage	Building Area (sq ft)	Landscape Area (sq ft)	Special Landscape Area (sq ft)	Population	Description

General Heavy Industry	1.00	1000sqft	0.02	1,000	0.00	—	—	—

1.3. User-Selected Emission Reduction Measures by Emissions Sector

No measures selected

2. Emissions Summary

2.1. Construction Emissions Compared Against Thresholds

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Un/Mit.	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unmit.	4.80	4.32	11.1	52.9	0.03	0.12	6.56	6.68	0.11	1.56	1.67	—	9,929	9,929	0.54	0.62	34.8	10,161
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unmit.	4.86	4.35	11.7	53.4	0.03	0.12	6.56	6.68	0.11	1.56	1.67	—	9,804	9,804	0.57	0.62	0.90	10,003
Average Daily (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unmit.	4.74	4.27	10.6	52.2	0.02	0.11	6.29	6.40	0.10	1.49	1.59	—	9,146	9,146	0.53	0.52	14.3	9,328
Annual (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unmit.	0.87	0.78	1.93	9.52	< 0.005	0.02	1.15	1.17	0.02	0.27	0.29	—	1,514	1,514	0.09	0.09	2.37	1,544

2.2. Construction Emissions by Year, Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Year	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e

Daily - Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2024	4.80	4.32	11.1	52.9	0.03	0.12	6.56	6.68	0.11	1.56	1.67	—	9,929	9,929	0.54	0.62	34.8	10,161
Daily - Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2024	4.86	4.35	11.7	53.4	0.03	0.12	6.56	6.68	0.11	1.56	1.67	—	9,804	9,804	0.57	0.62	0.90	10,003
Average Daily	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2024	4.74	4.27	10.6	52.2	0.02	0.11	6.29	6.40	0.10	1.49	1.59	—	9,146	9,146	0.53	0.52	14.3	9,328
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2024	0.87	0.78	1.93	9.52	< 0.005	0.02	1.15	1.17	0.02	0.27	0.29	—	1,514	1,514	0.09	0.09	2.37	1,544

2.4. Operations Emissions Compared Against Thresholds

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Un/Mit.	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unmit.	33.6	30.6	103	77.9	0.15	4.49	0.00	4.49	4.49	0.00	4.49	693	31,354	32,047	67.8	0.54	0.26	33,902
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unmit.	33.6	30.6	103	77.9	0.15	4.49	0.00	4.49	4.49	0.00	4.49	693	31,354	32,047	67.8	0.54	0.26	33,902
Average Daily (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unmit.	1.77	1.61	5.02	4.05	0.01	0.23	0.00	0.23	0.23	0.00	0.23	693	16,540	17,233	67.2	0.42	0.26	19,039
Annual (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Unmit.	0.32	0.29	0.92	0.74	< 0.005	0.04	0.00	0.04	0.04	0.00	0.04	115	2,738	2,853	11.1	0.07	0.04	3,152

2.5. Operations Emissions by Sector, Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Sector	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mobile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Area	0.04	0.03	< 0.005	0.04	< 0.005	< 0.005	—	< 0.005	< 0.005	—	< 0.005	—	0.18	0.18	< 0.005	< 0.005	—	0.18
Energy	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	—	0.00	—	15,625	15,625	2.53	0.31	—	15,780
Water	—	—	—	—	—	—	—	—	—	—	—	47.7	107	154	0.18	0.11	—	191
Waste	—	—	—	—	—	—	—	—	—	—	—	645	0.00	645	64.5	0.00	—	2,257
Refrig.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.26	0.26
Stationary	33.6	30.5	103	77.9	0.15	4.49	0.00	4.49	4.49	0.00	4.49	0.00	15,622	15,622	0.63	0.12	0.00	15,674
Total	33.6	30.6	103	77.9	0.15	4.49	0.00	4.49	4.49	0.00	4.49	693	31,354	32,047	67.8	0.54	0.26	33,902
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mobile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Area	0.03	0.03	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Energy	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	—	0.00	—	15,625	15,625	2.53	0.31	—	15,780
Water	—	—	—	—	—	—	—	—	—	—	—	47.7	107	154	0.18	0.11	—	191
Waste	—	—	—	—	—	—	—	—	—	—	—	645	0.00	645	64.5	0.00	—	2,257
Refrig.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.26	0.26
Stationary	33.6	30.5	103	77.9	0.15	4.49	0.00	4.49	4.49	0.00	4.49	0.00	15,622	15,622	0.63	0.12	0.00	15,674
Total	33.6	30.6	103	77.9	0.15	4.49	0.00	4.49	4.49	0.00	4.49	693	31,354	32,047	67.8	0.54	0.26	33,902
Average Daily	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Mobile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Area	0.03	0.03	< 0.005	0.02	< 0.005	< 0.005	—	< 0.005	< 0.005	—	< 0.005	—	0.09	0.09	< 0.005	< 0.005	—	0.09
Energy	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	—	0.00	—	15,625	15,625	2.53	0.31	—	15,780
Water	—	—	—	—	—	—	—	—	—	—	—	47.7	107	154	0.18	0.11	—	191
Waste	—	—	—	—	—	—	—	—	—	—	—	645	0.00	645	64.5	0.00	—	2,257
Refrig.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.26	0.26
Stationary	1.74	1.58	5.02	4.03	0.01	0.23	0.00	0.23	0.23	0.00	0.23	0.00	808	808	0.03	0.01	0.00	811
Total	1.77	1.61	5.02	4.05	0.01	0.23	0.00	0.23	0.23	0.00	0.23	693	16,540	17,233	67.2	0.42	0.26	19,039
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mobile	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Area	0.01	0.01	< 0.005	< 0.005	< 0.005	< 0.005	—	< 0.005	< 0.005	—	< 0.005	—	0.01	0.01	< 0.005	< 0.005	—	0.01
Energy	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	—	0.00	—	2,587	2,587	0.42	0.05	—	2,613
Water	—	—	—	—	—	—	—	—	—	—	—	7.90	17.7	25.6	0.03	0.02	—	31.6
Waste	—	—	—	—	—	—	—	—	—	—	—	107	0.00	107	10.7	0.00	—	374
Refrig.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.04	0.04
Stationary	0.32	0.29	0.92	0.74	< 0.005	0.04	0.00	0.04	0.04	0.00	0.04	0.00	134	134	0.01	< 0.005	0.00	134
Total	0.32	0.29	0.92	0.74	< 0.005	0.04	0.00	0.04	0.04	0.00	0.04	115	2,738	2,853	11.1	0.07	0.04	3,152

3. Construction Emissions Details

3.1. Fleet Vehicle Use (2024) - Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Location	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Onsite	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—
Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—
Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Average Daily	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—
Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—
Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Offsite	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	0.50	0.47	0.34	4.01	0.00	0.00	0.62	0.62	0.00	0.15	0.15	—	641	641	0.04	0.03	3.00	654

Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	0.51	0.47	0.39	4.11	0.00	0.00	0.62	0.62	0.00	0.15	0.15	—	628	628	0.05	0.03	0.08	638
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Average Daily	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	0.50	0.47	0.39	4.01	0.00	0.00	0.61	0.61	0.00	0.14	0.14	—	630	630	0.05	0.03	1.30	641
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	0.09	0.09	0.07	0.73	0.00	0.00	0.11	0.11	0.00	0.03	0.03	—	104	104	0.01	< 0.005	0.22	106
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00

3.3. Vendor-Contractor Vehicles (2024) - Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Location	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Onsite	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—

Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—
Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Average Daily	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—
Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—
Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Offsite	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	0.24	0.12	3.92	1.91	0.02	0.03	0.60	0.63	0.03	0.16	0.20	—	2,421	2,421	0.11	0.35	6.09	2,534
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00

Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	0.24	0.11	4.03	1.95	0.02	0.03	0.60	0.63	0.03	0.16	0.20	—	2,422	2,422	0.11	0.35	0.16	2,529
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Average Daily	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	0.17	0.08	2.89	1.39	0.01	0.02	0.42	0.44	0.02	0.12	0.14	—	1,738	1,738	0.08	0.25	1.88	1,817
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	0.03	0.02	0.53	0.25	< 0.005	< 0.005	0.08	0.08	< 0.005	0.02	0.03	—	288	288	0.01	0.04	0.31	301
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00

3.5. Equipment (2024) - Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Location	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Onsite	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Off-Road Equipment	0.42	0.34	4.09	14.4	0.01	0.09	—	0.09	0.08	—	0.08	—	1,387	1,387	0.05	0.01	—	1,392
Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—
Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00

Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Off-Road Equipment	0.42	0.34	4.09	14.4	0.01	0.09	—	0.09	0.08	—	0.08	—	1,387	1,387	0.05	0.01	—	1,392
Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—
Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Average Daily	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Off-Road Equipment	0.43	0.34	4.10	14.4	0.01	0.09	—	0.09	0.08	—	0.08	—	1,391	1,391	0.05	0.01	—	1,395
Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—
Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Off-Road Equipment	0.08	0.06	0.75	2.63	< 0.005	0.02	—	0.02	0.01	—	0.01	—	230	230	0.01	< 0.005	—	231
Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—
Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Offsite	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00

Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Average Daily	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00

3.7. Worker Vehicles (2024) - Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Location	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Onsite	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—

Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—
Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Average Daily	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—
Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Dust From Material Movement	—	—	—	—	—	—	0.00	0.00	—	0.00	0.00	—	—	—	—	—	—	—
Onsite truck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Offsite	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	3.63	3.39	2.78	32.7	0.00	0.00	5.34	5.34	0.00	1.25	1.25	—	5,480	5,480	0.34	0.23	25.7	5,582
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00

Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	3.69	3.42	3.21	33.0	0.00	0.00	5.34	5.34	0.00	1.25	1.25	—	5,366	5,366	0.37	0.23	0.67	5,444
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Average Daily	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	3.64	3.38	3.19	32.4	0.00	0.00	5.26	5.26	0.00	1.23	1.23	—	5,386	5,386	0.35	0.23	11.2	5,474
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Worker	0.66	0.62	0.58	5.91	0.00	0.00	0.96	0.96	0.00	0.22	0.22	—	892	892	0.06	0.04	1.85	906
Vendor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00
Hauling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	0.00	0.00	0.00	0.00

4. Operations Emissions Details

4.1. Mobile Emissions by Land Use

4.1.1. Unmitigated

Mobile source emissions results are presented in Sections 2.6. No further detailed breakdown of emissions is available.

4.2. Energy

4.2.1. Electricity Emissions By Land Use - Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Land Use	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e

Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
General Heavy Industry	—	—	—	—	—	—	—	—	—	—	—	—	15,625	15,625	2.53	0.31	—	15,780
Total	—	—	—	—	—	—	—	—	—	—	—	—	15,625	15,625	2.53	0.31	—	15,780
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
General Heavy Industry	—	—	—	—	—	—	—	—	—	—	—	—	15,625	15,625	2.53	0.31	—	15,780
Total	—	—	—	—	—	—	—	—	—	—	—	—	15,625	15,625	2.53	0.31	—	15,780
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
General Heavy Industry	—	—	—	—	—	—	—	—	—	—	—	—	2,587	2,587	0.42	0.05	—	2,613
Total	—	—	—	—	—	—	—	—	—	—	—	—	2,587	2,587	0.42	0.05	—	2,613

4.2.3. Natural Gas Emissions By Land Use - Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Land Use	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
General Heavy Industry	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	—	0.00	—	0.00	0.00	0.00	0.00	—	0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	—	0.00	—	0.00	0.00	0.00	0.00	—	0.00
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

General Heavy Industry	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	—	0.00	—	0.00	0.00	0.00	0.00	—	0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	—	0.00	—	0.00	0.00	0.00	0.00	—	0.00
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
General Heavy Industry	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	—	0.00	—	0.00	0.00	0.00	0.00	—	0.00
Total	0.00	0.00	0.00	0.00	0.00	0.00	—	0.00	0.00	—	0.00	—	0.00	0.00	0.00	0.00	—	0.00

4.3. Area Emissions by Source

4.3.1. Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Source	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Consumer Products	0.02	0.02	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Architectural Coatings	0.01	0.01	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Landscape Equipment	0.01	0.01	< 0.005	0.04	< 0.005	< 0.005	—	< 0.005	< 0.005	—	< 0.005	—	0.18	0.18	< 0.005	< 0.005	—	0.18
Total	0.04	0.03	< 0.005	0.04	< 0.005	< 0.005	—	< 0.005	< 0.005	—	< 0.005	—	0.18	0.18	< 0.005	< 0.005	—	0.18
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Consumer	0.02	0.02	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Architectural Coatings	0.01	0.01	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	0.03	0.03	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Consumer Products	< 0.005	< 0.005	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Architectural Coatings	< 0.005	< 0.005	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Landscape Equipment	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	—	< 0.005	< 0.005	—	< 0.005	—	0.01	0.01	< 0.005	< 0.005	—	0.01
Total	0.01	0.01	< 0.005	< 0.005	< 0.005	< 0.005	—	< 0.005	< 0.005	—	< 0.005	—	0.01	0.01	< 0.005	< 0.005	—	0.01

4.4. Water Emissions by Land Use

4.4.1. Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Land Use	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
General Heavy Industry	—	—	—	—	—	—	—	—	—	—	—	47.7	107	154	0.18	0.11	—	191
Total	—	—	—	—	—	—	—	—	—	—	—	47.7	107	154	0.18	0.11	—	191

Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
General Heavy Industry	—	—	—	—	—	—	—	—	—	—	—	47.7	107	154	0.18	0.11	—	191
Total	—	—	—	—	—	—	—	—	—	—	—	47.7	107	154	0.18	0.11	—	191
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
General Heavy Industry	—	—	—	—	—	—	—	—	—	—	—	7.90	17.7	25.6	0.03	0.02	—	31.6
Total	—	—	—	—	—	—	—	—	—	—	—	7.90	17.7	25.6	0.03	0.02	—	31.6

4.5. Waste Emissions by Land Use

4.5.1. Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Land Use	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
General Heavy Industry	—	—	—	—	—	—	—	—	—	—	—	645	0.00	645	64.5	0.00	—	2,257
Total	—	—	—	—	—	—	—	—	—	—	—	645	0.00	645	64.5	0.00	—	2,257
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
General Heavy Industry	—	—	—	—	—	—	—	—	—	—	—	645	0.00	645	64.5	0.00	—	2,257
Total	—	—	—	—	—	—	—	—	—	—	—	645	0.00	645	64.5	0.00	—	2,257

Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
General Heavy Industry	—	—	—	—	—	—	—	—	—	—	—	107	0.00	107	10.7	0.00	—	374
Total	—	—	—	—	—	—	—	—	—	—	—	107	0.00	107	10.7	0.00	—	374

4.6. Refrigerant Emissions by Land Use

4.6.1. Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Land Use	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
General Heavy Industry	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.26	0.26
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.26	0.26
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
General Heavy Industry	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.26	0.26
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.26	0.26
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
General Heavy Industry	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.04	0.04
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.04	0.04

4.7. Offroad Emissions By Equipment Type

4.7.1. Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Equipment Type	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

4.8. Stationary Emissions By Equipment Type

4.8.1. Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Equipment Type	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Emergency Generator	33.6	30.5	103	77.9	0.15	4.49	0.00	4.49	4.49	0.00	4.49	0.00	15,622	15,622	0.63	0.12	0.00	15,674

Total	33.6	30.5	103	77.9	0.15	4.49	0.00	4.49	4.49	0.00	4.49	0.00	15,622	15,622	0.63	0.12	0.00	15,674
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Emergency Generator	33.6	30.5	103	77.9	0.15	4.49	0.00	4.49	4.49	0.00	4.49	0.00	15,622	15,622	0.63	0.12	0.00	15,674
Total	33.6	30.5	103	77.9	0.15	4.49	0.00	4.49	4.49	0.00	4.49	0.00	15,622	15,622	0.63	0.12	0.00	15,674
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Emergency Generator	0.32	0.29	0.92	0.74	< 0.005	0.04	0.00	0.04	0.04	0.00	0.04	0.00	134	134	0.01	< 0.005	0.00	134
Total	0.32	0.29	0.92	0.74	< 0.005	0.04	0.00	0.04	0.04	0.00	0.04	0.00	134	134	0.01	< 0.005	0.00	134

4.9. User Defined Emissions By Equipment Type

4.9.1. Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Equipment Type	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

4.10. Soil Carbon Accumulation By Vegetation Type

4.10.1. Soil Carbon Accumulation By Vegetation Type - Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Vegetation	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

4.10.2. Above and Belowground Carbon Accumulation by Land Use Type - Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Land Use	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

4.10.3. Avoided and Sequestered Emissions by Species - Unmitigated

Criteria Pollutants (lb/day for daily, ton/yr for annual) and GHGs (lb/day for daily, MT/yr for annual)

Species	TOG	ROG	NOx	CO	SO2	PM10E	PM10D	PM10T	PM2.5E	PM2.5D	PM2.5T	BCO2	NBCO2	CO2T	CH4	N2O	R	CO2e
Daily, Summer (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Avoided	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Subtotal	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sequestered	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Subtotal	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Removed	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Subtotal	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Daily, Winter (Max)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Avoided	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Subtotal	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sequestered	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Subtotal	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Removed	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Subtotal	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Annual	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Avoided	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Subtotal	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Sequest	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Subtotal	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Removed	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Subtotal	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

5. Activity Data

5.1. Construction Schedule

Phase Name	Phase Type	Start Date	End Date	Days Per Week	Work Days per Phase	Phase Description
Fleet Vehicle Use	Site Preparation	1/1/2024	12/31/2024	7.00	366	—
Vendor-Contractor Vehicles	Site Preparation	1/1/2024	12/31/2024	5.00	262	—
Equipment	Grading	1/1/2024	12/31/2024	7.00	366	—
Worker Vehicles	Grading	1/1/2024	12/31/2024	7.00	366	—

5.2. Off-Road Equipment

5.2.1. Unmitigated

Phase Name	Equipment Type	Fuel Type	Engine Tier	Number per Day	Hours Per Day	Horsepower	Load Factor
Equipment	Aerial Lifts	Diesel	Average	6.00	1.00	84.0	0.37
Equipment	Forklifts	CNG	Average	7.00	1.00	70.0	0.30
Equipment	Off-Highway Trucks	Diesel	Average	4.00	1.00	367	0.40
Equipment	Rough Terrain Forklifts	Diesel	Average	6.00	1.00	96.0	0.40

5.3. Construction Vehicles

5.3.1. Unmitigated

Phase Name	Trip Type	One-Way Trips per Day	Miles per Trip	Vehicle Mix
Fleet Vehicle Use	—	—	—	—
Fleet Vehicle Use	Worker	100	8.80	LDA,LDT1,LDT2
Fleet Vehicle Use	Vendor	—	5.30	HHDT,MHDT
Fleet Vehicle Use	Hauling	0.00	20.0	HHDT
Fleet Vehicle Use	Onsite truck	—	—	HHDT
Vendor-Contractor Vehicles	—	—	—	—
Vendor-Contractor Vehicles	Worker	0.00	8.80	LDA,LDT1,LDT2
Vendor-Contractor Vehicles	Vendor	134	5.30	HHDT,MHDT
Vendor-Contractor Vehicles	Hauling	0.00	20.0	HHDT
Vendor-Contractor Vehicles	Onsite truck	—	—	HHDT
Equipment	—	—	—	—
Equipment	Worker	0.00	8.80	LDA,LDT1,LDT2
Equipment	Vendor	—	5.30	HHDT,MHDT
Equipment	Hauling	0.00	20.0	HHDT
Equipment	Onsite truck	—	—	HHDT
Worker Vehicles	—	—	—	—
Worker Vehicles	Worker	700	10.8	LDA,LDT1,LDT2
Worker Vehicles	Vendor	—	5.30	HHDT,MHDT
Worker Vehicles	Hauling	0.00	20.0	HHDT
Worker Vehicles	Onsite truck	—	—	HHDT

5.4. Vehicles

5.4.1. Construction Vehicle Control Strategies

Non-applicable. No control strategies activated by user.

5.5. Architectural Coatings

Phase Name	Residential Interior Area Coated (sq ft)	Residential Exterior Area Coated (sq ft)	Non-Residential Interior Area Coated (sq ft)	Non-Residential Exterior Area Coated (sq ft)	Parking Area Coated (sq ft)

5.6. Dust Mitigation

5.6.1. Construction Earthmoving Activities

Phase Name	Material Imported (cy)	Material Exported (cy)	Acres Graded (acres)	Material Demolished (sq. ft.)	Acres Paved (acres)
Fleet Vehicle Use	—	—	0.00	0.00	—
Vendor-Contractor Vehicles	—	—	0.00	0.00	—
Equipment	—	—	0.00	0.00	—
Worker Vehicles	—	—	0.00	0.00	—

5.6.2. Construction Earthmoving Control Strategies

Non-applicable. No control strategies activated by user.

5.7. Construction Paving

Land Use	Area Paved (acres)	% Asphalt
General Heavy Industry	0.00	0%

5.8. Construction Electricity Consumption and Emissions Factors

kWh per Year and Emission Factor (lb/MWh)

Year	kWh per Year	CO_2	CH_4	N_2O
2024	0.00	204	0.03	< 0.005

5.9. Operational Mobile Sources

5.9.1. Unmitigated

Land Use Type	Trips/Weekday	Trips/Saturday	Trips/Sunday	Trips/Year	VMT/Weekday	VMT/Saturday	VMT/Sunday	VMT/Year
Total all Land Uses	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

5.10. Operational Area Sources

5.10.1. Hearths

5.10.1.1. Unmitigated

5.10.2. Architectural Coatings

Residential Interior Area Coated (sq ft)	Residential Exterior Area Coated (sq ft)	Non-Residential Interior Area Coated (sq ft)	Non-Residential Exterior Area Coated (sq ft)	Parking Area Coated (sq ft)
0	0.00	1,500	500	—

5.10.3. Landscape Equipment

Season	Unit	Value
Snow Days	day/yr	0.00
Summer Days	day/yr	180

5.11. Operational Energy Consumption

5.11.1. Unmitigated

Electricity (kWh/yr) and CO2 and CH4 and N2O and Natural Gas (kBTU/yr)

Land Use	Electricity (kWh/yr)	CO2	CH4	N2O	Natural Gas (kBTU/yr)
General Heavy Industry	27,959,568	204	0.0330	0.0040	0.00

5.12. Operational Water and Wastewater Consumption

5.12.1. Unmitigated

Land Use	Indoor Water (gal/year)	Outdoor Water (gal/year)
General Heavy Industry	22,330,980	18,110,000

5.13. Operational Waste Generation

5.13.1. Unmitigated

Land Use	Waste (ton/year)	Cogeneration (kWh/year)
General Heavy Industry	1,197	—

5.14. Operational Refrigeration and Air Conditioning Equipment

5.14.1. Unmitigated

Land Use Type	Equipment Type	Refrigerant	GWP	Quantity (kg)	Operations Leak Rate	Service Leak Rate	Times Serviced
General Heavy Industry	Other commercial A/C and heat pumps	R-410A	2,088	0.30	4.00	4.00	18.0

5.15. Operational Off-Road Equipment

5.15.1. Unmitigated

Equipment Type	Fuel Type	Engine Tier	Number per Day	Hours Per Day	Horsepower	Load Factor

5.16. Stationary Sources

5.16.1. Emergency Generators and Fire Pumps

Equipment Type	Fuel Type	Number per Day	Hours per Day	Hours per Year	Horsepower	Load Factor
Emergency Generator	Diesel	3.00	2.00	25.0	779	1.00
Emergency Generator	Diesel	1.00	2.00	25.0	367	1.00
Emergency Generator	Diesel	1.00	2.00	25.0	320	1.00
Emergency Generator	Diesel	1.00	24.0	576	314	1.00

5.16.2. Process Boilers

Equipment Type	Fuel Type	Number	Boiler Rating (MMBtu/hr)	Daily Heat Input (MMBtu/day)	Annual Heat Input (MMBtu/yr)

5.17. User Defined

Equipment Type	Fuel Type

5.18. Vegetation

5.18.1. Land Use Change

5.18.1.1. Unmitigated

Vegetation Land Use Type	Vegetation Soil Type	Initial Acres	Final Acres

5.18.1. Biomass Cover Type

5.18.1.1. Unmitigated

Biomass Cover Type	Initial Acres	Final Acres

5.18.2. Sequestration

5.18.2.1. Unmitigated

Tree Type	Number	Electricity Saved (kWh/year)	Natural Gas Saved (btu/year)

6. Climate Risk Detailed Report

6.1. Climate Risk Summary

Cal-Adapt midcentury 2040–2059 average projections for four hazards are reported below for your project location. These are under Representation Concentration Pathway (RCP) 8.5 which assumes GHG emissions will continue to rise strongly through 2050 and then plateau around 2100.

Climate Hazard	Result for Project Location	Unit
Temperature and Extreme Heat	6.60	annual days of extreme heat
Extreme Precipitation	4.10	annual days with precipitation above 20 mm
Sea Level Rise	0.00	meters of inundation depth
Wildfire	9.82	annual hectares burned

Temperature and Extreme Heat data are for grid cell in which your project are located. The projection is based on the 98th historical percentile of daily maximum/minimum temperatures from observed historical data (32 climate model ensemble from Cal-Adapt, 2040–2059 average under RCP 8.5). Each grid cell is 6 kilometers (km) by 6 km, or 3.7 miles (mi) by 3.7 mi.
Extreme Precipitation data are for the grid cell in which your project are located. The threshold of 20 mm is equivalent to about ¾ an inch of rain, which would be light to moderate rainfall if received over a full day or heavy rain if received over a period of 2 to 4 hours. Each grid cell is 6 kilometers (km) by 6 km, or 3.7 miles (mi) by 3.7 mi.
Sea Level Rise data are for the grid cell in which your project are located. The projections are from Radke et al. (2017), as reported in Cal-Adapt (Radke et al., 2017, CEC-500-2017-008), and consider inundation location and depth for the San Francisco Bay, the Sacramento-San Joaquin River Delta and California coast resulting different increments of sea level rise coupled with extreme storm events. Users may select from four scenarios to view the range in potential inundation depth for the grid cell. The four scenarios are: No rise, 0.5 meter, 1.0 meter, 1.41 meters
Wildfire data are for the grid cell in which your project are located. The projections are from UC Davis, as reported in Cal-Adapt (2040–2059 average under RCP 8.5), and consider historical data of climate, vegetation, population density, and large (> 400 ha) fire history. Users may select from four model simulations to view the range in potential wildfire probabilities for the grid cell. The four simulations make different assumptions about expected rainfall and temperature are: Warmer/drier (HadGEM2-ES), Cooler/wetter (CNRM-CM5), Average conditions (CanESM2), Range of different rainfall and temperature possibilities (MIROC5). Each grid cell is 6 kilometers (km) by 6 km, or 3.7 miles (mi) by 3.7 mi.

6.2. Initial Climate Risk Scores

Climate Hazard	Exposure Score	Sensitivity Score	Adaptive Capacity Score	Vulnerability Score
Temperature and Extreme Heat	N/A	N/A	N/A	N/A
Extreme Precipitation	N/A	N/A	N/A	N/A
Sea Level Rise	N/A	N/A	N/A	N/A
Wildfire	N/A	N/A	N/A	N/A
Flooding	N/A	N/A	N/A	N/A

Drought	N/A	N/A	N/A	N/A
Snowpack Reduction	N/A	N/A	N/A	N/A
Air Quality Degradation	N/A	N/A	N/A	N/A

The sensitivity score reflects the extent to which a project would be adversely affected by exposure to a climate hazard. Exposure is rated on a scale of 1 to 5, with a score of 5 representing the greatest exposure.
The adaptive capacity of a project refers to its ability to manage and reduce vulnerabilities from projected climate hazards. Adaptive capacity is rated on a scale of 1 to 5, with a score of 5 representing the greatest ability to adapt.
The overall vulnerability scores are calculated based on the potential impacts and adaptive capacity assessments for each hazard. Scores do not include implementation of climate risk reduction measures.

6.3. Adjusted Climate Risk Scores

Climate Hazard	Exposure Score	Sensitivity Score	Adaptive Capacity Score	Vulnerability Score
Temperature and Extreme Heat	N/A	N/A	N/A	N/A
Extreme Precipitation	N/A	N/A	N/A	N/A
Sea Level Rise	N/A	N/A	N/A	N/A
Wildfire	N/A	N/A	N/A	N/A
Flooding	N/A	N/A	N/A	N/A
Drought	N/A	N/A	N/A	N/A
Snowpack Reduction	N/A	N/A	N/A	N/A
Air Quality Degradation	N/A	N/A	N/A	N/A

The sensitivity score reflects the extent to which a project would be adversely affected by exposure to a climate hazard. Exposure is rated on a scale of 1 to 5, with a score of 5 representing the greatest exposure.
The adaptive capacity of a project refers to its ability to manage and reduce vulnerabilities from projected climate hazards. Adaptive capacity is rated on a scale of 1 to 5, with a score of 5 representing the greatest ability to adapt.
The overall vulnerability scores are calculated based on the potential impacts and adaptive capacity assessments for each hazard. Scores include implementation of climate risk reduction measures.

6.4. Climate Risk Reduction Measures

7. Health and Equity Details

7.1. CalEnviroScreen 4.0 Scores

The maximum CalEnviroScreen score is 100. A high score (i.e., greater than 50) reflects a higher pollution burden compared to other census tracts in the state.

Indicator	Result for Project Census Tract
Exposure Indicators	—
AQ-Ozone	6.40
AQ-PM	8.33
AQ-DPM	1.94
Drinking Water	69.5
Lead Risk Housing	39.5
Pesticides	69.9
Toxic Releases	4.78
Traffic	30.0
Effect Indicators	—
CleanUp Sites	87.5
Groundwater	99.1
Haz Waste Facilities/Generators	99.3
Impaired Water Bodies	51.2
Solid Waste	83.3
Sensitive Population	—
Asthma	22.0
Cardio-vascular	38.5
Low Birth Weights	7.06
Socioeconomic Factor Indicators	—
Education	7.40
Housing	81.9
Linguistic	0.00
Poverty	44.9
Unemployment	67.5

7.2. Healthy Places Index Scores

The maximum Health Places Index score is 100. A high score (i.e., greater than 50) reflects healthier community conditions compared to other census tracts in the state.

Indicator	Result for Project Census Tract
Economic	—
Above Poverty	51.63608366
Employed	0.230976517
Median HI	47.9019633
Education	—
Bachelor's or higher	52.66264596
High school enrollment	100
Preschool enrollment	20.94187091
Transportation	—
Auto Access	92.6344155
Active commuting	57.93660978
Social	—
2-parent households	92.39060695
Voting	25.18927242
Neighborhood	—
Alcohol availability	97.0101373
Park access	4.722186578
Retail density	7.404080585
Supermarket access	2.399589375
Tree canopy	53.80469652
Housing	—
Homeownership	0.436288977
Housing habitability	62.00436289
Low-inc homeowner severe housing cost burden	99.12742205

Low-inc renter severe housing cost burden	76.40189914
Uncrowded housing	77.4541255
Health Outcomes	—
Insured adults	99.2429103
Arthritis	0.0
Asthma ER Admissions	72.7
High Blood Pressure	0.0
Cancer (excluding skin)	0.0
Asthma	0.0
Coronary Heart Disease	0.0
Chronic Obstructive Pulmonary Disease	0.0
Diagnosed Diabetes	0.0
Life Expectancy at Birth	78.6
Cognitively Disabled	87.2
Physically Disabled	99.2
Heart Attack ER Admissions	56.4
Mental Health Not Good	0.0
Chronic Kidney Disease	0.0
Obesity	0.0
Pedestrian Injuries	19.6
Physical Health Not Good	0.0
Stroke	0.0
Health Risk Behaviors	—
Binge Drinking	0.0
Current Smoker	0.0
No Leisure Time for Physical Activity	0.0
Climate Change Exposures	—

Wildfire Risk	0.0
SLR Inundation Area	0.0
Children	0.1
Elderly	99.5
English Speaking	94.4
Foreign-born	2.8
Outdoor Workers	87.6
Climate Change Adaptive Capacity	—
Impervious Surface Cover	90.1
Traffic Density	15.0
Traffic Access	0.0
Other Indices	—
Hardship	41.2
Other Decision Support	—
2016 Voting	26.1

7.3. Overall Health & Equity Scores

Metric	Result for Project Census Tract
CalEnviroScreen 4.0 Score for Project Location (a)	35.0
Healthy Places Index Score for Project Location (b)	28.0
Project Located in a Designated Disadvantaged Community (Senate Bill 535)	No
Project Located in a Low-Income Community (Assembly Bill 1550)	Yes
Project Located in a Community Air Protection Program Community (Assembly Bill 617)	No

a: The maximum CalEnviroScreen score is 100. A high score (i.e., greater than 50) reflects a higher pollution burden compared to other census tracts in the state.
b: The maximum Health Places Index score is 100. A high score (i.e., greater than 50) reflects healthier community conditions compared to other census tracts in the state.

7.4. Health & Equity Measures

No Health & Equity Measures selected.

7.5. Evaluation Scorecard

Health & Equity Evaluation Scorecard not completed.

7.6. Health & Equity Custom Measures

No Health & Equity Custom Measures created.

8. User Changes to Default Data

Screen	Justification
Construction: Construction Phases	Operational vehicle and equipment use modeled here.
Construction: Off-Road Equipment	Based on applicant provided information.
Construction: Trips and VMT	Based on applicant provided information.
Operations: Energy Use	Based on applicant provided information. All electric.
Operations: Water and Waste Water	Based on applicant provided information. Outdoor water use for launch support.
Operations: Solid Waste	Based on applicant provided information.
Operations: Refrigerants	etwer
Operations: Emergency Generators and Fire Pumps	Existing permitted generators for GHG emissions.

SC-GHG-2021 Interim Costs Alternative 1

				2021 Interim Estimates									Cost of CO2			Cost of CH4			Cost of N2O			Total Cost of GHGs		
	Metric Tons per year			SC-CO2 per Metric Ton			SC-CH4 per Metric Ton			SC-N2O per Metric Ton														
Year	CO_2	CH_4	N_2O	5.00%	3.00%	2.50%	5.00%	3.00%	2.50%	5.00%	3.00%	2.50%	5.00%	3.00%	2.50%	5.00%	3.00%	2.50%	5.00%	3.00%	2.50%	5.00%	3.00%	2.50%
2025	13,205.00	12.60	1.63	16.4	55	81.6	774	1660	2160	6600	20400	29400	$216,562	$726,275	$1,077,528	$9,752	$20,916	$27,216	$10,758	$33,252	$47,922	$237,072	$780,443	$1,152,666
2026	13,205.00	12.60	1.63	17	56	83	800	1700	2200	6800	21000	30000	$224,485	$739,480	$1,096,015	$10,080	$21,420	$27,720	$11,084	$34,230	$48,900	$245,649	$795,130	$1,172,635
2027	13,205.00	12.60	1.63	17.4	57.2	84.2	828	1760	2260	7000	21400	30600	$229,767	$755,326	$1,111,861	$10,433	$22,176	$28,476	$11,410	$34,882	$49,878	$251,610	$812,384	$1,190,215
2028	13,205.00	12.60	1.63	17.8	58.4	85.4	856	1820	2320	7200	21800	31200	$235,049	$771,172	$1,127,707	$10,786	$22,932	$29,232	$11,736	$35,534	$50,856	$257,571	$829,638	$1,207,795
2029	13,205.00	12.60	1.63	18.2	59.6	86.6	884	1880	2380	7400	22200	31800	$240,331	$787,018	$1,143,553	$11,138	$23,688	$29,988	$12,062	$36,186	$51,834	$263,531	$846,892	$1,225,375
2030	13,205.00	12.60	1.63	18.6	60.8	87.8	912	1940	2440	7600	22600	32400	$245,613	$802,864	$1,159,399	$11,491	$24,444	$30,744	$12,388	$36,838	$52,812	$269,492	$864,146	$1,242,955
												Total	**$1,391,807**	**$4,582,135**	**$6,716,063**	**$63,680**	**$135,576**	**$173,376**	**$69,438**	**$210,922**	**$302,202**	**$1,524,925**	**$4,928,633**	**$7,191,641**

SC-GHG 2022 Draft Alternative 1

	2022 Draft Costs																							
	Metric Tons per year			SC-CO2 per Metric Ton			SC-CH4 per Metric Ton			SC-N2O per Metric Ton			Cost of CO2			Cost of CH4			Cost of N2O			Total Cost of GHGs		
Year	CO_2	CH_4	N_2O	2.50%	2.00%	1.50%	2.50%	2.00%	1.50%	2.50%	2.00%	1.50%	2.50%	2.00%	1.50%	2.50%	2.00%	1.50%	2.50%	2.00%	1.50%	2.50%	2.00%	1.50%
2025	13,205.00	12.60	1.63	128	208	356	1524	1950	2650	39024	59041	93625	$1,690,240	$2,746,640	$4,700,980	$19,202	$24,570	$33,390	$63,609	$96,237	$152,609	$1,773,052	$2,867,447	$4,886,979
2026	13,205.00	12.60	1.63	130	212	360	1590	2025	2737	39972	60267	95210	$1,716,650	$2,799,460	$4,753,800	$20,034	$25,515	$34,486	$65,154	$98,235	$155,192	$1,801,838	$2,923,210	$4,943,479
2027	13,205.00	12.60	1.63	133	215	365	1657	2101	2823	40920	61492	96796	$1,756,265	$2,839,075	$4,819,825	$20,878	$26,473	$35,570	$66,700	$100,232	$157,777	$1,843,843	$2,965,780	$5,013,172
2028	13,205.00	12.60	1.63	136	219	370	1724	2176	2910	41868	62718	98381	$1,795,880	$2,891,895	$4,885,850	$21,722	$27,418	$36,666	$68,245	$102,230	$160,361	$1,885,847	$3,021,543	$5,082,877
2029	13,205.00	12.60	1.63	139	223	375	1791	2252	2996	42916	63944	99966	$1,835,495	$2,944,715	$4,951,875	$22,567	$28,375	$37,750	$69,953	$104,229	$162,945	$1,928,015	$3,077,319	$5,152,569
2030	13,205.00	12.60	1.63	141	226	380	1857	2327	3083	43764	65169	101552	$1,861,905	$2,984,330	$5,017,900	$23,398	$29,320	$38,846	$71,335	$106,225	$165,530	$1,956,639	$3,119,876	$5,222,276
												Total	**$8,966,195**	**$14,459,475**	**$24,429,250**	**$108,599**	**$137,101**	**$183,317**	**$341,387**	**$511,152**	**$801,805**	**$9,416,182**	**$15,107,727**	**$25,414,373**

Appendix B

Exhaust Plume Calculations for SpaceX Merlin5 Booster Engine

Sierra Engineering & Software, Inc.

ANALYSIS REPORT	NUMBER: 2019-002 DATE: 14 June 2019
SUBJECT: Exhaust Plume Calculations for SpaceX Merlin5 Booster Engine	**PAGE 1 OF 11** **NO. OF APPEN. 0**
PREPARED FOR: Matthew Thompson, SpaceX	**(W.O. 6012)**
DISTRIBUTION: Katy Smith, SpaceX	

1.0 SUMMARY

Calculations were performed to estimate the far-field exhaust constituents of the SpaceX Merlin 5 LOX-kerosene booster rocket engine firing under sea-level conditions. Although the exit-plane exhaust is fuel-rich and contains high concentrations of carbon monoxide (CO), subsequent entrainment of ambient air results in complete conversion of the CO into carbon dioxide (CO_2) and oxidation of the soot from the gas generator exhaust. A small amount of thermal nitrous oxides (NOx) is formed, all as NO. The NO emission is predicted to be 1.047 lb_m/s under nominal power (100%) operation.

2.0 ENGINE DESCRIPTION

The subject engine is the baseline booster engine for the SpaceX Falcon 9 launch vehicle family. This analysis address the latest version of the engine, the Merlin 5. The propellants are liquid oxygen (LOX) and the RP-1 grade of kerosene. The subject engine consists of a 16.27:1 regeneratively-cooled thrust chamber nozzle exhaust plus a fuel-rich gas exhaust from the turbopump drive system. As a simplification needed to address the problem with the existing axisymmetric analysis tools, the computational nozzle exit plane includes an outer annulus of low mixture ratio turbine exhaust gas generator surrounding the physical thrust chamber exhaust plume. Characteristic dimensions of the thrust chamber nozzle are included in Table 1.

The nominal operating condition for the Merlin 5 engine is an injector face stagnation pressure (Pc) of 1859 psia and an engine O/F mixture ratio (MR) of 2.356. The associated thrust chamber MR is 2.576 and the gas generator (GG) MR is 0.423. The GG mass fraction is about 4.28% of the total engine flow. The current analysis was performed for the 100% nominal engine operating pressure (Pc=1859 psia) and an engine MR of 2.58.

Table 1: Merlin 5 Nozzle Characteristics

Throat Radius (in)	4.429
Downstream radius of curvature (in)	1.250
Tangency angle (deg)	35.33
Nozzle lip exit angle (deg)	8.973
Nozzle exit diameter (in) [excluding GG exhaust duct]	35.733
Nozzle throat to exit length (in)	39.617

3.0 ANALYSIS APPROACH

A series of simulations were required to estimate the emissions from the Merlin 5 engine. The PERCORP analysis model[1] was used to estimate the O/F mixture ratio variations that exist within the Merlin 5 thrust chamber. The fuel-rich combustion model in PERCORP was also used to estimate the gas generate exhaust constituents. The VIPER parabolized Navier-Stokes model[2] was used to kinetically expand the thrust chamber exhaust to the nozzle exit plane. The VIPER results were used to assess the validity of the PERCORP solution, correlating engine thrust, mass flow rate and specific impulse (ISP) to test results. PERCORP input parameters were adjusted until there was good agreement between the VIPER performance predictions and the test results. The SPF code[3] was used to predict the flow structure of the free exhaust plume and the entrainment of ambient air. VIPER solution was used as the starting condition for the SPF. Though the SPF code can handle detailed chemical kinetics within the plume evolving flow field, the strong barrel shock downstream of the nozzle exit produces numerical convergence problems with the version of SPF used. The present SPF simulations were performed without chemical kinetics. The results were air entrainment and gas temperature profiles. The SPF and VIPER results were used as inputs for one-dimensional kinetic modelling of the plume flow field. The kinetic model in the TDK code[4] was used to model chemical reactions within the evolving plume flow field.

TDK modelling of the plume flow field included chemical mechanism that address a) the oxidation of CO to CO_2, b) the complex oxidation of hydrocarbons to H_2O and CO_2, c) the oxidation of soot to CO_2, and d) the thermal generation of NOx in a mixture of air and combustion products. Table 2 includes the chemical reactions and rates used in the TDK simulation.

Table 2: Kinetic Reactions Included in One Dimensional Chemistry Simulations*

	A	N	B
H + H + m = H2 + m†	6.4E17	1.0	0.0
H + OH + m = H2O + m	8.4E21	2.0	0.0
O + O + m = O2 + m	1.9E13	0.0	-1.79
CO + O + m = CO2 + m	1.0E14	0.0	0.0
O + H + m = OH + m	3.62E18	1.0	0.0
CH4 + m = CH3 + H + m	1.259E17	0	88.4
HCO + m = CO + H + m	5.012E14	0	19.0
C2H3 + m = C2H2 + H + m	7.943E14	0	31.5
N+NO = N2+O	2.700E13	0	0.355
N+O2 = NO+O	9.000E9	-1.0	6.5
N+OH = NO+H	3.360E13	0	0.385
HO2+NO = NO2+OH	2.110E12	0	-0.480
NO2+O = NO+O2	3.900E12	0	-0.240
NO2+H = NO+OH	1.320E14	0	0.360
O2 + H = O + OH	2.2E14	0.0	16.8
H2 + O = H + OH	1.8E10	-1.	8.9
H2 + OH = H2O + H	2.2E13	0.0	5.15
OH + OH = H2O + O	6.3E12	0.0	1.09
CO + OH = CO2 + H	1.5E7	-1.3	-.765
CO + O = CO2	2.5E6	0.0	3.18
CO2 + O = CO + O2	1.7E13	0.0	52.7
CH4+ OH = CH3 + H2O	3.162E13	0	6.0
H + CH4 = CH3 + H2	6.310E14	0	15.1
O + CH4 = CH3 + OH	3.981E14	0	14.0
CH3 + O = CH2O + H	1.259E14	0	2.0
CH3 + OH = CH2O + H2	3.981E12	0	0
C2H2 + OH = C2H + H2O	6.310E12	0	7.0
H + CH2O = HCO + H2	3.162E14	0	10.5
O + CH2O = HCO + OH	1.995E13	0	3.1

* TDK reaction format is k=AT**(-N)*EXP(-1000B/RT) [cc-Kcal-K-mole-s]

† m is any molecule for a third body reaction

Table 2: Kinetic Reactions Included in One Dimensional Chemistry Simulations (ctd)

	A	N	B
OH + CH2O = HCO + H2O	7.943E12	0	0.2
H + HCO = CO + H2	1.995E14	0	0
OH + HCO = CO + H2O	1.000E14	0	0
H + C2H2 = C2H + H2	1.995E14	0	19.0
O + C2H2 = CH2 + CO	5.012E13	0	3.7
C2H + O2 = HCO + CO	1.000E13	0	7.0
CH2 + O2 = HCO + OH	1.000E14	0	3.7
H + C2H4 = C2H3 + H2	1.000E14	0	8.5
C2H2 + H = C2H3	5.500E12	0	2.39
H + C3H6 = C2H4 + CH3	3.981E12	0	0
C(GR)‡ + OH = CO + H	6.02E8	-0.5	0

4.0 ANALYSIS RESULTS

The PERCORP modelling of the Merlin 5 thrust chamber included 11.1% fuel film cooling injected at two locations down the chamber wall. The SpaceX supplied chamber wall temperature profile agreed well with the PERCORP results. The PERCORP solution for the nominal 319.36 lbf-s/lb_m thrust chamber specific impulse includes a 2.0% core mixing loss, yielding a characteristic velocity (C*) efficiency of 96.4%. The C* efficiency agrees well with SpaceX test data. The fuel-rich combustion model was used to predict the GG exhaust species mass fractions (Table 3). The PERCORP results included initial boundary conditions for the VIPER nozzle flow field simulation. The predicted thrust chamber nozzle exit species mass fractions from VIPER are listed in Table 4.

The GG exhaust species from PERCORP and the nozzle exhaust species, temperature and velocity fields from VIPER were used as initial conditions for the SPF exhaust plume flow field modelling. Three heavy hydrocarbon species ($C_{12}H_{23}$, C_7H_{14} and C_3H_6) predicted to exist in the GG exhaust were thermally cracked into smaller constituents (C_2H_2, C_2H_4, CH_4, H_2) using relationships suggested by Reference 5.

The SPF modelling stepped to 100 nozzle exit radii (Rexit = 18.3214 inches, 1.527 ft). Predicted plume contours for temperature and mass fractions of N_2, CO and soot are presented in Figure 1 through Figure 4. Since there plume entrainment and mixing field is simulated for chemically frozen flow, the N_2 contours are representative of the air entrainment, while the CO and soot contours indicate key products of incomplete combustion.

‡ C(GR) is the carbon representative of soot

Table 3: Gas Generator Exhaust Species Mass Fraction from PERCORP

Species	Mass Fraction
CO	0.3035
CO2	0.0625
H2	0.0030
H2O	0.0918
CH4	0.0476
C2H2	0.0114
C2H4	0.2098
C(GR)	0.0030
C2H6	0.0471
C3H6	0.0662
C7H14	0.0397
C12H23	0.1144

Table 4: Thrust Chamber Nozzle Exit Species Mass Fraction from VIPER Simulation

Species	Mass Fraction
CO2	0.4230
H2O	0.2538
CO	0.2536
O2	0.0367
H2	0.0086
C(GR)	0.0066
OH	0.0064
C2H2	0.0062
CH4	0.0027
O	0.0013
C2H4	7.79E-04
H	1.31E-04
HCO	1.49E-05

Figure 1: Plume Temperature Contours (degrees K)
R is radius normalized by Rexit, X is axial distance from nozzle exit normailzied by Rexit

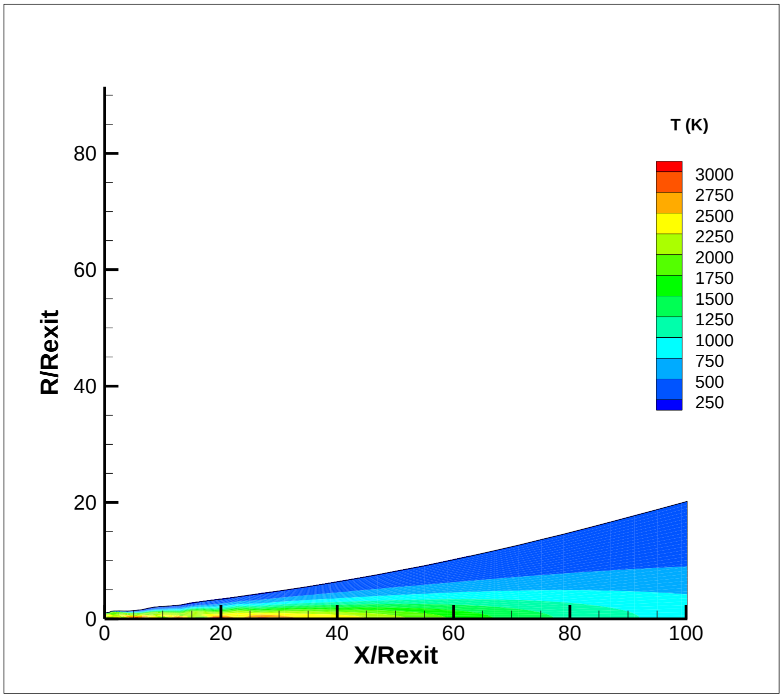


Figure 2: Plume N_2 Mass Fraction Contours (degrees K)
R is radius normalized by Rexit, X is axial distance from nozzle exit normailzied by Rexit

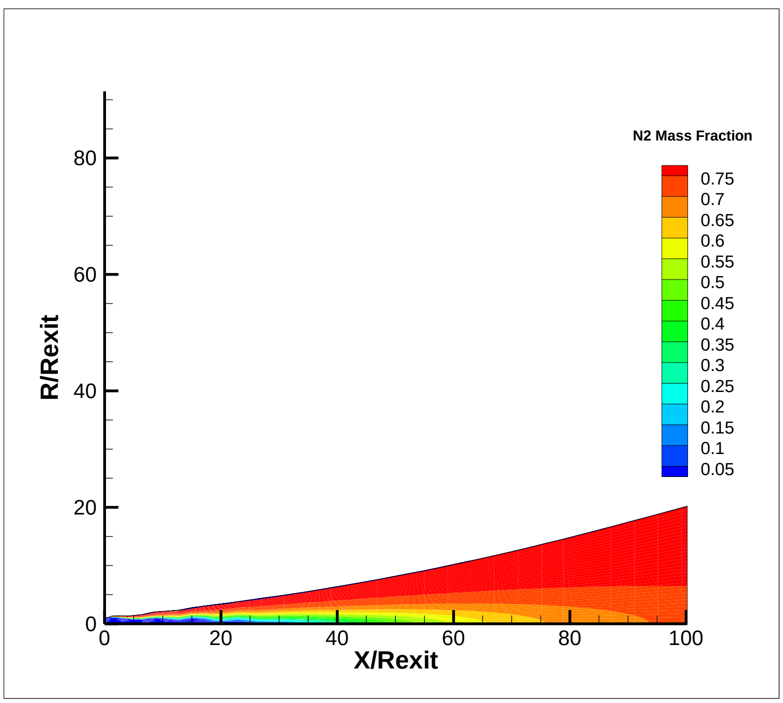


Figure 3: Plume CO Mass Fraction
R is radius normalized by Rexit, X is axial distance from nozzle exit normailzied by Rexit

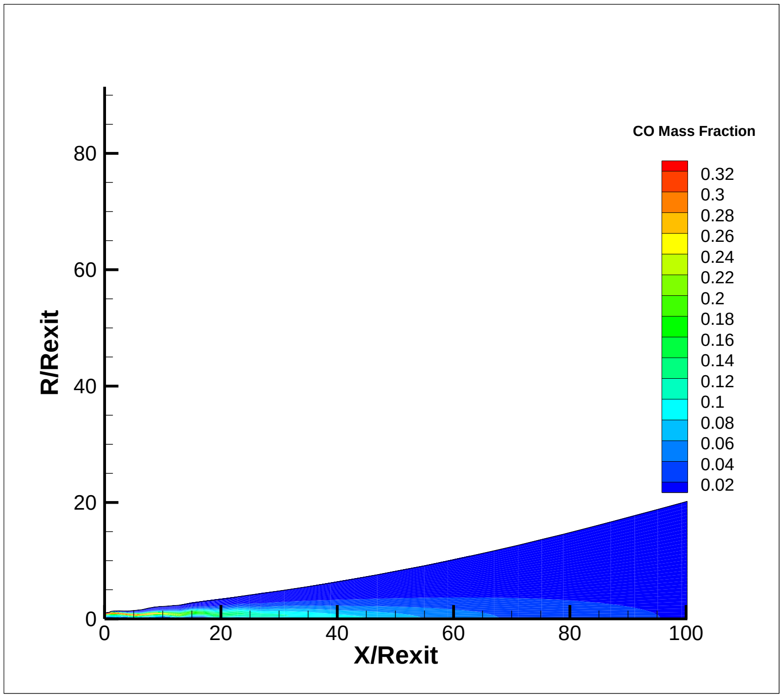
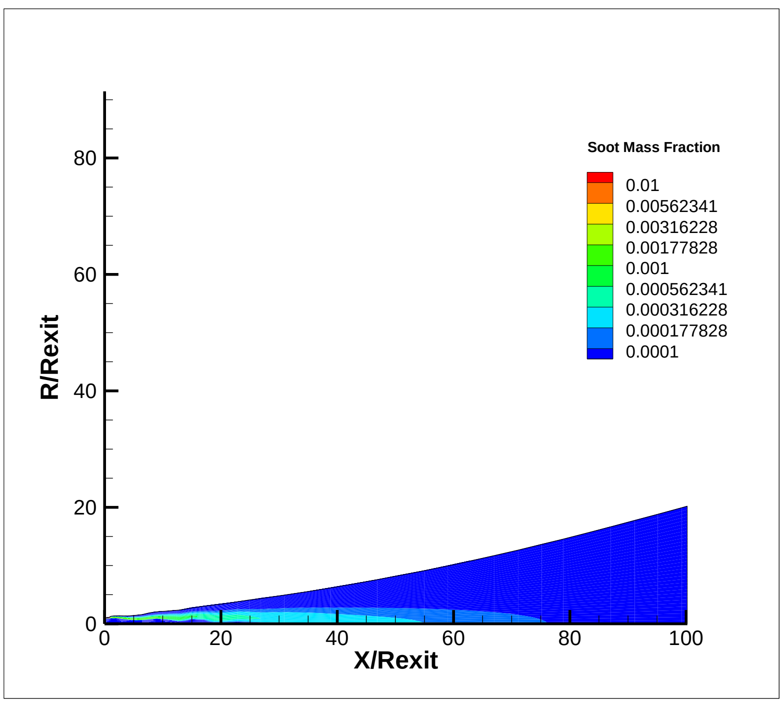


Figure 4: Plume Soot Mass Fraction Contours
R is radius normalized by Rexit, X is axial distance from nozzle exit normailzied by Rexit



The reactive plume was defined to include all flow that had a CO concentration greater than 1,000 ppm. Integration of the SPF data indicates that 18,390 lb/s air is entrained by the end of the simulation (Figure 5). It is estimated that the 153 meter entrainment end point is reached 294 msec after the plume flow exits the nozzle.

Figure 5: Axial Air Entrainment Estimates from SPF.

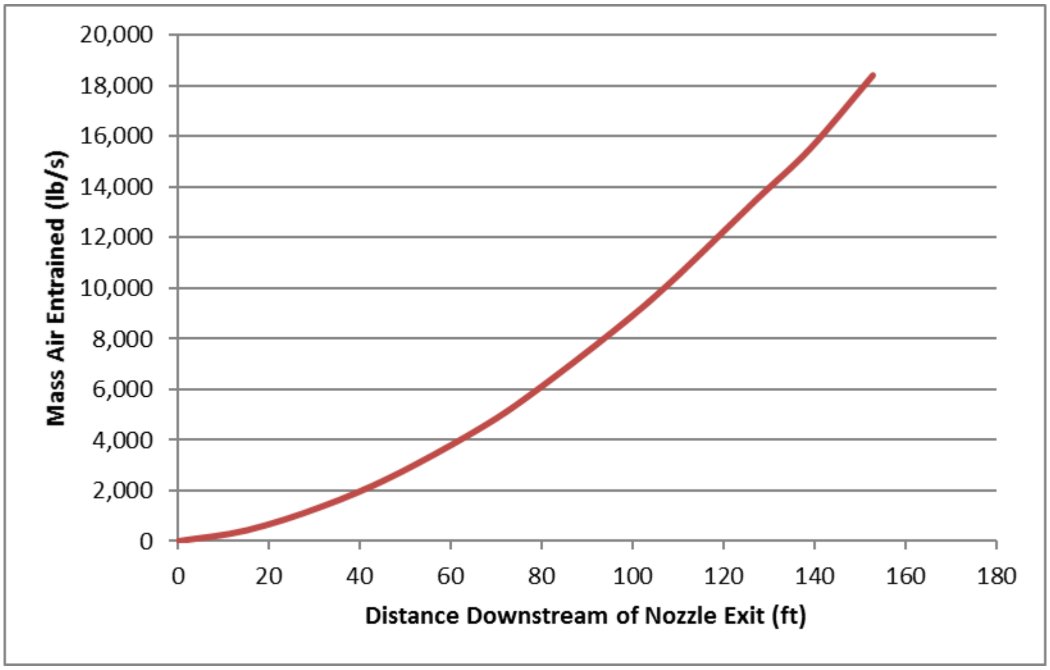
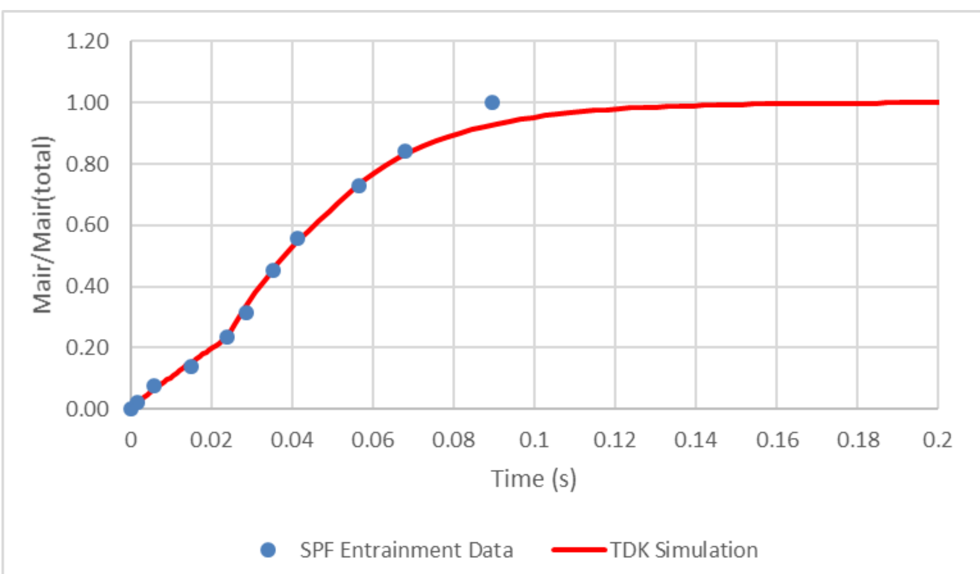


Figure 6: Approximate Air Entrainment Profile used in TDK Simulations



The subsequent TDK simulation of the plume chemistry required an approximate fit of the air entrainment rate. The SPF air entrainment profile was fit to an "availability profile" for the TDK simulations, whereby ambient air is mixed into the plume flow. Figure 6 shows that the approximate TDK air addition agrees well with the entrainment rate predicted by SPF.

The one-dimensional kinetics modeling of the after-burning characteristics of the exhaust plume was performed assuming a piecemeal constant pressure (13.6-14.7 psia) and entrainment of ambient temperature air. The model predicted that all the soot quickly (<5 msec) burns out (i.e. converts to CO). Complete CO oxidation occurs within 35 msec, with concentrations reduced to 2 ppm. The small concentration of unburnt hydrocarbons (CH_4, C_2H_2, C_2H_4, CH_3) are rapidly oxidized, surviving less than 1 msec. The limited thermal NO formation occurs during the early part of the entrainment process, with NO mass fraction constant after about 10 msec. The NO mass fraction at the end of the 157 ft long plume entrainment is 0.000055. Given the total mixed plume mass flow rate of 19041 lb/s, this corresponds to a NO mass flow of 1.047 lb/s. Figure 7 and Figure 8 show the predicted temperature and pollutant species mass fraction profiles. The pollutant flow rates were calculated in terms of lb_m generated per second of steady engine operation.

Figure 7: Predicted Profile of Bulk Plume Temperature and Species Concentration

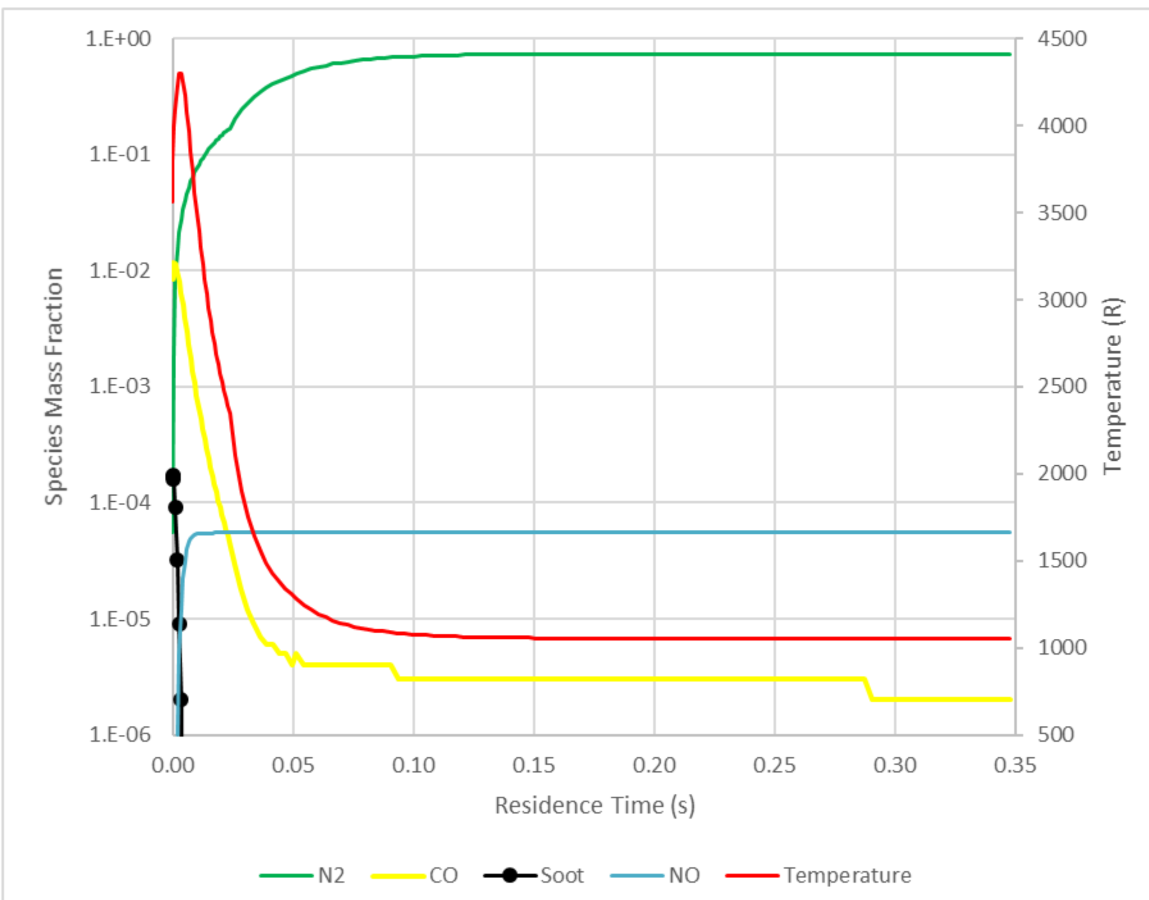
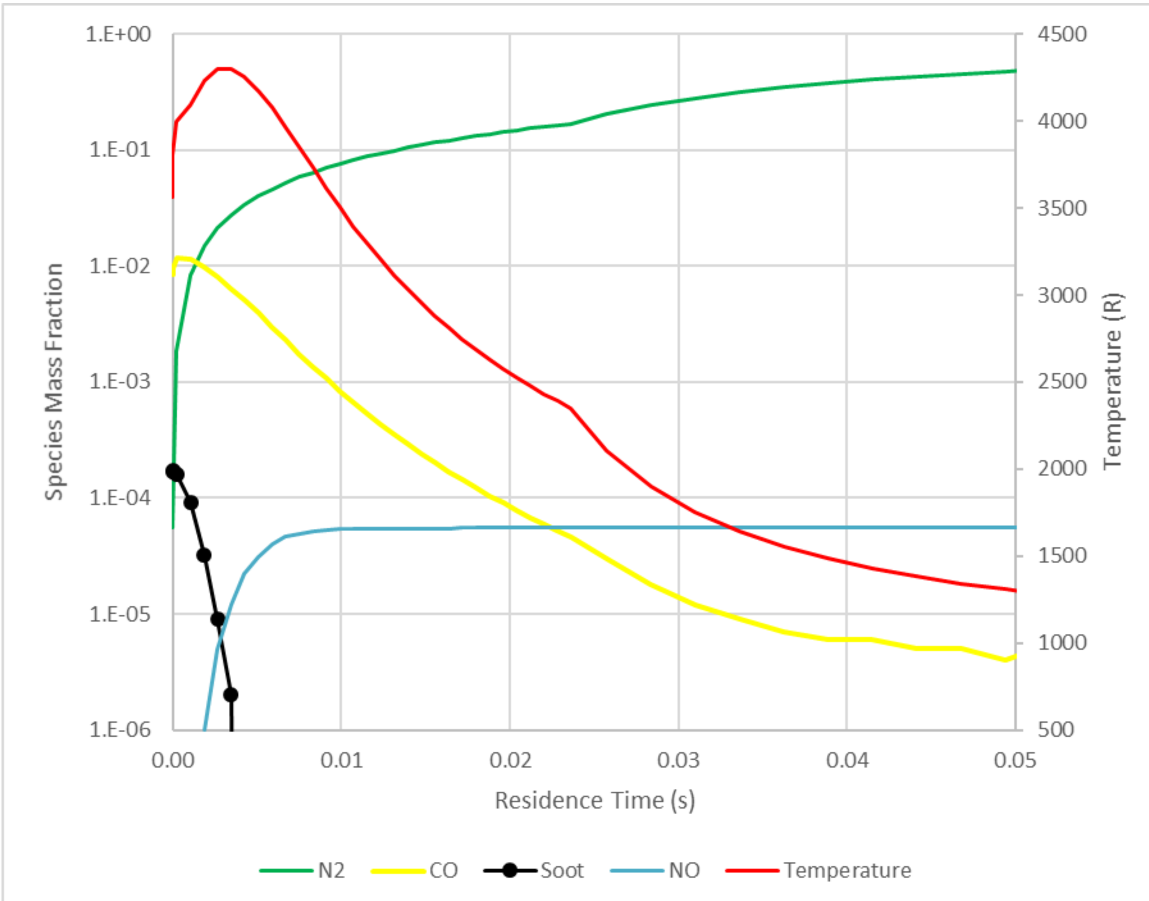


Figure 8: Predicted Profile of Bulk Plume Temperature and Species Concentration for Initial Residence Times



5.0 REFERENCES

[1] *Performance Correlation Program (PERCORP 2006) Reference and User's Manual, Version 2.0*, Sierra Engineering Inc., Carson City, NV, June 2009

[2] *Viscous Interaction Performance Evaluation Routine For Two-Phase Nozzle Flows With Finite Rate Chemistry, VIPER 4.5*, Software and Engineering Associates, Carson City, NV, 2018

[3] Taylor, M.W. and Pergament, H.S.; *Standardized Plume Flowfield Model SPF-III, Version 4.2 Program User's Manual*, PST TR-51, Propulsion Science and Technology, Inc. East Windsor, NJ, June 2000

[4] Nickerson, G. R., Dunn, S.S., Coats, D.E. and Berker, D.R.; *Two-Dimensional Kinetics (TDK) Nozzle Performance Computer Program User's Manual*, Software and Engineering Associates, Carson City, NV, Jan 1999

[5] Nickerson, G.R. and Johnson, C.W.; "A Sooting Model for Fuel Rich LOX/Hydrocarbon Combustion", 28th JANNAF Combustion Meetings, San Antonio, TX, 28 Oct-1 Nov, 1991

Appendix F

Sound – Background & Regulatory Requirements

F.1 Definition of Sound and Characteristics

Sound is a physical phenomenon consisting of minute vibrations that travel through a medium, such as air or water, and are sensed by the human ear. Noise is defined as unwanted or annoying sound that interferes with or disrupts normal human activities. Although continuous and extended exposure to high noise levels (e.g., through occupational exposure) can cause hearing loss, the principal human response to noise is annoyance. The response of different individuals to similar noise events is diverse and is influenced by the type of noise, perceived importance of the noise, its appropriateness in the setting, time of day, type of activity during which the noise occurs, and sensitivity of the individual.

The perception and evaluation of sound involves three basic physical characteristics:

- Intensity – the acoustic energy, which is expressed in terms of sound pressure, in decibels (dB)
- Frequency – the number of cycles per second the air vibrates, in Hertz (Hz)
- Duration – the length of time the sound can be detected

Noise is defined as unwanted or annoying sound that interferes with or disrupts normal human activities. The primary human response to noise is annoyance, which is defined by the United States (U.S.) Environmental Protection Agency (EPA) as any negative subjective reaction on the part of an individual or group (U.S. Environmental Protection Agency 1974). The response of different individuals to similar noise events is diverse and is influenced by the type of noise, perceived importance of the noise, its appropriateness in the setting, time of day, type of activity during which the noise occurs, and sensitivity of the individual. While aircraft are not the only sources of noise in an urban or suburban environment, they are readily identified by their noise output.

F.2 Sound Intensity and Weighting

The loudest sounds that can be detected comfortably by the human ear have intensities that are a trillion times higher than those of sounds that can barely be heard. Because of this vast range, it is unwieldy to use a linear scale to represent the intensity of sound. As a result, a logarithmic unit known as the decibel represents the intensity or amplitude of a sound, also referred to as the sound level. The dB scale simplifies the broad range of encountered sound pressures detected by the human ear and allows the measurement of sound to be more easily understood. A sound level of 0 dB is approximately the threshold of human hearing and is barely audible under extremely quiet listening conditions. Normal speech has a sound level of approximately 60 dB. Sound levels above 120 dB begin to be felt inside the human ear as discomfort. Sound levels between 130 and 140 dB are felt as pain (Berglund 1995).

All sounds have a spectral content, which means their magnitude or level changes with frequency, where frequency is measured in cycles per second or Hz. To mimic the human ear's non-linear sensitivity and perception of different frequencies of sound, the spectral content is weighted. For example, environmental noise measurements are usually on an "A-weighted" scale, which places less weight on very low and very high frequencies in order to replicate human hearing sensitivity. The general range of human hearing is from 20 to 20,000 cycles per second, or Hz; humans hear best in the range of 1,000–4,000 Hz. A-weighting is a frequency-dependent adjustment of sound level used to approximate the natural range and sensitivity of the human auditory system.**Table F-1** provides a comparison of how the human ear perceives changes in loudness on the logarithmic scale.

Table F-1: Subjective Responses to Changes in A-Weighted Decibels

Change	Change in Perceived Loudness
3 dB	Barely perceptible
5 dB	Quite noticeable
10 dB	Dramatic – twice or half as loud
20 dB	Striking – fourfold change

Note: dB = decibel(s)

Figure F-1 provides a chart of A-weighted sound levels from typical noise sources (Cowan 1994; Harris 1979). Some noise sources (e.g., air conditioner, vacuum cleaner) are continuous sounds that maintain a constant sound level for some period of time. Other sources are time-varying events and reach a maximum sound level during an event, such as a vehicle passing by. Sounds can also be part of the ambient environment (e.g., urban daytime, urban nighttime) and are described by averages taken over extended periods. A variety of noise metrics has been developed to describe noise, particularly aircraft noise, in different contexts and over different time periods.

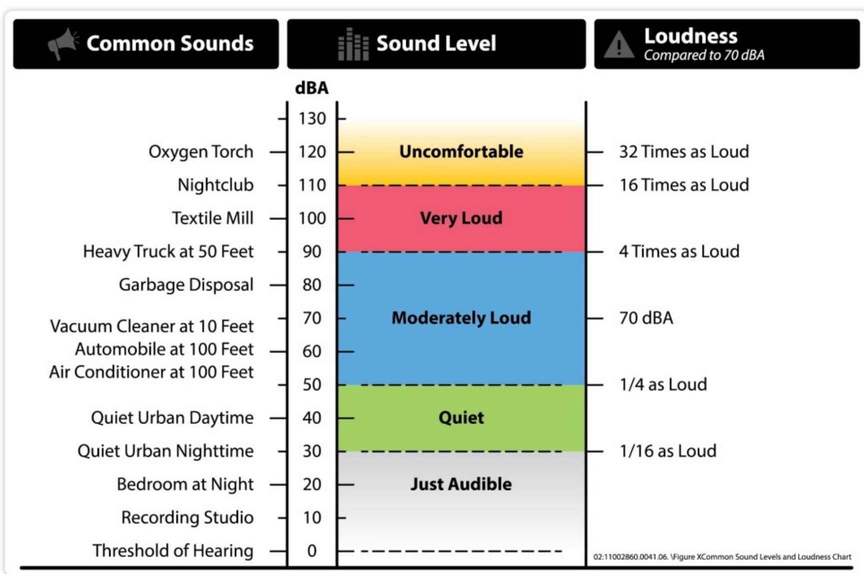


Figure F-1: A-Weighted Sound Levels from Typical Sources

F.3 Sound Metrics

A "metric" is a system for measuring or quantifying a particular characteristic of a subject. Since noise is a complex physical phenomenon, different noise metrics help to quantify the noise environment. The Day-Night Average Sound Level (DNL) metric is the energy-averaged sound level measured over a 24-hour period, with a 10 dB nighttime adjustment to account for heightened human sensitivity to noise when ambient sound levels are low, such as when sleep disturbance could occur. DNL does not represent a sound level heard at any given time but instead represents long-term exposure. Scientific studies have found good correlation between the percentages of groups of people highly annoyed and the level of their average noise exposure measured in DNL (U.S. Department of the Navy et al. 1978; U.S. Environmental Protection Agency 1999). While DNL is the primary metric used to determine noise impacts by the U.S. Department of Housing and Urban Development, Federal Aviation Administration (FAA), and EPA, California has adopted the use of the Community Noise Equivalent Level (CNEL). While CNEL, like DNL, is an energy-averaged sound level measured over a 24-hour period. However, CNEL adds a ten times weighting (equivalent to a 10 dBA [A-weighted decibel] "penalty") to each operation between 10:00 p.m. and 7:00 a.m., CNEL also adds a three times weighting (equivalent to a 4.77 dBA penalty) for each operation during evening hours (7:00 p.m. to 10:00 p.m.). As such, DNL and CNEL have been determined to be a reliable measure of long-term community annoyance.

CNEL values are average quantities, mathematically representing the continuous sound level (L_{eq1H}) that would be present if all of the variations in sound level that occur over a 24-hour period were averaged to have the same total sound energy. The CNEL metric quantifies the total sound energy received and is therefore a cumulative measure, but it does not provide specific information on the number of noise events or the individual sound levels that occur during the 24-hour day.

Of note is that methods for quantifying noise depend on the potential impacts in question and on the type of noise. Another useful noise measurement in determining the effects of noise is the 1-hour average sound level, abbreviated L_{eq1H}. The L_{eq1H} can be thought of in terms of equivalent sound; that is, if a L_{eq1H} is 45.3 dB, this is what would be measured if a sound measurement device were placed in a sound field of 45.3 dB for 1 hour. The L_{eq1H} is usually A weighted unless specified otherwise (dBA). A weighting is a standard filter used in acoustics that approximates human hearing and in some cases is the most appropriate weighting filter when investigating the impacts of noise on wildlife as well as humans.

F.4 Sound Propagation

In an ideal setting in which sound propagates away from a point source without any outside influence (e.g., a barrier reflecting or attenuating the sound), sound energy radiates uniformly outward in all directions from the source in a pattern referred to as spherical spreading. As sound energy propagates away from the sound source, both the sound level and frequency change. For each doubling of distance from the source, the sound level attenuates (or drops off) at a rate of 6 dBA.

In a real-world setting, a number of factors can influence how sound propagates in the environment; the ideal case of spherical spreading is at best only an approximation of attenuation with distance. Wind has been shown to be the single most important meteorological factor within approximately 500 feet (152 meters) of the sound source, while vertical air temperature gradients are more important in sound propagation over longer distances. Other atmospheric conditions such as air temperature, humidity, and turbulence also can have a major effect on received sound levels.

Whether natural or manmade, a large object or barrier in the path between a sound source and a receptor can attenuate sound levels substantially. The impact of this shielding depends on the size and material of the object as well as the frequency content of the sound source. Natural terrain, buildings, and walls can serve as noise barriers in which attenuation of 5–10 dB is often not noticeable.

F.5 Noise Control Act

The Noise Control Act (NCA) (42 United States Code 4901 et seq.) sought to limit the exposure and disturbance that individuals and communities experience from noise. It focuses on surface transportation and construction sources, particularly near airport environments. The NCA also specifies that performance standards for transportation equipment be established with the assistance of the

U.S. Department of Transportation. Section 7 of the NCA regulates sonic booms and gave the FAA regulatory authority after consultation with the EPA. Furthermore, the 1987 Quiet Community amendment gave state and local authorities greater involvement in controlling noise.

F.6 Ambient Sound Guidance Documents

Ambient sound standards regulate ambient sound levels through time-averaged sound limits. Sound standards for land use compatibility established by DoD and civilian jurisdictions are expressed in terms of the DNL.

F.7 Federal Interagency Committee on Urban Noise Criteria

The federal government has established suggested land use compatibility criteria for different noise zones. However, land use compatibility with differing noise levels is regulated at the local level (Federal Interagency Committee on Urban Noise 1980). Residential areas and schools are considered compatible where the DNL is less than or equal to 65 dBA, and outdoor recreational activities are compatible with noise levels less than or equal to 70 dBA. Furthermore, parks are compatible with noise levels less than or equal to 75 dBA based on Land Use Guidelines.

F.8 U.S. Environmental Protection Agency Noise Standards

The level of environmental noise at which no measurable hearing loss would be expected to occur over a lifetime, as identified by the EPA, is a 24-hour exposure level of 70 dB (U.S. Environmental Protection Agency 1974).

F.9 Bibliography

Cowan, J. P. 1994. Handbook of Environmental Acoustics. New York, NY: John Wiley & Sons.

Federal Interagency Committee on Urban Noise. 1980. Guidelines for Considering Noise in Land Use Planning and Control. Washington, DC: U.S. Environmental Protection Agency, U.S. Department of Transportation, U.S. Department of Housing and Urban Development, U.S. Department of Defense, and Veterans Administration.

Harris, C. 1979. Handbook of Noise Control. New York, NY: McGraw-Hill.

U.S. Department of the Navy, U.S. Department of the Air Force, and U.S. Department of the Army. 1978. Environmental Protection: Planning in the Noise Environment. (AFM 19-10 TM 5-803-2). Washington, DC.

FALCON 9 NOISE ASSESSMENT FOR FLIGHT AND TEST OPERATIONS AT VANDENBERG SPACE FORCE BASE

TN 24-02

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Executive Summary

Space Exploration Technologies Corporation (SpaceX) is planning to conduct flight operations and testing of the Falcon 9 launch vehicle at Space Launch Complex (SLC)-4 at Vandenberg Space Force Base (VSFB). To support environmental studies for FAA launch licensing, KBR, Inc. conducted this noise modeling study to estimate the single event and cumulative noise levels in the vicinity of VSFB from future Falcon 9 launches, booster landings, and static fire tests at SLC-4.

The RNOISE model, which computes far field noise levels in the community, was used to estimate rocket noise from Falcon 9 flight and test operations at SLC-4. Sonic boom exposure levels were estimated for the flight operations using the PCBoom model; PCBoom computes single-event sonic boom footprints, including contours of peak overpressure and signatures from any supersonic vehicle executing arbitrary maneuvers in a three-dimensional atmosphere. SpaceX provide the operations data required to conduct the noise modeling, including orbital launch and booster landing trajectories, engine operating data, static fire test parameters, and the projected annual number of Falcon 9 daytime and nighttime launch, landing, and static fire test operations at SLC-4.

Conclusions are that rocket noise from individual launch, landing, and static fire test events is expected to be heard by people in the communities surrounding SLC-4, primarily Lompoc to the east, Narlon and Orcutt to the north, and Conception to the south. However, due to the levels and expected frequency of events, these individual noise events are not expected to cause general annoyance or pose health concerns, though noise complaints may occur. Projected annual operations at SLC-4, with an approximate 50% daytime and 50% nighttime operations split, are expected to generate cumulative noise levels in residential areas that are below levels associated with adverse noise exposure (i.e., below the California Noise Equivalent Level (CNEL) 65 dBA threshold); additionally, the CNEL 65 dBA contour from these projected operations combined is expected to be located entirely within Vandenberg SFB property. Recent criteria used to assess the potential for structural damage indicates that no damage is expected from Falcon 9 launches or any of the other operations that generate lower noise levels than launches (i.e., the 134 dB L_{max} contour for all Falcon 9 flight and test operations is well within VSFB property, such that no damage is expected to structures off-base).

Falcon 9 launch events at SLC-4 are expected to generate sonic booms over the Pacific Ocean with levels ranging from 0.1 to 0.5 pounds per square foot (psf) in most areas with the possibility that a limited number of small focal regions could experience levels up to 5.0 psf. For booster landing events at SLC-4, boom levels in the vicinity of the landing pad are expected to range from about 5.0 psf to 8.0 psf and vary depending on the descent/landing trajectory and atmospheric conditions. Away from the landing pad and towards the surrounding communities, landing boom levels range from 0.2 to 2.0 psf. In general, booms in the 0.2 to 0.3 psf range could be heard by someone who is expecting it and listening for it, but usually would not be noticed. Booms of 0.5 psf are more likely to be noticed, and booms of 1.0 psf and higher are certain to be noticed and may cause people to be startled or annoyed. Boom levels over land, which are less than 5.0 psf in most areas, are unlikely to cause structural damage.

1 Introduction

Space Exploration Technologies Corporation (SpaceX) plans to increase the number of annual Falcon 9 Block 5 flight and test operations at Vandenberg Space Force Base (VSFB), California. The Falcon 9 Block 5, hereafter referred to as the Falcon 9, is a two-stage vehicle comprised of a booster and second stage (vehicle with payload); the vehicle has a total height of 229 ft and includes nine Merlin 1D engines that each provide sea-level thrust of 190,000 lbf, with a maximum thrust of 1.71 MM lbf during launch. The Falcon 9 has vertical take-off and landing (VTOL) capability and is reusable. KBR, Inc. conducted this study to estimate the single event and cumulative noise levels in the vicinity of VSFB from future Falcon 9 launches, booster landings, and static fire tests at Vandenberg's Space Launch Complex 4 (SLC-4).

SpaceX provided the following data for noise modeling:

- Orbital launch trajectories for the Falcon 9 vehicle from liftoff to stage separation.
- Merlin 1D engine operating data and nominal ascent thrust profile.
- Falcon 9 booster reentry and descent/landing trajectories from separation to landing with descent thrust profile.
- Static fire test parameters for the Falcon 9 booster.
- Projected annual launch, landing, and static fire test operations at SLC-4.

This study estimates rocket noise exposure levels for flight events (launches and landings) and static test events and sonic boom exposure levels for flight events. Rocket noise levels were estimated for Falcon 9 flight and static test operations at SLC-4 using the RNOISE[1,2] model. RNOISE, a far-field (distances beyond several hundred feet) community noise model for launch noise assessment is described further in Section 2. Sonic boom levels were estimated for Falcon 9 flight operations at SLC-4 using the PCBoom model[13,14]; PCBoom computes single-event sonic boom footprints, including contours of peak overpressure and signatures from any supersonic vehicle executing arbitrary maneuvers in a three-dimensional atmosphere (described further in Section 7).

In the following sections of this report, a description of rocket noise fundamentals is provided in Section 2 followed by estimated single event noise levels for Falcon 9 orbital launches (Section 3), Falcon 9 landings (Section 4), and static fire tests (Section 5). Section 6 presents cumulative noise level estimates for future projected Falcon 9 launches, landings, and static fire tests at SLC-4; cumulative noise is assessed for all projected operations combined. Sonic boom fundamentals, including metrics and assessment criteria, are presented in Section 7 followed by Falcon 9 launch and landing sonic boom exposure levels in Sections 8 and 9, respectively. The report references are provided in Section 10.

2 Rocket Noise Background and Metrics

2.1 Background

Rockets generate significant noise from the combustion process and turbulent mixing of the exhaust flow with the surrounding air. Figure 1 is a sketch of rocket noise. There is a supersonic potential core of exhaust flow, surrounded by a mixing region. Noise is generated in this flow. It is directional, with the highest noise levels at an angle of 40 to 50 degrees from the direction of the exhaust flow. The fundamentals of predicting rocket noise were established by Wilhold et al.[3] for moving rockets and by Eldred et al.[4] for static firing. Sutherland[5] refined modeling of rocket source noise, improving its consistency relative to jet noise theory. Based on those fundamentals, Wyle has developed the PAD model for near field rocket noise[6] and the RNOISE model for far field noise in the community. RNOISE was used for the current analysis.

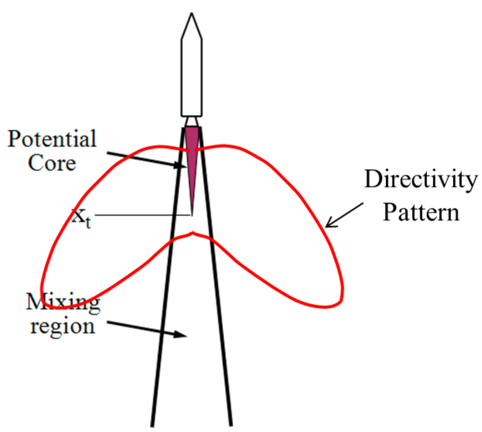

Figure 1. Rocket Noise Source

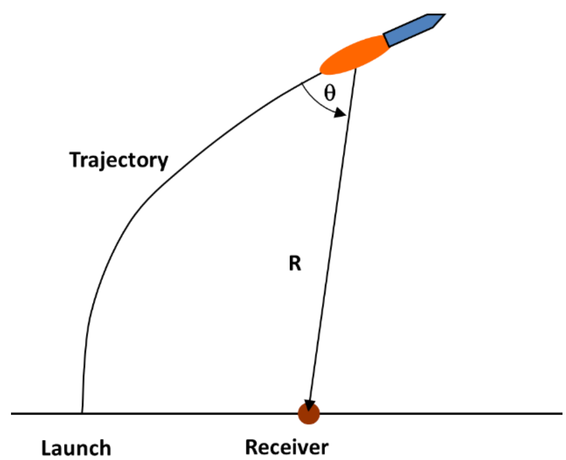

Figure 2. Modeling Rocket Noise at the Ground

Figure 2 is a sketch of far field rocket noise as treated by RNOISE. The vehicle's position and attitude are known from the trajectory. Rocket noise source characteristics are known from the engine properties, with thrust and exhaust velocity being the most important parameters. The emission angle and distance to the receiver are known from the flight path and receiver position. Noise at the ground is computed accounting for distance, ground impedance,[7] atmospheric absorption of sound,[8] and uniform ground elevation. RNOISE propagates the full spectrum to the ground, accounting for Doppler shift from vehicle motion. It is a time simulation model, computing the noise at individual points or on a regular grid for every time point in the trajectory. Propagation time from the vehicle to the receiver is accounted for, yielding a spectral time history at the ground (including a range of frequencies from 1 Hz to 16 kHz). A variety of noise metrics can be computed from the full calculated noise field and the metrics commonly used to assess rocket noise are described in the following section.

2.2 Rocket Noise Metrics and Assessment Criteria

2.2.1 Noise Metrics

FAA Order 1050.1F[9] specifies Day-Night Average Sound Level (DNL) as the standard metric for community noise impact analysis, but also specifies that other supplemental metrics may be used as appropriate for the circumstances. DNL is appropriate for continuous noise sources, such as airport noise and road traffic noise. Community Noise Equivalent Level (CNEL) is a variation of DNL specified by law in California (California Code of Regulations Title 21, Public Works) (Wyle Laboratories, 1970)[10]. CNEL has the 10-dB nighttime penalty for events between 10:00 p.m. and 7:00 a.m. but also includes a 4.8-dB penalty for events during the evening period of 7:00 p.m. to 10:00 p.m. The penalties account for the added intrusiveness of sounds during these periods. For airports DNL and CNEL represent the average sound level for annual average daily aircraft events. The noise metrics used for rocket noise analysis are:

- DNL, as defined by FAA Order 1050.1F, and CNEL;
- SEL, the Sound Exposure Level, for individual events;
- L_{Amax}, the maximum A-weighted overall sound pressure level (OASPL), for individual events;
- L_{max}, the maximum unweighted OASPL, for individual events; and
- One third octave spectra at certain sensitive receptors.

As mentioned, DNL and CNEL are necessary for policy. The next three metrics provide a measure of the impact of individual events; SEL and L_{Amax} are A-weighted and L_{max} is un-weighted. Loud individual events can pose a hearing damage hazard to people, and can also cause adverse reactions by animals. Adverse animal reactions can include flight, nest abandonment, and interference with reproductive activities. L_{max} along with spectra, may be needed to assess potential damage to structures and adverse reaction of species whose hearing response is not like that of humans.

L_{Amax} is appropriate for community noise assessment of a single event, such as a rocket launch or static fire test. This metric represents the highest A-weighted integrated sound level for the event in which the sound level changes value with time. Slowly varying or steady sounds are generally integrated over a period of one second. L_{Amax} is important in judging the interference caused by a noise event with conversation, TV listening, sleep, or other common activities. Similarly, L_{max} is the highest unweighted integrated sound level for the event, used to assess the potential for structural damage. Although A-weighted maximum sound level provides some measure of the intrusiveness of the event, it does not completely describe the total event, because it does not include the duration that the sound is heard.

SEL is a composite metric that represents both the level of a sound and its duration. Individual time-varying noise events (e.g., aircraft overflights) have two main characteristics: a sound level that changes throughout the event and a period during which the event is heard. SEL provides a measure of the total acoustic energy transmitted to the listener during the event, but it does not directly represent the sound level heard at any given time. For example, during an aircraft flyover, SEL would include both the maximum noise level and the lower noise levels produced during the entire overflight. Mathematically, it represents the sound level of a constant sound that would, in one second, generate the same acoustic energy as the actual time-varying noise event. For a rocket launch, SEL is expected to be greater than L_{Amax}.

2.2.2 Noise Assessment Guidelines

Land Use Compatibility Guidelines for Cumulative Noise Exposure

As previously mentioned, DNL and CNEL (used in California) represent the average sound level for annual average daily aircraft events which are used to assess cumulative noise exposure; both metrics are similar except CNEL includes an additional noise penalty for evening operations. FAA's published 14 Code of Federal Regulations (CFR) Part 150 defines land use compatibility guidelines for aviation noise exposure that are also applicable to rocket noise exposure. These guidelines consider land use compatibility for different uses over a range of DNL (or CNEL) noise exposure levels, including the adoption of DNL 65 dBA (or CNEL 65 dBA as specified by California law) as the limit for residential land use compatibility.

Hearing Conservation

Occupational Safety and Health Administration (OSHA)[11] guidelines are to protect human hearing from long-term, continuous exposures to high noise levels and aid in the prevention of noise-induced hearing loss (NIHL). OSHA's permissible daily noise exposure limits include a L_{Amax} of 115 dBA (slow response) for a duration of 0.25 hours or less. This is the criteria used in this study to evaluate areas around launch, landing, and static fire test sites that would require implementing a hearing conservation program, i.e., areas within the L_{Amax} 115 dBA contour. This level was chosen as a conservative indicator of when a hearing conservation program should be implemented since all proposed flight and test operations, individually or together, are not expected to exceed 0.25 hours in duration on any given day.

Structural Damage Potential

The potential for structural damage due to launch, landing, and static fire test events is assessed using the conclusions from a recent, applicable study to ascertain whether range activities (i.e., test, evaluation, demilitarization, and training activities of items such as weapons systems, ordinance, and munitions would cause structural damage. The study concluded that structural damage becomes improbable below 140 dB [Maximum Un-weighted or linear Sound Level (L_{max})]. No glass or plaster damage is expected below 140 dB and no damage is expected below 134 dB[12].

Estimated rocket noise results for Falcon 9 launch, landing, and static fire test events are presented in the following sections. These results include L_{Amax}, SEL, and L_{max} contours for single event noise assessment over the study area (Sections 3 through 5) and CNEL contours to assess the cumulative noise from all projected annual flight and test events at SLC-4 (Section 6).

3 Orbital Launch Noise Levels

3.1 Falcon 9 Launch Noise at SLC-4

RNOISE was used to estimate the L_{Amax}, SEL, and L_{max} contours for Falcon 9 orbital launches at VSFB SLC-4 using trajectory data, from liftoff to stage separation, provided by SpaceX in file 'EROS_C_ASCENT_80_12_RNOISE2.TXT'. The L_{Amax} contours indicate the maximum sound level at each location over the duration of the launch where engine thrust varies according to the ascent thrust profile provided.

RNOISE computations were done using a radial grid consisting of 128 azimuths and 100 intervals out to 500,000 feet from the launch point. Land areas were modeled using a single ground impedance value estimated from the most common ground cover type in the vicinity of Vandenberg SFB, and water areas modeled as acoustically hard. Ground effect was based on a weighted average over the propagation path. As will be shown in the resulting noise contour maps (Figures 3 through 8), the shape of the innermost contours is approximately circular. The shape of the outermost contours is due to rocket noise directivity and the difference between the ground impedance values used for water areas and land areas. The launch pad location at SLC-4 is indicated in the map legends as is the Vandenberg SFB property line and nearby cities including Lompoc, CA.

The L_{Amax} 90 dB through 130 dB contours shown in Figures 3 and 4 represent the maximum levels estimated for each Falcon 9 orbital launch at SLC-4; Figure 4 shows these contours using a zoomed in map scale (1" = 4 miles) to better show the extent of the noise exposure relative to cities located around SLC-4. The higher L_{Amax} contours (100 – 130 dB) are located within about 4 miles of SLC-4. Only the 90 dB contour extends beyond the Vandenberg SFB property line as far as the western side of Lompoc, CA. If a Falcon 9 orbital launch occurs during the day, when background levels are in the 50 dB to 60 dB range, residents of Lompoc may notice launch noise levels above 70 dB and up to 90 dB. If the same launch occurs during the night, when background levels are lower than during the day (e.g., below 40 dB to 50 dB range), Lompoc residents and the residents of Orcutt, CA to the north and Conception, CA to the south may notice launch noise levels that exceed 60 dB. A prevailing on-shore or off-shore breeze may also strongly influence noise levels in these communities.

Estimated SEL contour levels of 90 dB through 140 dB, in 10 dB increments, are shown in Figures 5 and 6 for each Falcon 9 orbital launch at SLC-4 with Figure 6 showing a zoomed in map scale. As mentioned previously, SEL is an integrated metric and is expected to be greater than the L_{Amax} because the launch event is up to several minutes in duration whereas the maximum sound level (L_{Amax}) occurs instantaneously. In Figure 6, the 100 dB SEL contour is expected to extend to the west side of Lompoc and the 90 dB SEL contour to extend further, beyond the eastern side of Lompoc.

Orbital launch events are the loudest single events of all the flight and test operations assessed in this modeling study. Accordingly, Falcon 9 orbital launch single event noise levels are related to guidelines for hearing conservation and potential for structural damage as follows.

An estimate of the areas in the vicinity of Falcon 9 orbital launches at SLC-4, where a hearing conservation program should apply was made using OSHA's permissible daily noise exposure limit of 115 dBA (slow response) for a duration of 0.25 hours or less. Figure 4 shows that noise levels (L_{Amax}) are less than OSHA's 115 dBA upper noise limit guideline at distances greater than approximately 1.5 miles from the launch pad (i.e., hearing conservation should apply within 1.5 miles from the launch pad). Falcon 9 orbital launch noise events will last a few minutes at most, at a single location, with the highest noise levels occurring for less than a minute such that OSHA's 115 dBA daily noise exposure limit is not expected to be exceeded.

The potential for structural damage due to Falcon 9 orbital launch events is assessed using the criteria described in Section 2.2.2. Applying these criteria indicates that no damage is expected from Falcon 9 launches or any of the other Falcon 9 operations that generate lower noise levels than launches. The 134 dB Maximum Unweighted Sound Level (L_{max}) contour for all Falcon 9 flight and test operations is well within VSFB property, such that no off-base impacts are expected. The L_{max} 110 dB through 150 dB contours estimated for Falcon 9 orbital launch events at SLC-4 are shown in Figures 7 and 8 (zoomed in). Falcon 9 orbital launch events are estimated to generate L_{max} of 134 dB approximately 0.5 miles from the launch pad (Figure 8).

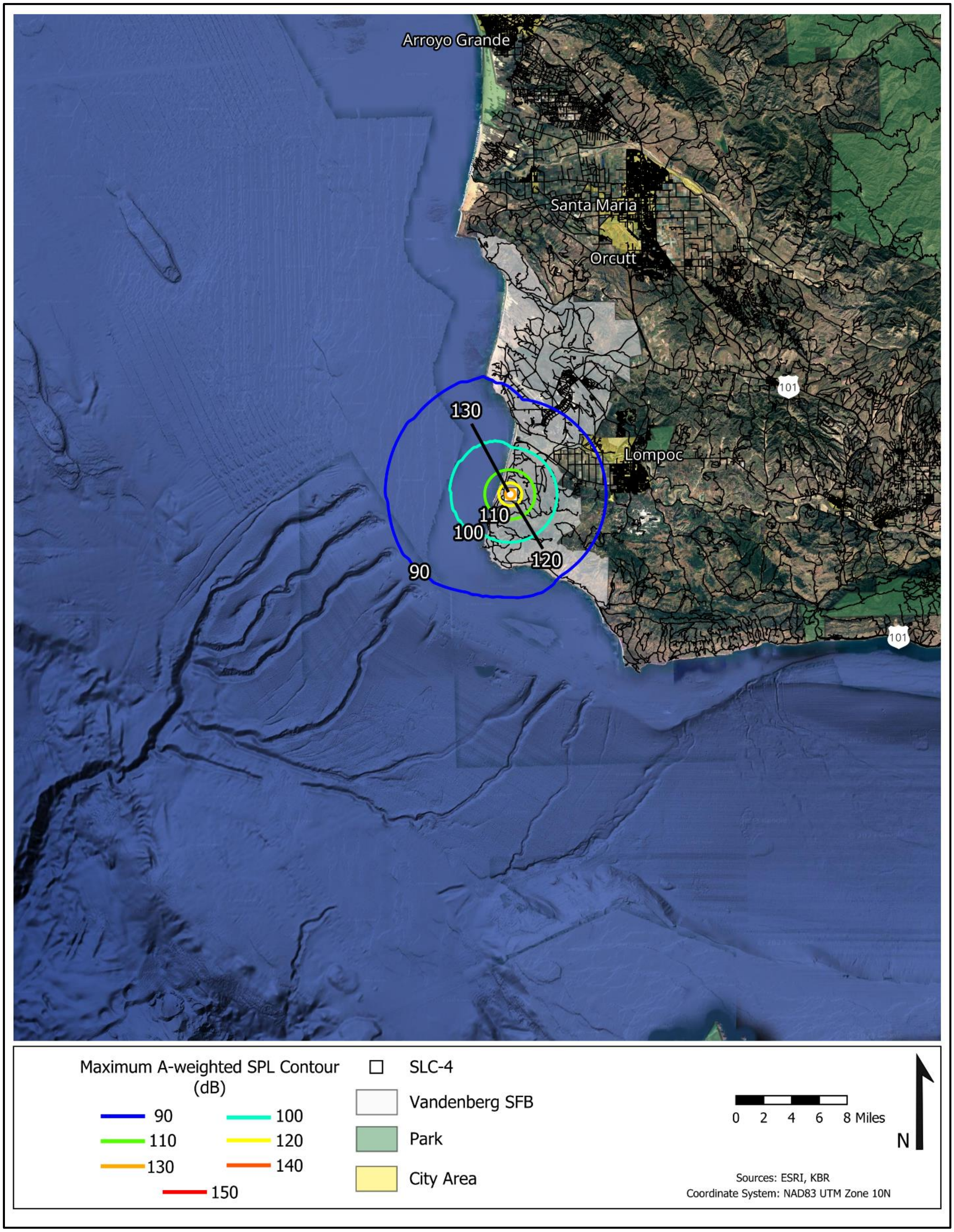

Figure 3. Falcon 9 Orbital Launch from SLC-4: Maximum A-Weighted Sound Levels (Zoom Out)

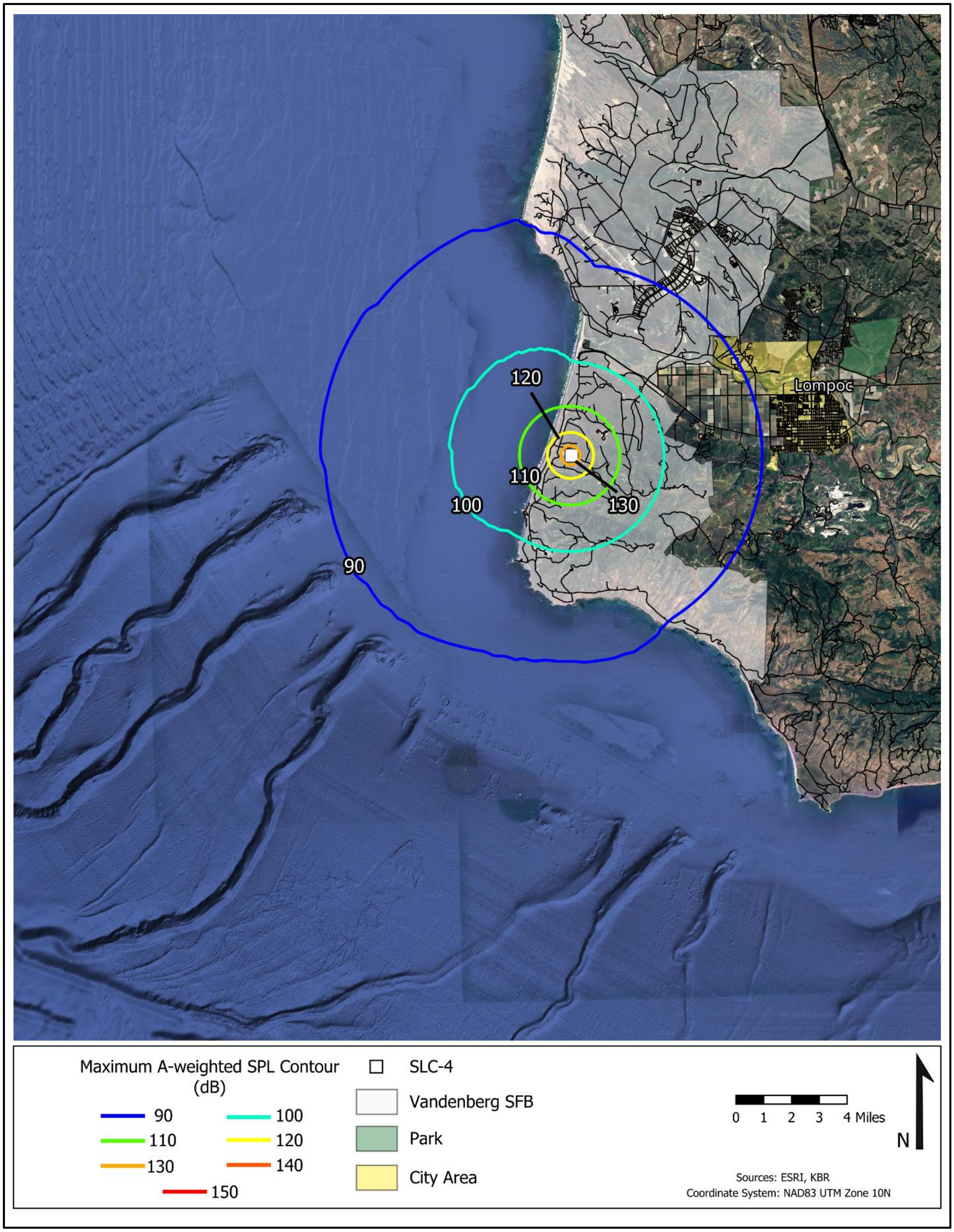

Figure 4. Falcon 9 Orbital Launch from SLC-4: Maximum A-Weighted Sound Levels

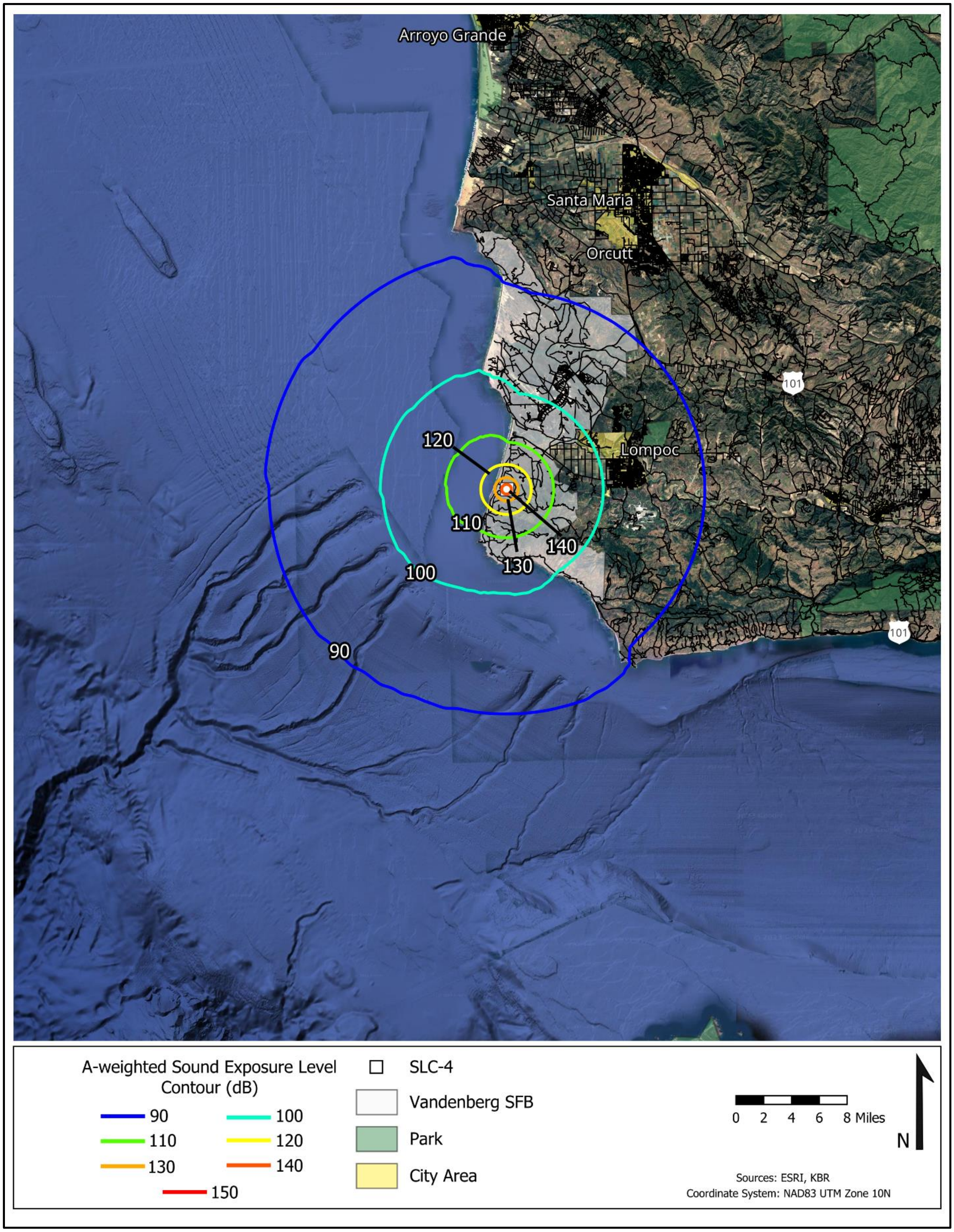

Figure 5. Falcon 9 Orbital Launch from SLC-4: Sound Exposure Levels (Zoom Out)

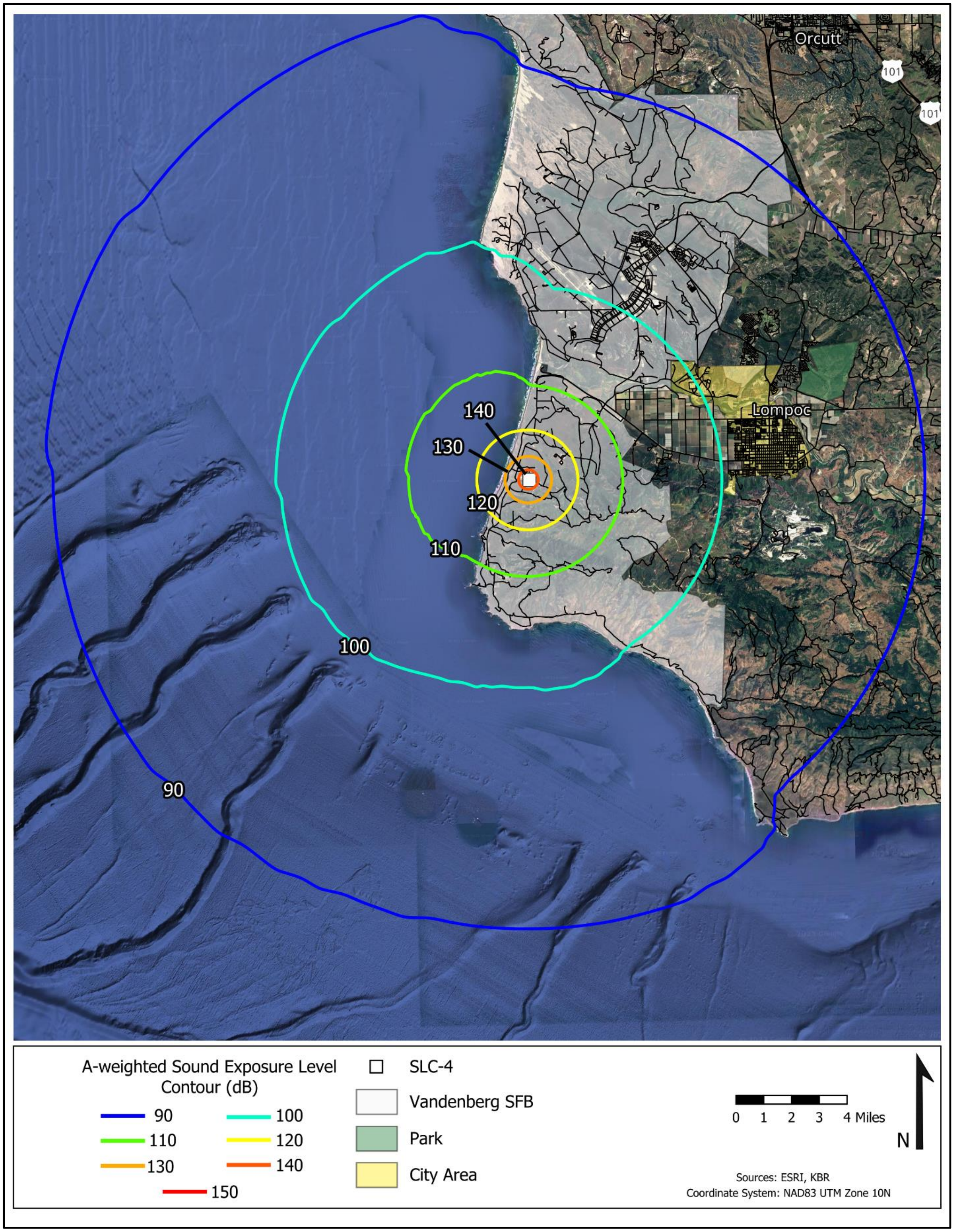

Figure 6. Falcon 9 Orbital Launch from SLC-4: Sound Exposure Levels

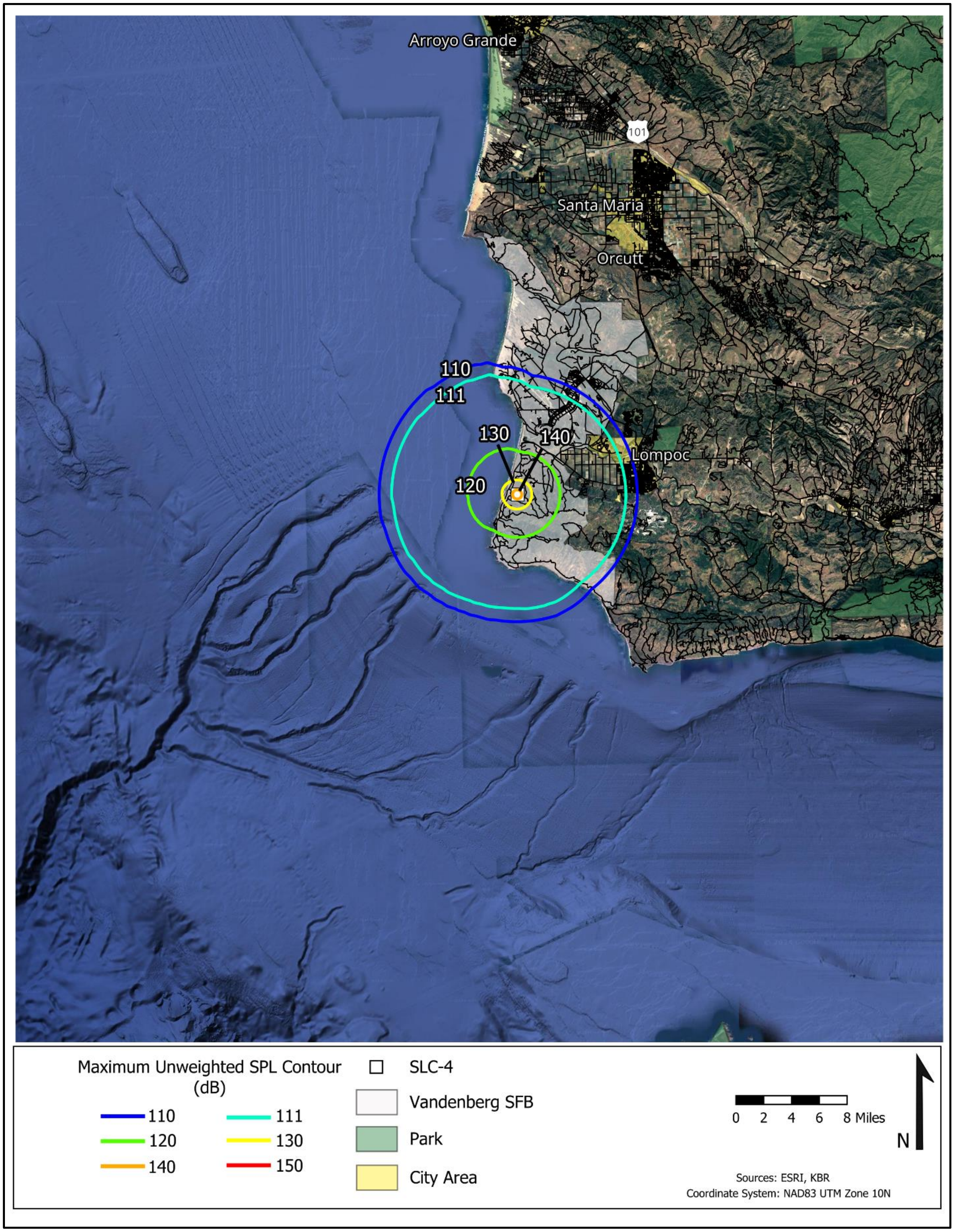

Figure 7. Falcon 9 Orbital Launch from SLC-4: Maximum Un-Weighted Sound Levels (Zoom Out)

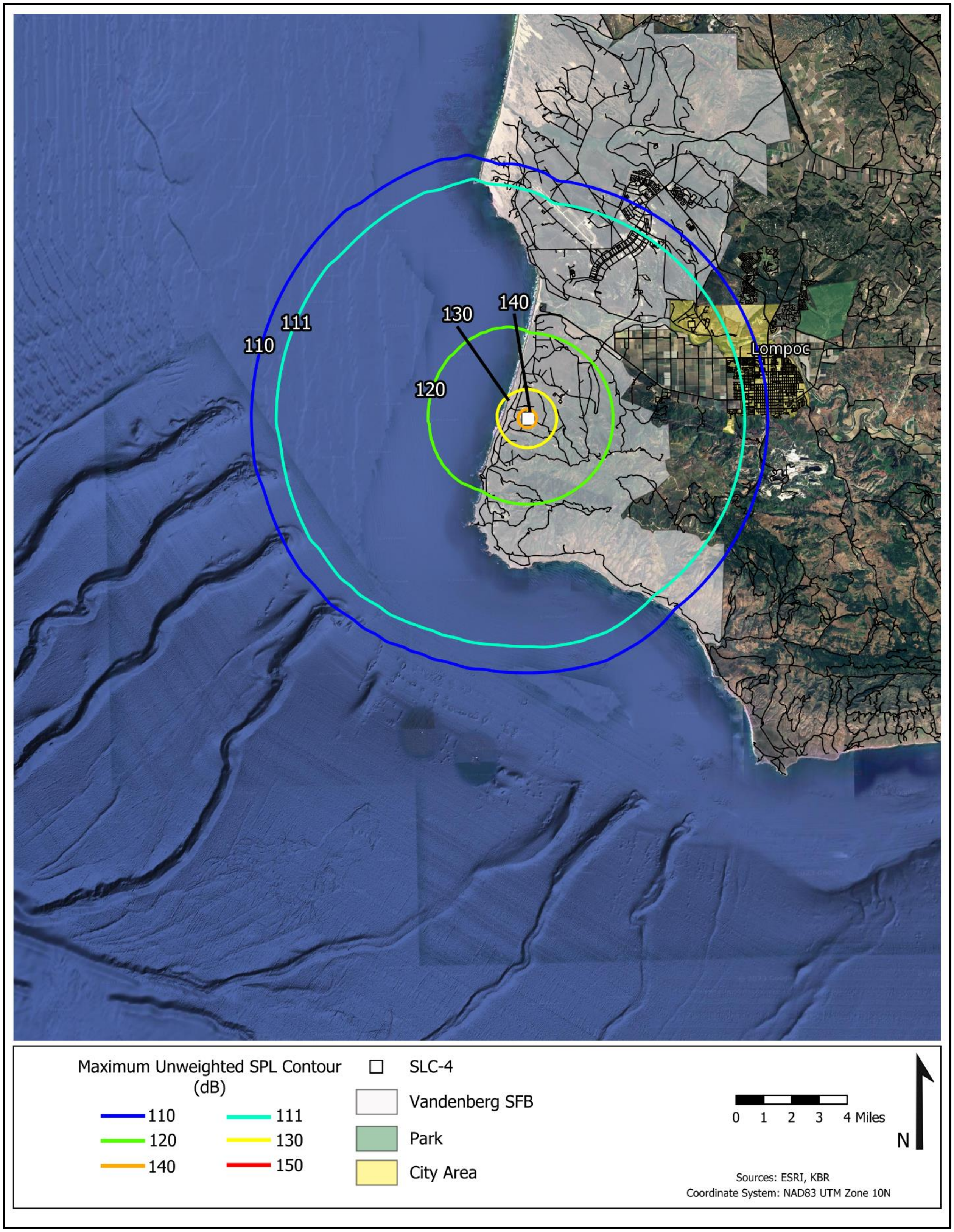

Figure 8. Falcon 9 Orbital Launch from SLC-4: Maximum Un-Weighted Sound Levels

4 Descent/Landing Noise Levels

4.1 Falcon 9 Booster Landings at SLC-4

RNOISE was used to estimate the L_{Amax}, SEL and L_{max} contours for Falcon 9 booster landings at SLC-4. The Falcon 9 booster reentry and landing trajectories were provided by SpaceX in file 'EROS_C_SLC6E_SLC4LANDING_STAGE1_80_12.ASC'. L_{Amax} contours indicate the maximum sound level at each location over the duration of the landing where booster engine thrust varies according to the reentry/descent thrust schedule provided.

RNOISE computations were done using a radial grid consisting of 128 azimuths and 100 intervals out to 500,000 feet from the launch point. Land areas were modeled using a single ground impedance value estimated from the most common ground cover type in the vicinity of Vandenberg SFB, and water areas modeled as acoustically hard. Ground effect was based on a weighted average over the propagation path. As will be shown in the resulting noise contour maps (Figures 9 through 11), the shape of the innermost contours is approximately circular. The shape of the outermost contours is due to rocket noise directivity and the difference between the ground impedance values used for water areas and land areas. The landing pad location at SLC-4 is indicated in the map legends as is the Vandenberg SFB property line and nearby cities including Lompoc, CA. Figures 9 through 11 display the L_{Amax}, SEL, and L_{max} contours, respectively, for a Falcon 9 landing at SLC-4.

In Figure 9 the 90 dB L_{Amax} contour is entirely within the Vandenberg SFB property line. Residents of Lompoc, CA may notice Falcon 9 landing event levels above 60 dB L_{Amax}, especially nighttime events. Compared with the Falcon 9 orbital launch noise levels reported in Section 3, Falcon 9 descent/landing noise levels at SLC-4 are considerably lower due to the much lower total engine thrust and limited firing schedule used for landing operations.

Figures 10 and 11 show the SEL and L_{max} contours, respectively, estimated for Falcon 9 landings at SLC-4. The 90 dB SEL contour is expected to extend near the west side of Lompoc though levels are considerably less than those from a Falcon 9 launch at SLC-4. In Figure 11, the 134 dB L_{max} contour, located between the 130 dB and 140 dB contours and used to assess the potential for structural damage, is entirely within VSFB property.

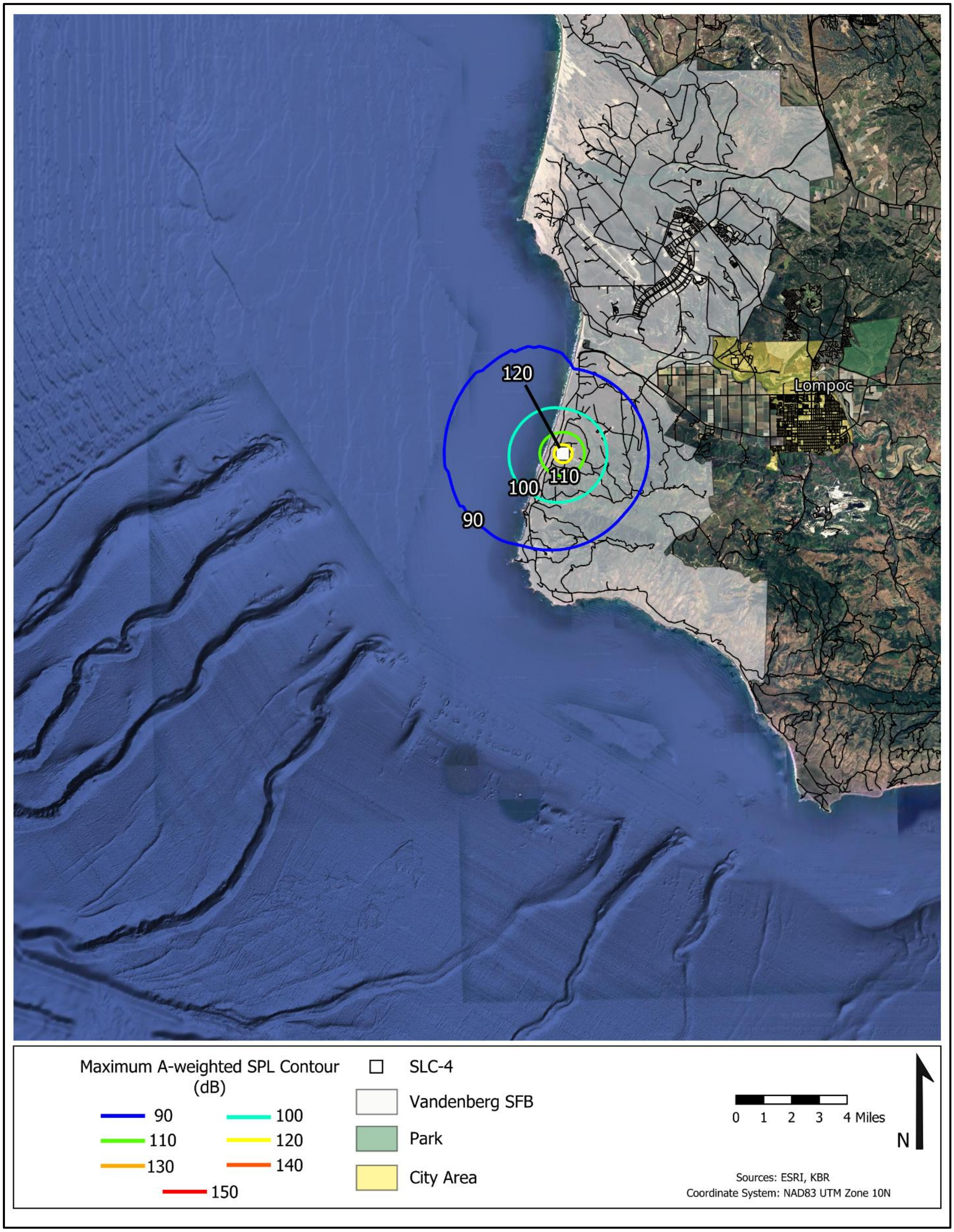

Figure 9. Falcon 9 Landing at SLC-4: Maximum A-Weighted Sound Levels

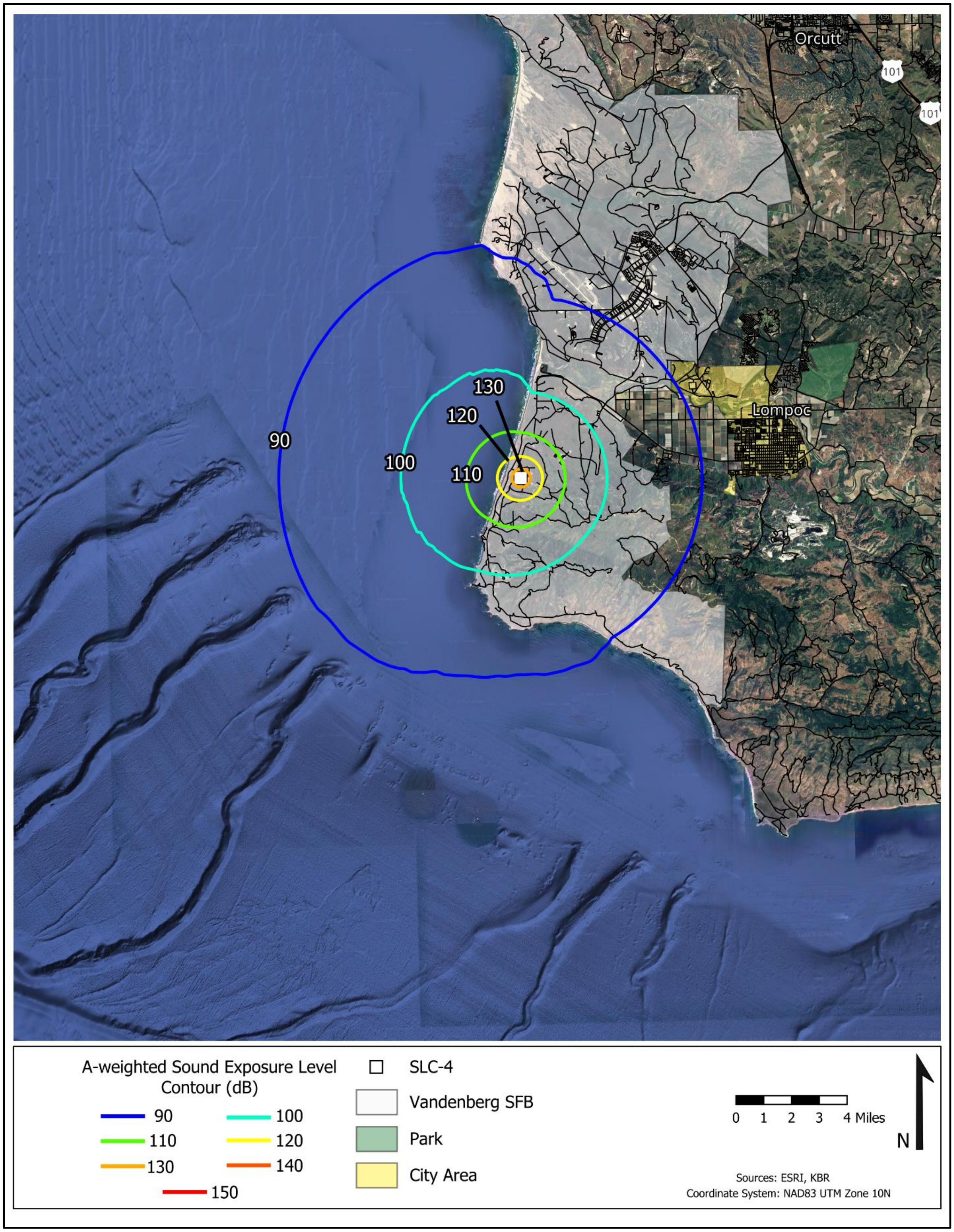

Figure 10. Falcon 9 Landing at SLC-4: Sound Exposure Levels

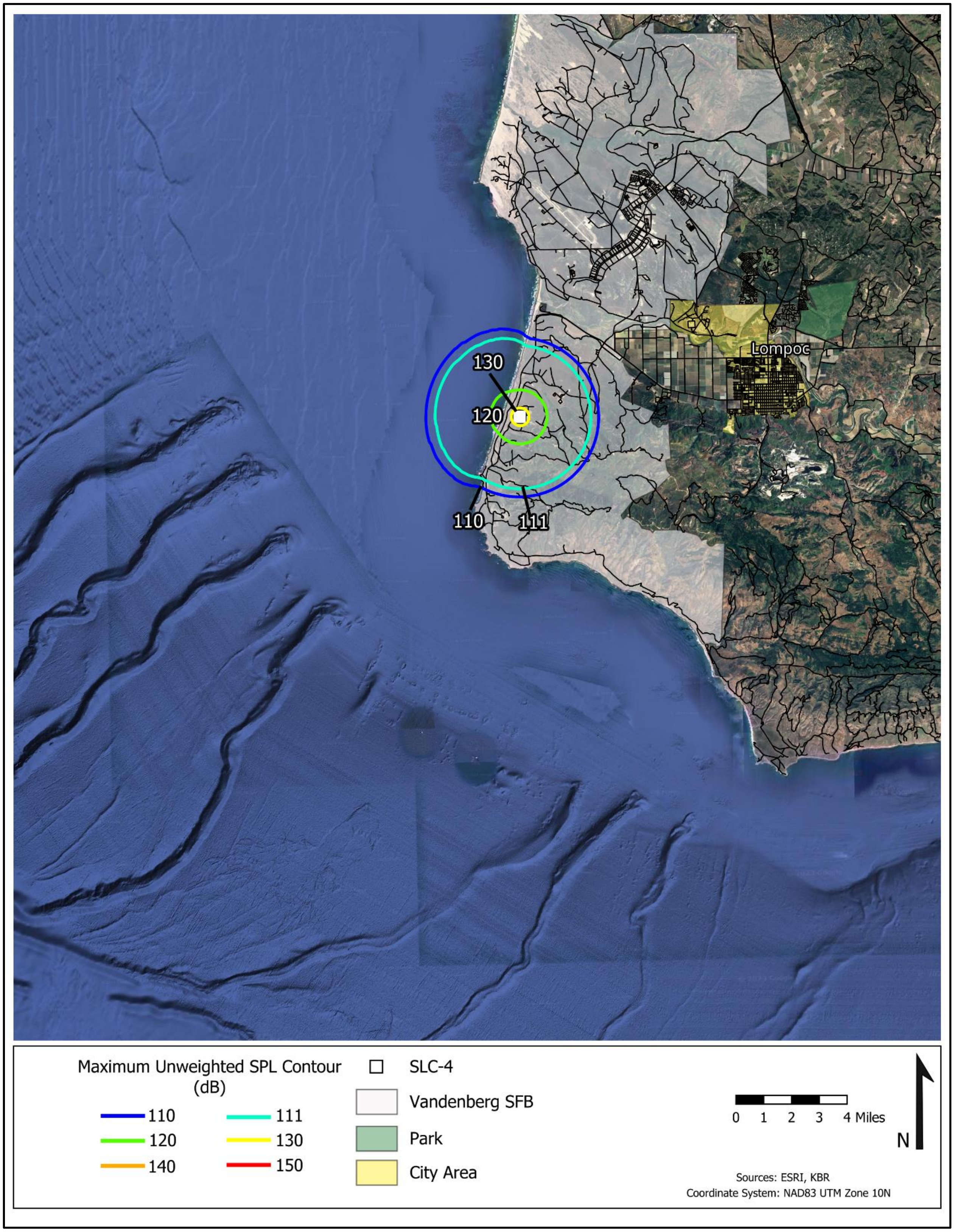

Figure 11. Falcon 9 Landing at SLC-4: Maximum Un-Weighted Sound Levels

5 Static Fire Test Noise Levels

5.1 Falcon 9 Static Fire Test Noise at SLC-4

Falcon 9 static fire tests are planned to occur at SLC-4 where 9 engines, that each generate 190 Klbs of thrust at sea level, will be fired for 7 seconds. Figures 12 through 14 show the estimated L_{Amax}, SEL, and L_{max} contours, respectively, for a static fire test at SLC-4. The L_{Amax} 90 dB contour (Figure 12) and SEL 90 dB contour (Figure 13) do not extend off Vandenberg SFB property. The L_{max} 134 dB contour, between the 130 dB and 140 dB contours in Figure 14 and used to assess the potential for structural damage, is located entirely within VSFB property. To the west of SLC-4, these contours extend much farther out due to modeling sound propagation over water compared with propagation over land to the east. Residents of Lompoc, CA may hear Falcon 9 static test events above 60 dB, and particularly at night and if onshore wind conditions favor sound propagation to the east (historically, winds are most often from the west for 3.9 months per year, from May 11 to September 9, with a peak percentage of 60% on July 16).

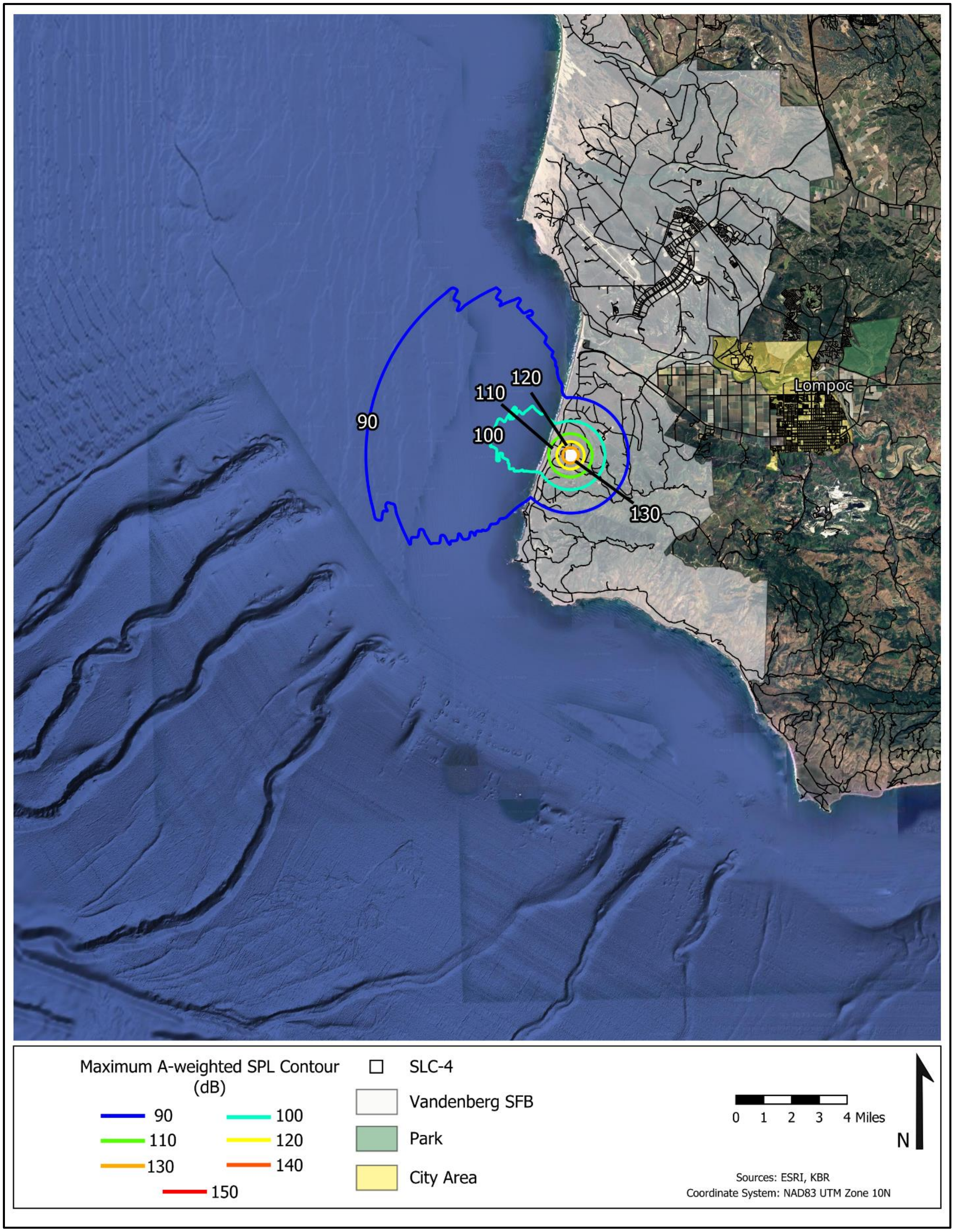

Figure 12. Falcon 9 Static Fire Test at SLC-4: Maximum A-Weighted Sound Levels

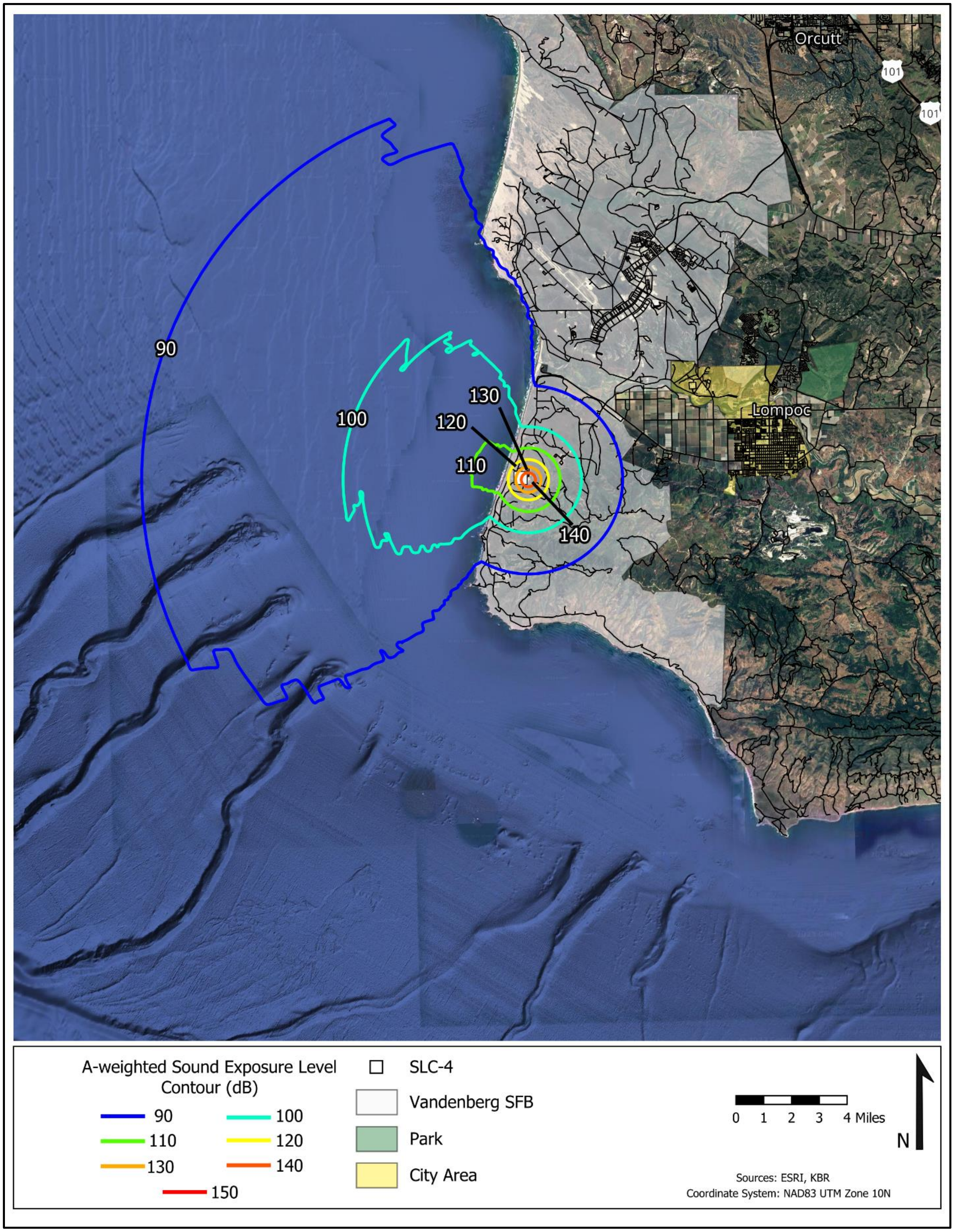

Figure 13. Falcon 9 Static Fire Test at SLC-4: Sound Exposure Levels

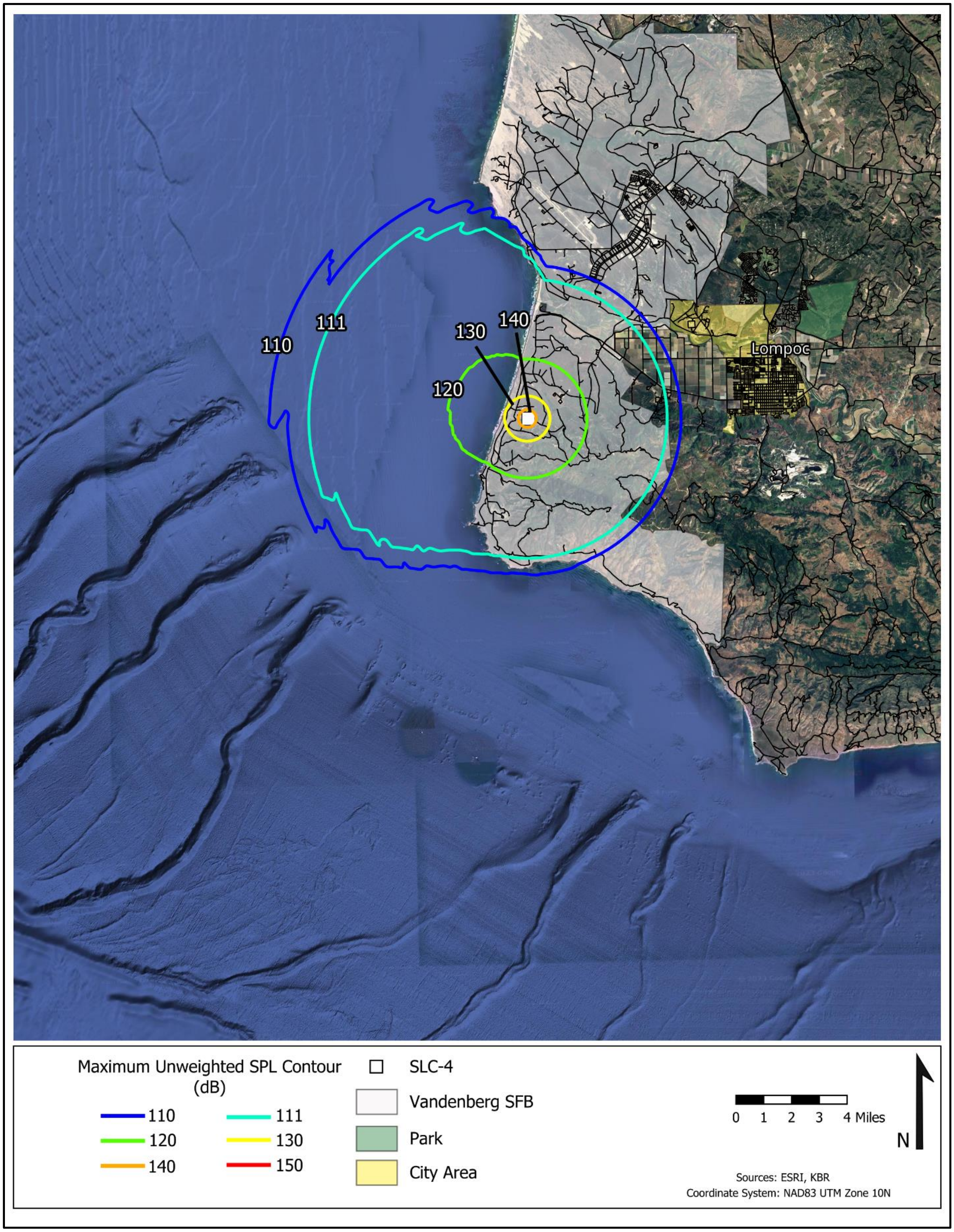

Figure 14. Falcon 9 Static Fire Test at SLC-4: Maximum Un-Weighted Sound Levels

6 Cumulative Noise Levels for Falcon 9 Operations

6.1 Projected Falcon 9 Launch, Landing, and Static Tests at SLC-4

Cumulative noise levels were estimated, using CNEL, for projected Falcon 9 launch, landing, and static fire test operations at SLC-4 and results indicate that none of the operation types alone are expected to cause adverse community noise exposure using the CNEL 65 dB contour for assessment purposes. Additionally, when cumulative noise is assessed for a projected combination of these operation types, as described below, noise exposure is still estimated to be less than CNEL 65 dB in populated areas east of the Vandenberg SFB property line.

One scenario was analyzed for a combination of projected annual Falcon 9 launch, landing, and static fire operations at SLC-4 that are expected to fulfill mission and test requirements at Vandenberg SFB as follows.

SLC-4

- 50 Falcon 9 launches (25 day / 25 night)
- 12 Falcon 9 stage 1 landings (6 day / 6 night)
- 30 Falcon 9 static fire tests (15 day / 15 night)

The above operations at SLC-4 include the projected daytime/nighttime split. Each Falcon 9 landing event includes 1 booster landing. Estimated CNEL contours in the vicinity of Vandenberg SFB for the combined annual operations listed above are shown in Figure 15. For these combined Falcon 9 operations, it can be seen from Figure 15 that the 65 CNEL contour is located entirely within Vandenberg SFB property; the area within the 65 CNEL contour includes facilities associated with Space Launch Complex 4 but does not include residential land use.

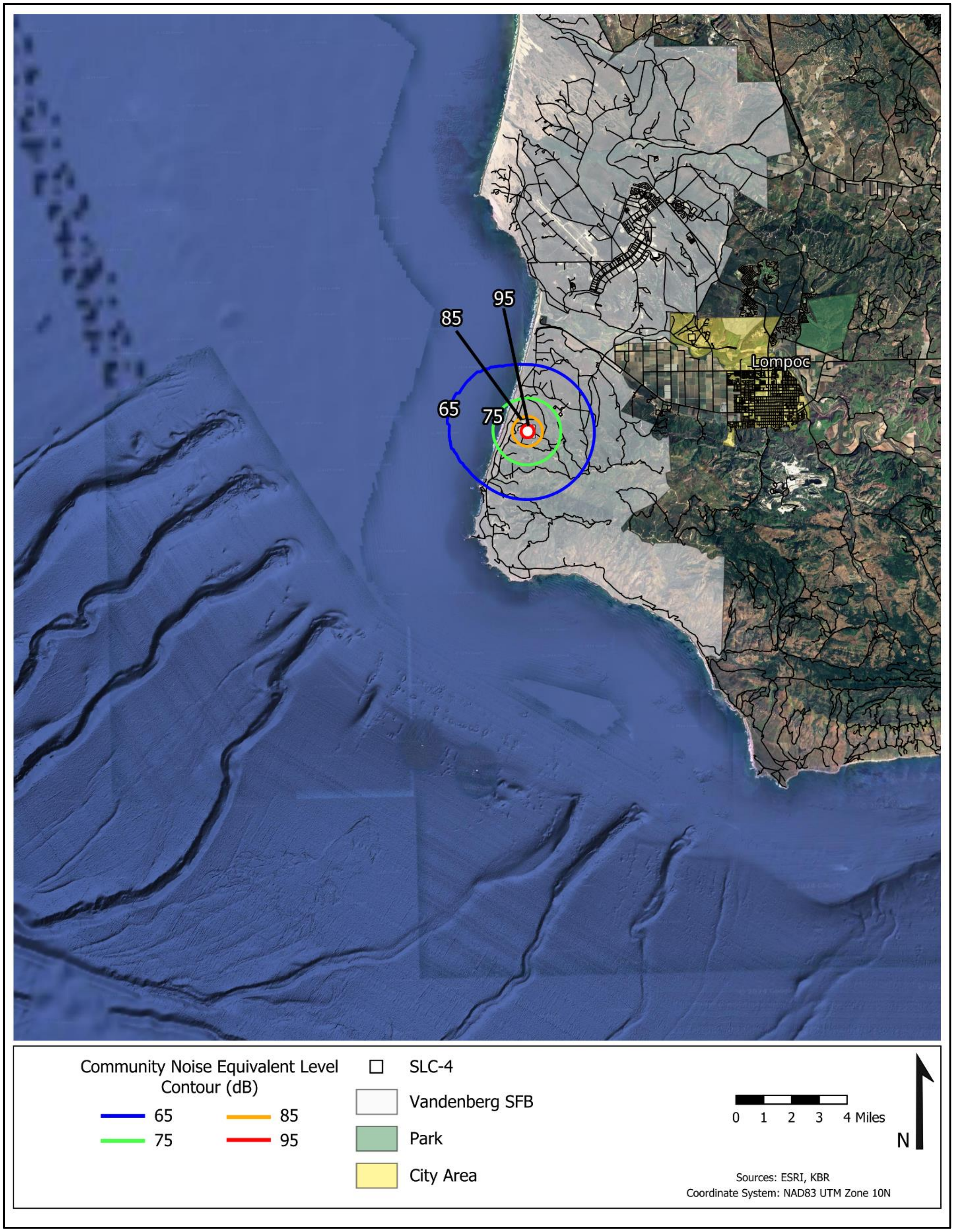

Figure 15. Falcon 9 Combined Operations at SLC-4: CNEL Contours

7 Sonic Boom Background

A sonic boom is the wave field about a supersonic vehicle. As the vehicle moves, it pushes the air aside. Because flight speed is faster than the speed of sound, the pressure waves can't move away from the vehicle, as they would for subsonic flight, but stay together in a coherent wave pattern. The waves travel with the vehicle. Figure 16 is a classic sketch of sonic boom from an aircraft in level flight. It shows a conical wave moving with the aircraft, much like the bow wave of a boat. While Figure 41 shows the wave as a simple cone, whose ground intercept extends indefinitely, temperature gradients in the atmosphere generally distort the wave from a perfect cone to one that refracts upward, so the ground intercept goes out to a finite distance on either side. A sonic boom is not a onetime event as the aircraft "breaks the sound barrier" but is often described as being swept out along a "carpet" across the width of the ground intercepts and the length of the flight track. Booms from steady or near-steady flight are referred to as carpet booms.

The waveform at the ground is generally an "N-wave" pressure signature, as sketched in the figure, where compression in the forward part of the vehicle and expansion and recompression at the rear coalesce into a bow shock and a tail shock, respectively, with a linear expansion between.

Figure 16 is drawn from the perspective of aircraft coordinates. The wave cone exists as shown at a particular time but is generated over a time period. Booms can also be viewed from the perspective of rays propagating relative to ground-fixed coordinates. Figure 17 shows both perspectives. The cone represents rays that are generated at a given time, and which reach the ground at later times. The intercept of a given ray cone with the ground is called an "isopemp." When computing sonic booms the ray perspective is appropriate, since one starts the analysis from the aircraft trajectory points and each isopemp is identified with flight conditions at a given time. As sketched in Figure 17, the isopemps are forward facing crescents.

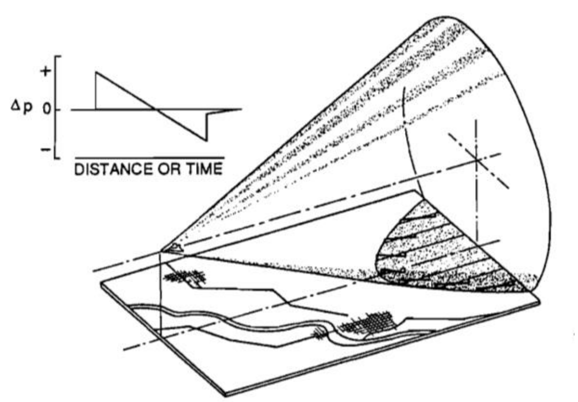

Figure 16. Sonic Boom Wave Field

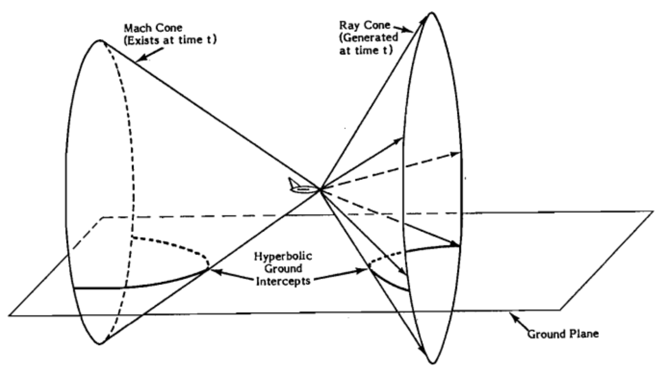

Figure 17. Wave versus Ray Viewpoints

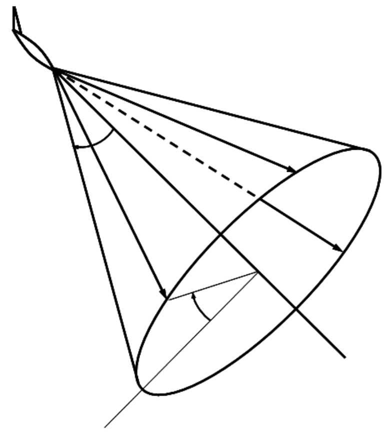

Figure 18. Ray Cone in Diving Flight

Figures 16 and 17 are drawn for steady level flight. If the aircraft climbs or dives, the ray cone tilts along with it. Figure 18 shows a ray cone in diving flight. At the angle in the figure the isopemp would still be a forward-facing crescent but would wrap around further than shown in Figure 17. In a steeper dive the isopemp could go full circle. If the vehicle is climbing at an angle steeper than the ray cone angle, there will be no boom at the ground. During very steep descent (near vertical) and at high Mach numbers the rays can be emitted at a shallow enough angle that they would refract upward and not reach the ground. For a descending vehicle that eventually decelerates to subsonic speed, some part of the trajectory will generate boom that reaches the ground.

Supersonic vehicles can turn and accelerate or decelerate. That affects the boom loudness, and under some conditions cause focused superbooms. Figure 19 is a sketch of rays from an accelerating aircraft. As the Mach number increases the ray angles steepen. The rays cross and overlap, with the focus along the "caustic" line indicated in the figure. The boom on a focusing ray is a normal N-wave before it gets close to the caustic, is amplified by a factor of two to five as it reaches the caustic, then is substantially attenuated as a "post-focus" boom after it passes the caustic.

Figure 20 shows the isopemps for this type of acceleration focus. The focal zone is the concentrated region at the left end of the footprint. The maximum focus area – where the boom is more than twice the unfocused normal boom – is very narrow, generally a hundred yards or less.

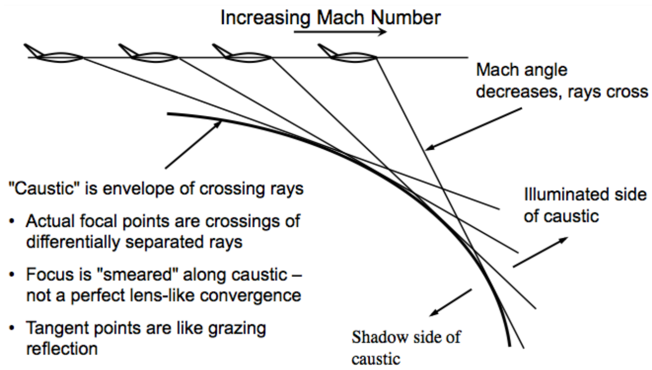

Figure 19. Ray Crossing and Overlap in an Acceleration Focus

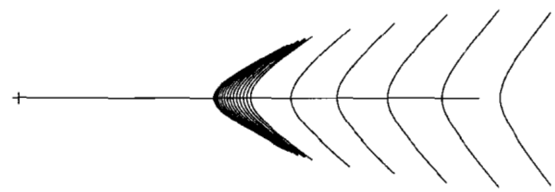

Figure 20. Isopemp Overlap in an Acceleration Focus

8 Launch Sonic Boom Levels

8.1 Sonic Boom from Falcon 9 Launches at SLC-4

Falcon 9 launch trajectories from SLC-4 were provided by SpaceX in data file "EROS_C_ASCENT_80_12_RNOISE2.TXT". This file contains the liftoff and ascent part of the trajectory which is supersonic above approximately 24,000 feet until Stage 1 apogee.

The sonic boom footprint for the Falcon 9 launch was computed using PCBoom[13,14]. A shape factor estimated for the Falcon 9 launch, using Carlson's method[15], was used as the sonic boom source in PCBoom (and likewise for modeling of the Falcon 9 launches and landings described following). Figure 21 shows the sonic boom footprint, in the form of overpressure contours, pounds per square foot (psf) for the Falcon 9 launch from SLC-4. The ground tracks from the launch at SLC-4 is also shown in the figure. The ascent phase of the launch generates a broad forward-facing crescent region (contour at the bottom of the map) as the vehicle pitches over.

- Peak overpressure levels from Falcon 9 launch at SLC-4, shown in Figure 21, are between 0.1 and 1.0 psf (1.0 psf represented by several red colored, narrow focus regions located on the eastern side of the crescent); and the crescent-shaped contour is located entirely over water.

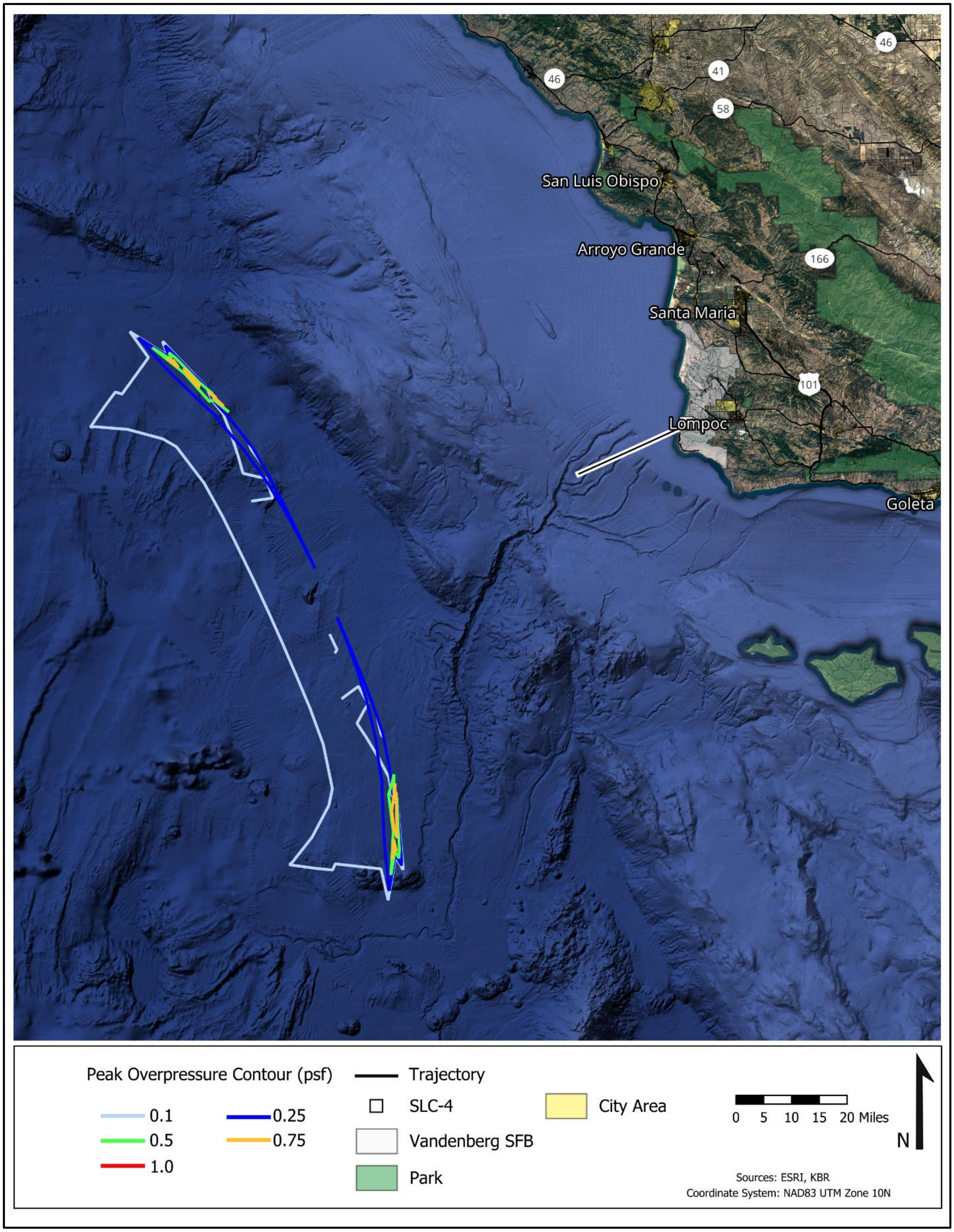

Figure 21. Sonic Boom from Falcon 9 Launch at SLC-4: psf Contours

9 Landing Sonic Boom Levels

9.1 Sonic Boom from Falcon 9 Landings at SLC-4

Falcon 9 launches at Vandenberg SFB will result in a limited number of stage 1 booster recoveries via landing operations. Falcon 9 landing trajectories for SLC-4 were provided by SpaceX in data file "EROS_C_SLC6E_SLC4LANDING_STAGE1_80_12.ASC". The descent portion of the landing at SLC-4 is supersonic from shortly after the apogee until it passes through an altitude just below 16,000 feet. Most of the stage 1 descent is unpowered.

The boom footprints at SLC-4 were computed using PCBoom.[13,14] The vehicle is a cylinder generally aligned with the velocity vector, descending engines first. The landing trajectory kinematics includes the effect of atmospheric drag and the retro burn.

Figure 22 shows the sonic boom footprint, in the form of overpressure contours, pounds per square foot (psf) for the Falcon 9 landing at SLC-4. The ground track of the entire trajectory is also shown in Figure 22. There is a broad forward-facing crescent region generated as the vehicle descends below 200,000 feet at a heading of approximately 68 degrees. After the burn finishes there is an oval boom footprint region that ends when vehicle speed becomes subsonic. There are two narrow focus lines (magenta color), with contour levels in the 5.0 psf to 7.5 psf range, located on the northern edge of the crescent, generated as the vehicle accelerates at the end of the retro burn. At lower altitudes drag slows the descent, so boom following the focus is a conventional carpet boom.

- The boom levels in the vicinity of the landing pad, located at latitude 34.632989 degrees and longitude -120.615203 degrees, range from about 5.0-7.5 psf.
- Boom levels on Vandenberg SFB range from 0.1-5.0 psf in areas away from the landing pad.
- The highest boom levels offshore are up to 7.5 psf in the narrow focus region just inside the north facing crescent shown in Figure 22. This zone is narrow – about 100 yards wide. The location will vary with weather conditions, so it is very unlikely that any given location will experience the focus more than once over multiple events.
- The broad crescent, with boom levels of 0.1 psf is located mostly over the Pacific Ocean, however this contour surrounds Vandenberg SFB and Lompoc, CA and Orcutt, CA the east as well as Conception, CA to the south.

In general, booms in the 0.2 to 0.3 psf range could be heard by someone who is expecting it and listening for it, but usually would not be noticed. Booms of 0.5 psf are more likely to be noticed, and booms of 1.0 psf are certain to be noticed. Therefore, people in the western half of Lompoc, CA are likely to notice booms from Falcon 9 landings as are people located on Vandenberg SFB. People located on Vandenberg SFB within the 1.0 psf and 2.0 psf region could be startled and possibly annoyed. Announcements of upcoming Falcon 9 launches and landings serve to warn people about these noise events and are likely to help reduce adverse reactions to these noise events.

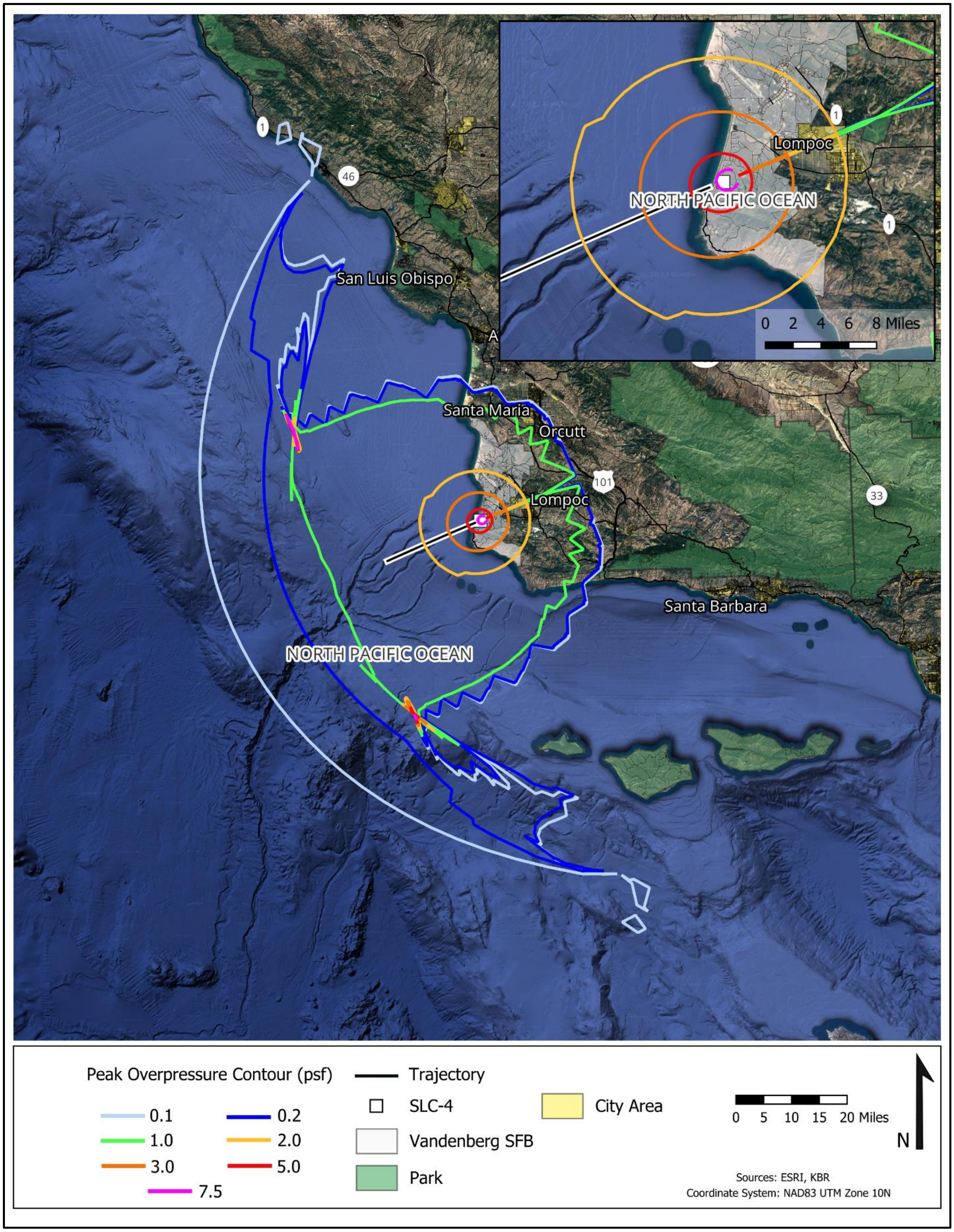

Figure 22. Sonic Boom from Falcon 9 Landing at SLC-4: psf Contours

10 References

1. Plotkin, K.J., Sutherland, L.C., and Moudou, M., "Prediction of Rocket Noise Footprints During Boost Phase," AIAA Paper 1997-1660, May 1997.

2. Plotkin, K.J., "A model for the prediction of community noise from launch vehicles. (A)," *J. Acoust. Soc. Am.* 127, 1773, April 2010.

3. Wilhold, G. A.; Guest, S. H.; and Jones, J. H., "A Technique for Predicting Far-Field Acoustic Environments Due to a Moving Rocket Sound Source," NASA TN D-1832, 1963.

4. Eldred, K. McK., et al, "Acoustic loads generated by the propulsion system," NASA Space Vehicle Design Criteria (Structures), NASA SP-8072, June 1971.

5. Sutherland, L. C., "Progress and problems in rocket noise prediction for ground facilities", AIAA Paper 1993-4383, Oct. 1993.

6. Plotkin, K.J., Sutherland, L.C, and Vu, B.T., "Lift-Off Acoustics Predictions for the Ares I Launch Pad," AIAA Paper 2009-3163, May 2009.

7. Chien, C.F. and W.W. Soroka. "Sound Propagation Along An Impedance Plane," *Journal of Sound and Vibration* 43(1), 9-20, 1975.

8. "American National Standard Method for Calculation of the Absorption of Sound by the Atmosphere," ANSI S1.26 (R2004).

9. U.S. Department of Transportation. Federal Aviation Administration Order 1050.1F "Environmental Impacts: Policies and Procedures," 2015.

10. Wyle Laboratories. 1970. Supporting Information for the Adopted Noise Regulations for California Airports. Wyle Report WCR 70-3(R).

11. OSHA, "Federal Regulation Title 29 - Labor, Subtitle B, Chapter XVII, Part 1910 - Occupational Safety and Health Standards, Subpart G - Occupational Health and Environmental Control, 1910.95 - Occupational noise exposure," [Online]. Available: http://www.ecfr.gov/. [Accessed Dec 2020].

12. Fenton, R., and R. Methold. 2016. Mod Shoeburyness and Pendine noise and vibration study criteria for the assessment of potential building damage effects from range activities. June. Southdowns Environmental Consultants, Lewes, East Sussex, UK. 55 pp.

13. Bradley, K. A., et al, 2018. User guides for noise modeling of commercial space operations – RUMBLE and PCBoom. Airport Cooperative Research Program Research Report 183. Produced by Wyle Laboratories, Inc., Arlington, VA and Blue Ridge Research and Consulting, LLC, Asheville, NC.

14. Page, J.A., Plotkin, K.J., and Wilmer, C., "PCBoom Version 6.6 Technical Reference and User Manual," Wyle Report WR 10-10, December 2010.

15. Carlson, H.W., "Simplified Sonic-Boom Prediction," NASA Technical Paper 1122, NASA Langley Research Center, March 1978.

16. https://www.nasa.gov/centers/armstrong/news/FactSheets/FS-016-DFRC.html.

Appendix G

Marine Biological Resources

G.1 ESA-Listed Fishes

G.1.1 Steelhead (*Onchorhynchus mykiss*)

G.1.1.1 Status

The National Marine Fisheries Service (NMFS) listed several Evolutionarily Significant Units of anadromous steelhead as endangered or threatened, including the Southern California Distinct Population Segment (DPS) of steelhead, which encompasses the populations occurring from the Santa Maria River in Santa Barbara County to the California-Mexico border, as endangered in 1997 (62 Federal Register [FR] 43937). In January 2012, NMFS issued a final Recovery Plan to stabilize and restore steelhead trout populations in coastal streams from the Santa Maria River in Santa Barbara County south to the United States and Mexico border (NMFS 2012).

Steelhead populations have experienced significant declines along the Pacific Coast of North America since the early 1900s. The Santa Ynez River in Santa Barbara County, California, once supported what was likely the largest steelhead run south of San Francisco Bay. The run size for the Santa Ynez, Santa Clara, and Ventura Rivers and Malibu Creek is estimated to have been between 32,000 and 46,000 individuals (Boughton & Fish 2003; Helmbrecht & Boughton 2005; Good et al. 2005; Williams et al. 2011). Even after the construction of Gibraltar Dam in 1920, 72 mi (116 km) upstream of the Santa Ynez River mouth, historic run sizes for the Santa Ynez River were estimated at 12,995 to 25,032 individuals (Shapovalov & Taft 1954; Busby et al. 1996). Runs remained large and supported a recreational fishing industry until the construction of Bradbury Dam in 1954 (Alagona et al. 2012). Bradbury Dam is located 48 mi (77 km) upstream from the Pacific Ocean on the mainstem of the Santa Ynez River. It is an impassable barrier that blocks two-thirds of the former steelhead spawning and rearing habitat (Alagona et al. 2012). Following Bradbury Dam's construction, runs of steelhead on the Santa Ynez River were reported at less than 100 individuals on an annual basis (Nehlsen et al. 1991; Reavis 1991). Between 2001 and 2011, an average of 3.4 adult steelhead were trapped per year at a lower Santa Ynez River monitoring station and no adults were observed between 2010 and 2016 (NMFS 2016a).

G.1.1.2 Life History

There is considerable variation in this life history pattern within the population, partly due to Southern California's variable seasonal and annual climatic conditions. Some winters produce heavy rainfall and flooding, which allow juvenile steelhead easier access to the ocean, while dry seasons and periods of drought may close the mouths of coastal streams and rivers, limiting juvenile steelheads' access to marine waters (NMFS 1997) as well as adult access to spawning grounds (U.S. Bureau of Reclamation 2013).

G.1.1.3 Occurrence within the Action Area

The natural range of anadromous steelhead includes the U.S. Pacific Coast to Southern California (Good et al. 2005), but it has been introduced throughout the world. Spawning and rearing habitat are found outside of the ROI in freshwater creek and river systems, where adults may migrate up to 930 mi (1,497 km) from their ocean habitats to reach their freshwater spawning grounds in high-elevation tributaries. Near the Action Area, the primary rivers that steelhead migrate into are the Santa Maria and Santa Ynez Rivers (Good et al. 2005), as well as Jalama Creek. Steelhead hatch in freshwater streams, where they spend their first 1 to 3 years. They later move into the ocean, where most of their growth occurs. After spending between 1 and 4 years in the ocean, steelhead return to their home freshwater stream to spawn. Unlike other species of Pacific salmon, steelhead do not necessarily die after spawning and are able to spawn more than once.

G.1.1.4 Critical Habitat

In September 2005, the NMFS issued the final critical habitat designation for the Southern California Steelhead DPS (70 FR 52488). This critical habitat designation does not include VSFB because it was excluded under section 4(b)(2) of the ESA and exempted under section 4(a)(3) of the ESA. In addition, designated critical habitat for steelhead in Southern California is restricted to rivers and estuaries and therefore does not overlap with the Action Area

G.1.2 Chinook Salmon (*Onchorhynchus mykiss*)

Several ESUs of chinook salmon may be present in the ROI in the Pacific Ocean offshore of California, which are described with specific details below.

G.1.2.1 Lower Columbia River ESU

The Lower Columbia River Chinook Salmon ESU was listed as threatened on 24 March 1999 (64 FR 14308), their status reaffirmed on 28 June 2005 (70 FR 37160), and status subsequently updated on 14 April 2014 (79 FR 20802). This ESU includes naturally spawned Chinook salmon originating from the Columbia River and its tributaries downstream of a transitional point east of the Hood and White Salmon Rivers, and any such fish originating from the Willamette River and its tributaries below Willamette Falls.

In general, the more abundant juvenile Lower Columbia River fall-run Chinook migrate north upon entering the Pacific Ocean (Fisher et al. 2014). However, the less-abundant juvenile Lower Columbia River spring-run Chinook, though more common beyond the continental shelf, with most migrating far offshore after their first year of marine residence (Quinn & Myers 2005; Sharma 2009), have been detected in the coastal waters of Oregon and Washington for much of the year (Fisher et al. 2014). Occurrence of chinook salmon from the Lower Columbia River ESU would be rare in the ROI.

G.1.2.2 California Coastal ESU

The California Coastal Chinook Salmon ESU was listed as threatened on 16 September 1999 (64 FR 50394), their status reaffirmed on 28 June 2005 (70 FR 37160), and status subsequently updated on 14 April 2014 (79 FR 20802). This ESU includes naturally spawned Chinook salmon originating from rivers and streams south of the Klamath River to and including the Russian River (79 FR 20802).

The California Coastal Chinook salmon ESU produces primarily ocean-type juveniles that reside for less than a year in fresh water before moving to the ocean between March and August of their first year. In the ocean, California coastal Chinook remain primarily between Pt. Reyes and southern Oregon, with highest abundances in the Fort Bragg and Klamath subareas (Bellinger et al. 2015; Satterthwaite et al. 2015). Adults of the California Coastal Chinook DPS (fall-run) migrate from September through December or January in larger rivers that remain open to the ocean all summer (NMFS 2019a). This ESU occurs within the ROI.

G.1.2.3 Sacramento River Winter-Run ESU

The Sacramento River Winter-Run Chinook Salmon ESU was listed as threatened on 4 August 1989 (54 FR 32085) and was reclassified as endangered in 1994 (55 FR 46515). This ESU includes all naturally spawned populations of winter-run Chinook salmon in the Sacramento River and its tributaries, as well as two conservation programs maintained at the Livingston-Stone National Fish Hatchery (79 FR 20802).

Juvenile fry and smolts emigrate downstream from July through March through the Sacramento River and reach the Delta from September through June (Satterthwaite et al. 2015). Due to limited data, Teel et al. (2015) combined this ESU with other California ESUs. They found that the distribution of these fish largely occurred in Oregon and California coastal waters, consistent with other authors (Hendrix et al. 2019; Moyle 2002; Windell et al. 2017). Returning adults migrate through coastal waters and enter San Francisco Bay, then migrate up the Sacramento River in November and continue upstream from December through early August (California Department of Fish and Wildlife [CDFW] 2022a). Due to the coastal distribution of this ESU, Sacramento River Winter-Run Chinook salmon occur in the ROI.

G.1.3 Coho Salmon (*Oncorhynchus kisutch*)

Several ESUs of coho salmon may be present in the ROI in the Pacific Ocean offshore of California, which are described with specific details below.

G.1.3.1 Southern Oregon and Northern California Coast ESU

The Southern Oregon and Northern California Coast Coho Salmon ESU was listed as threatened on 6 May 1997 (62 FR 24588), their status reaffirmed on 28 June 2005 (70 FR 37160), and status subsequently updated on 14 April 2014 (79 FR 20802). This ESU includes naturally spawned coho salmon originating from coastal streams and rivers between Cape Blanco, Oregon, and Punta Gorda, California (79 FR 20802).

Although juvenile behaviors, life histories, and habitat associations can be variable, the majority of coho juveniles reside about one year in fresh water before migrating to sea (NMFS 2019a). Upon entry into the open ocean, juvenile coho use nearshore marine habitats, with some fish remaining in local waters and others moving northward along the continental shelf to central Alaska (Fisher et al. 2014). In general, fish in this ESU exhibit a three-year life cycle, with adults entering natal streams and rivers from mid-November to January (NMFS 2019a). Due to prevalence of coho in Oregon coastal waters, Southern Oregon and Northern California Coast coho salmon are present in the ROI.

G.1.3.2 Central California Coast ESU

The Central California Coast Coho Salmon ESU was listed as threatened on 31 October 1996 (61 FR 56138) and downgraded to endangered on 28 June 2005 (70 FR 37160). The ESU status was reaffirmed as endangered on 2 April 2012, (77 FR 19552) and subsequently updated on 14 April 2014 (79 FR 20802). This ESU includes naturally spawned coho salmon originating from rivers south of Punta Gorda (Monterey County, CA) to and including Aptos Creek (Ventura County, CA), as well as such coho salmon originating from tributaries to San Francisco Bay (79 FR 20802).

Coho smolts from this population begin migrating downstream to the ocean in late March or early April but can sometimes begin prior to March and persist well into July (CDFW 2022b). Once in the ocean, immature coho remain in in-shore waters, congregating in schools as they move north along the continental shelf (CDFW 2022b; Fisher et al., 2014). Adults in this ESU generally enter freshwater to spawn from September through January, with spawning mainly from November to January, although it can extend into February or March (CDFW 2022b). Due to prevalence of coho in Oregon coastal waters, Central California Coast coho salmon occur in the ROI.

G.1.4 Green Sturgeon (*Acipenser medirostris*)

G.1.4.1 Status

The Southern DPS of North American Green Sturgeon was listed as threatened on 7 April 2006 (71 FR 17757) and critical habitat for this DPS was designated on 9 October 2009 (74 FR 52300).

G.1.4.2 Occurrence within the Action Area

Subadult green sturgeon leave their Californian natal rivers and disperse widely along continental shelf waters of the West Coast within the 360 ft. (110-meter [m] contour (Erickson & Hightower 2007; Moyle 2002; NMFS 2005). This DPS preferentially distributes north of their natal river during fall and moves into bays and estuaries during summer and fall (Heironimus et al. 2022; Israel et al., 2009). Sub-adult and mature fish exhibit a narrow and shallow depth distribution in marine habitat of < 328 ft. (100 m) within the 360 ft. (110 m) contour of the continental shelf, typically occupying depths of 130 to 230 ft. (40–70 m; Erickson & Hightower, 2007; NMFS 2005; Payne et al., 2015). While Huff et al. (2011) found that green sturgeon appeared to prefer marine areas with high seafloor complexity and boulder presence, Payne et al. (2015) found that that green sturgeon are also associated with flat, soft bottom habitats that lack high relief bottoms. Information regarding their preference for areas of high seafloor complexity and prey selection in coastal waters (benthic prey) indicate green sturgeon reside and migrate along the seafloor while in coastal waters. Huff et al. (2011) found that green sturgeon in the open ocean may also occupy the upper 65 ft. (20 m) of the water column on a seasonal basis (July to November) and use deeper habitats throughout the rest of the year.

The primary concentration of sturgeon is estimated to be approximately 41–51.5° North within the 656 ft. (200 m) isobath in the coastal waters of Washington, Oregon, and Vancouver Island (Huff et al. 2012). Additionally, Huff et al. (2011) suggested that green sturgeon occur at low densities in the coastal marine environment. Southern DPS are likely to be present in the ROI.

G.1.4.3 Critical Habitat

Critical habitat includes coastal U.S. marine waters within 360 ft. (110 m) depth from Monterey Bay, California north to Cape Flattery, Washington, including the Strait of Juan de Fuca, Washington, to the U.S. boundary. Critical habitat includes several rivers and estuaries along the U.S. West Coast (74 FR 52300).

For coastal marine areas, the physical or biological features of critical habitat designated for green sturgeon include food resources, migratory corridors, and water quality. Corresponding species life history events include subadult growth and development, movement between estuarine and marine areas, and migration between marine areas, as well as adult sexual maturation, growth and development, movements between estuarine and marine areas, migration between marine areas, and spawning migration (74 FR 52300). Green sturgeon critical habitat does not overlap the ROI.

G.1.5 Oceanic Whitetip Shark (*Carcharhinus longimanus*)

G.1.5.1 Status

NMFS completed a comprehensive status review of the oceanic whitetip shark and based on the best scientific and commercial information available, including the status review report (Young et al. 2016), and listed the species as threatened on 1 March 2018 (83 FR 4153).

G.1.5.2 Occurrence within the Action Area

Oceanic whitetip sharks are found worldwide in warm tropical and subtropical waters between the 30° North and 35° South latitude near the surface of the water column (Young et al. 2016). Oceanic whitetips occur throughout the Central Pacific, including the Hawaiian Islands south to Samoa Islands and in the eastern Pacific from Southern California to Peru, including the Gulf of California. This species has a clear preference for open ocean waters, with abundances decreasing with greater proximity to continental shelves. In terms of California fish fauna, Allen and Cross (2006) categorized oceanic white tip sharks as holoepipelagic and individuals would be found mostly far from shore. Preferring warm waters near or over 20°C (68°F), and offshore areas, the oceanic whitetip shark is known to undertake seasonal movements to higher latitudes in the summer (NOAA 2016) and may regularly survey extreme environments (deep depths, low temperatures) as a foraging strategy (Young et al. 2016).

Oceanic whitetip sharks could occur in deep open ocean areas in the California Current Large Marine Ecosystem. They are known to occur in Baja California and may be found in surface waters off the continental shelf (Baum et al. 2015). Oceanic whitetip sharks are therefore expected to occur within the ROI.

G.1.5.3 Critical Habitat

Critical habitat has not been designated for this species.

G.1.6 Scalloped Hammerhead Shark (*Sphyrna lewini*)

G.1.6.1 Status

On 3 July 2014, four of six identified distinct population segments of scalloped hammerhead sharks were listed as endangered or threatened (79 FR 38214). The Eastern Pacific distinct population segment of the scalloped hammerhead population, which includes the west coast of the United States and the Southern California Range Complex, is listed as endangered under the ESA. The scalloped hammerhead shark has undergone substantial declines throughout its range (Baum et al. 2003). There is evidence of population increases in some areas of the southeast U.S., such as the Gulf of Mexico (Ward-Paige et al. 2012), but because many catch records do not differentiate between the hammerhead species, or shark species in general, population estimates and commercial or recreational fishing landing data are unavailable in the ROI. Most of the abundance data is from the Gulf of California, where it is estimated that the scalloped hammerhead population is currently decreasing by 6 percent per year (INP 2006).

G.1.6.2 Occurrence in the Action Area

The scalloped hammerhead shark is a coastal and semi-oceanic species distributed in temperate and tropical waters (Froese & Pauly 2016). Distribution in the eastern Pacific Ocean extends from the coast of southern California, including the Gulf of California, to Ecuador and possibly Peru (Compagno 1984), and off Hawaii in the central Pacific Ocean. A genetic marker study suggests that females remain close to coastal habitats, while males disperse across larger open ocean areas (Daly-Engel et al. 2012).

Juveniles rear in coastal nursery areas in the southern California portion of the Action Area (Duncan & Holland 2006), but rarely inhabit the open ocean (Kohler & Turner 2001). Sub adults and adults occur over shelves and adjacent deep waters close to shore and entering bays and estuaries (Compagno 1984). In the California Current Large Marine Ecosystem, records of the presence of scalloped hammerhead sharks in this area are very rare. Sighting and landings in the ROI are documented to have occurred in San Diego Bay in 1981, 1996, and 1997 (Shane 2001).

G.1.6.3 Critical Habitat

Critical habitat has not been designated for this species.

G.2 Sea Turtles

G.2.1 General Background

Sea turtles are highly migratory, long-lived reptiles that occur throughout the open-ocean and coastal regions of the Action Area. Generally, sea turtles are distributed throughout tropical to subtropical latitudes (i.e., in warmer waters closer to the equator), with some species extending poleward into temperate seasonal foraging areas. In general, sea turtles spend most of their time at sea, with the notable exception of mature females returning to land, primarily beaches, to nest. The habitat preferred by sea turtles and their distribution at sea varies by species and life stage (i.e., hatchling, juvenile, adult).

G.2.2 Green Sea Turtle (*Chelonia mydas*)

G.2.2.1 Status

The green sea turtle was listed under the ESA in July 1978 because of excessive commercial harvest, a lack of effective protection, evidence of declining numbers, and habitat degradation and loss (NMFS and USFWS 2007a). A revised final rule listing the East Pacific and Central North Pacific DPSs of the green sea turtle was issued in 2016 (81 FR 20057).

G.2.2.2 Occurrence in the Action Area

The green sea turtle is found in tropical and subtropical coastal and open ocean waters, between 30° North and 30° South. Green sea turtles are widely distributed in the subtropical coastal waters of southern Baja California, Mexico, and Central America (Cliffton et al. 1995; NMFS and USFWS 1998a). Another green sea turtle population resides in Long Beach, California, although less is known about this population (Eguchi et al. 2010). Ocean waters off southern California and northern Baja California are designated as areas of occurrence because of the presence of rocky ridges and channels and floating kelp habitats suitable for green sea turtle foraging and resting (Stinson 1984); however, these waters are often at temperatures below the thermal preferences of this primarily tropical species.

G.2.2.3 Critical Habitat

Critical habitat has been proposed in the Pacific Ocean (88 FR 46572) but would not overlap the action area.

G.2.3 Loggerhead Turtle (*Caretta caretta*)

G.2.3.1 Status

In September 2011, NMFS listed all three Pacific Ocean distinct population segments of loggerhead sea turtles as endangered (76 FR 588868). In the Pacific, there are two distinct population segments of loggerheads. The North Pacific Ocean DPS nests only on the coasts of Japan. This population has declined 50 to 90 percent during the last 60 years, however the overall nesting trend in Japan has been stable or slightly increasing over the last decade. The South Pacific Ocean DPS nests primarily in Australia with some nesting in New Caledonia. In 1977, about 3,500 females may have nested in the South Pacific—today there are only around 500 per year.

G.2.3.2 Occurrence in the Action Area

Loggerhead turtles are found worldwide mainly in subtropical and temperate regions of the Atlantic, Pacific, and Indian Oceans, and in the Mediterranean Sea (Conant et al. 2009). In the eastern Pacific, the loggerheads primary range extends from offshore of Vancouver Island, south to Central America. The highest densities of loggerheads can be found just north of Hawaii in the North Pacific Transition Zone

(Polovina et al. 2000). The North Pacific Transition Zone is defined by convergence zones of high productivity that stretch across the entire North Pacific Ocean from Japan to California (Polovina et al. 2001). The loggerhead turtle is known to occur at sea off of southern California, but does not nest on southern California beaches.

G.2.3.3 Critical Habitat

There is no critical habitat designated for the North Pacific Ocean DPS.

G.2.4 Olive Ridley Sea Turtle (*Lepidochelys olivacea*)

G.2.4.1 Status

The breeding population along the Pacific coast of Mexico was listed as endangered under the ESA in 1978 (43 FR 32800), because of extensive overharvesting of olive ridley turtles in Mexico, which caused a severe population decline (NMFS and USFWS 1998b). Olive ridleys offshore of California and Baja Mexico would likely belong to this population. All other populations are listed under the ESA as threatened. A five-year review was completed in 2014 (NMFS and USFWS 2014).

G.2.4.2 Occurrence in the Action Area

Most olive ridley turtles lead a primarily open ocean existence (NMFS and USFWS 1998b). Individuals occasionally occur in waters as far north as California and as far south as Peru, spending most of their life in the oceanic zone (NMFS and USFWS 2007b). The olive ridley has a large range in tropical and subtropical regions in the Pacific Ocean, and is generally found between 40° North and 40° South. There are few documented occurrences of olive ridley sea turtles in waters off the west coast of the United States (NMFS and USFWS 1998b). One deceased olive ridley sea turtle washed up on North VSFB in April 2023 (Evans pers comm, 2024).

G.2.4.3 Critical Habitat

Critical habitat has not been designated for the olive ridley turtle.

G.2.5 Hawksbill Sea Turtle (*Eretmochelys imbricata*)

G.2.5.1 Status

The hawksbill turtle is listed as endangered throughout its range in 1970 under the ESA (35 FR 8491). A five-year review was completed in 2013 (NMFS and USFWS 2013a).

G.2.5.2 Occurrence in the Action Area

Water temperature in the southern California offshore waters is generally too low for hawksbills, and their occurrence offshore of California would be considered rare. They are more common in nearshore foraging grounds, including coral reefs and mangrove estuaries from Baja California to South America (NMFS and USFWS 2013a). However, hatchlings utilize floating algal mats and drift lines in pelagic (open sea) habitat (NMFS and USFWS 2013a) and therefore may be found in the ROI.

G.2.5.3 Critical Habitat

Critical habitat has not been designated for the hawksbill in the Pacific Ocean.

G.2.6 Leatherback Sea Turtle (*Dermochelys coriacea*)

G.2.6.1 Status

The leatherback sea turtle is listed as a single population and is classified as endangered under the ESA (35 FR 8491). Although USFWS and NMFS believe the current listing is valid, preliminary information indicates an analysis and review of the species should be conducted under the DPS policy (NMFS and USFWS 2013b). In early 2018, NMFS and the USFWS initiated a status review for the globally listed endangered leatherback sea turtles, to determine if DPS existed and if so, given their status, to consider whether the listing (currently "endangered") should be changed for each DPS. The status review was completed in 2020 (NMFS and USFWS 2020). While seven populations of leatherbacks were found globally distinct due to their genetic discontinuity, spatial differences (i.e., marked separation of the seven populations at nesting beaches), and separation due to physical factors, including land masses, oceanographic features and currents, all populations were found to be at risk of extinction. This is as a result of reduced nesting female abundance, declining nest trends, and numerous, severe threats (NMFS and USFWS 2020). Therefore, the leatherback sea turtle remains globally endangered under the ESA.

Most leatherback nesting populations in the Pacific Ocean are faring poorly and have declined by more than 80 percent since the 1980s. The International Union for Conservation of Nature has predicted a decline of 96 percent for the western Pacific subpopulation and a decline of nearly 100 percent for the eastern Pacific subpopulation by the year 2040 (Sarti-Martinez et al. 1996; Clark et al. 2010; NMFS 2016c). Causes for the decline in the Pacific include the intensive, illegal egg harvest at leatherback rookeries and high levels of mortality through the 1980s associated with bycatch in gill net fisheries (NMFS 2016c).

G.2.6.2 Occurrence in the Action Area

The leatherback sea turtle is the most widely distributed of all sea turtles, found from tropical to subpolar oceans. Because leatherback nest on tropical and occasionally subtropical beaches, it has the most extensive range of any turtle (Eckert 1995; Myers & Hays 2006; NMFS and USFWS 2013b; NMFS and USFWS 2020). Leatherbacks are also the most migratory sea turtles, with populations traversing the Pacific, Atlantic, and Indian oceans between nesting and foraging grounds, and migratory routes extending into subpolar regions (Spotila 2004; Bailey et al. 2012; Gaspar & Lalire 2017).

Pacific leatherbacks are split into western and eastern Pacific subpopulations based on their distribution and biological and genetic characteristics (Bailey et al. 2012). Eastern Pacific leatherbacks nest along the Pacific coast of the Americas, primarily in Mexico and Costa Rica, and forage throughout coastal and pelagic habitats of the eastern tropical Pacific. Western Pacific leatherbacks nest in the Indo-Pacific, primarily in Indonesia, Papua New Guinea, and the Solomon Islands, disperse after hatching into the central North Pacific along the North Pacific Transition Zone, and forage in the eastern North Pacific as juveniles and adults (Bailey et al. 2012; Gaspar & Lalire 2017; NMFS and USFWS 2020).

Leatherback sea turtles are regularly seen off the west coast of the United States, with the greatest densities found in waters along Central California during summer and fall when sea surface temperatures are highest (Bailey et al. 2012). The Action Area does not include any known or suitable leatherback sea turtle nesting habitat (NMFS and USFWS 2020).

G.2.6.3 Critical Habitat

In 2012, NMFS designated critical habitat for the leatherback sea turtle in California waters from Point Arena to Point Arguello out to the 3,000-m isobath (77 FR 4169; Figure 3.2-1). The Primary Constituent Elements (PCEs) defining leatherback critical habitat are the occurrence of prey species, primarily scyphomedusae, commonly known as jellies, of the order Semaeostomeae (Chrysaora, Aurelia, Phacellophora, and Cyanea), of sufficient condition, distribution, diversity, abundance, and density necessary to support individual as well as population growth, reproduction, and development of leatherbacks…" (50 C.F.R. 226.207).

G.3 Marine Mammals

G.3.1 Blue Whale (*Balaenoptera musculus*)

G.3.1.1 Status

The world's population of blue whales can be separated into three subspecies, based on geographic location and some morphological differences. Within the ROI the subspecies *Balaenoptera musculus* is present. The blue whale is listed as endangered under the ESA and as depleted under the Marine Mammal Protection Act (MMPA) throughout its range. A revised Recovery Plan was completed in 2020 (NMFS 2020).

G.3.1.2 Occurrence in the Action Area

The blue whale inhabits all oceans and typically occurs near the coast, over the continental shelf, though they are also found in oceanic waters (Stafford et al. 2001; Stafford et al. 2004; Ferguson 2005; Hamilton et al. 2009; Bradford et al. 2013; Klinck et al. 2015; Barlow 2016).

The Eastern North Pacific Stock of blue whales includes animals found in the eastern north Pacific from the northern Gulf of Alaska to the eastern tropical Pacific (Carretta et al. 2019). Relatively high densities of blue whales occur off Central and Southern California during the summer and fall (Barlow et al. 2009; Becker et al. 2010; Becker et al. 2012; Forney et al. 2012; Becker et al. 2016). Data from year-round surveys conducted off Southern California from 2004 to 2013 show that the majority of blue whales were sighted in summer (62 sightings) and fall (9 sightings), with only single sightings in winter and spring (Campbell et al. 2015).

Most baleen whales spend their summers feeding in productive waters near the higher latitudes and winters in the warmer waters at lower latitudes (Širović et al. 2004). Blue whales in the eastern north Pacific are known to migrate between higher latitude feeding grounds of the Gulf of Alaska and the Aleutian Islands to lower latitudes, including Southern California; Baja California, Mexico; and the Costa Rica Dome (Calambokidis & Barlow 2004; Calambokidis et al. 2009a; Calambokidis et al. 2009b; Mate et al. 2015b; Mate et al. 2016; Palacios et al. 2019). The West Coast is known to be a blue whale feeding area for the Eastern North Pacific stock during summer and fall (Bailey et al. 2012; Calambokidis et al. 2015; Mate et al. 2015b; Calambokidis et al. 2019; Palacios et al. 2019). Of the nine feeding areas for blue whales identified by Calambokidis et al. (2015) along the U.S. West Coast as "Biologically Important Areas" (BIAs), the "Point Conception/Arguello" feeding area overlaps the Action Area in the summer to fall (June through October) feeding season.

The blue whale feeding areas identified in waters extending from Point Conception to the Mexico border represent only a fraction of the total area within those waters where habitat models predict high densities of blue whales (Calambokidis et al. 2015; Ferguson et al. 2015). Additionally, while those identified areas tend to have the highest blue whale density from July through October when averaged over multiple years, the areas are associated with ephemeral prey distributions that are less predictable over the short term (Ferguson et al. 2015; Abrahms et al. 2019).

Blue whales have shown site fidelity, returning to their mother's feeding grounds on their first migration (Calambokidis & Barlow 2004), and exhibit strong foraging site fidelity, even when conditions are not conducive to successful foraging in less than optimal years (Palacios et al. 2019). However, a sufficient density of prey is necessary to balance the energy requirements of their lunge feeding strategy (Goldbogen et al. 2015; Hazen & Goldbogen 2015; Straley et al. 2017), and there are daily, seasonal, interannual, and decadal variability in the locations and density of krill at a given feeding location (Brinton & Townsend 2003).

G.3.1.3 Critical Habitat

There is no designated critical habitat for this species.

G.3.2 Fin Whale (*Balaenoptera physalus*)

G.3.2.1 Status

The fin whale is listed as depleted under the MMPA and endangered under the ESA throughout its range, but there is no designated critical habitat for this species. A Recovery Plan was completed for the fin whale in 2010 (NMFS 2010a). In the North Pacific, NMFS recognizes three fin whale stocks: (1) a Northeast Pacific stock in Alaska; (2) a California, Oregon, and Washington stock; and (3) a Hawaii stock. NMFS does not recognize fin whales from the Northeast Pacific stock as being present in Southern California.

G.3.2.2 Occurrence in the Action Area

The fin whale is found in all the world's oceans and is the second-largest species of whale (Jefferson et al. 2008). Fin whales prefer temperate and polar waters and are scarcely seen in warm, tropical waters (Reeves et al. 2002). This species has been documented from 60° North to 23° North. Fin whales have frequently been recorded in waters within Southern California and are present year-round (Širović et al. 2004; Barlow & Forney 2007; Mizroch et al. 2009).

Fin whales are not known to have a specific habitat and are highly adaptable, following prey, typically off the continental shelf (Azzellino et al. 2008; Panigada et al. 2008; Scales et al. 2017). Off the U.S. West Coast, fin whales typically congregate in areas of high productivity, allowing for extended periods of localized residency that are not consistent with the general baleen whale migration model (Scales et al. 2017).

Based on predictive habitat-based density models derived from line-transect survey data collected between 1991 and 2009 off the U.S. West Coast, relatively high densities of fin whales are predicted off Southern California during the summer and fall (Barlow et al. 2009; Becker et al. 2010; Becker et al. 2012; Becker et al. 2016). Aggregations of fin whales are present year-round in Southern and Central California (Forney et al. 1995; Forney & Barlow 1998; Douglas et al. 2014; Jefferson et al. 2014; Campbell et al. 2015; Scales et al. 2017), although their distribution shows seasonal shifts. In 2005–2006, during a period of cooler ocean temperatures, fin whales were encountered more frequently than during normal years (Peterson et al. 2006). Sightings from year-round surveys off Southern California from 2004 to 2013 show fin whales farther offshore in summer and fall and closer to shore in winter and spring (Douglas et al. 2014; Campbell et al. 2015).

G.3.2.3 Critical Habitat

No critical habitat has been designated for the fin whale.

G.3.3 Western North Pacific Gray Whale (*Eschrichtius robustus*)

G.3.3.1 Status

There are two north Pacific populations of gray whales: the Western subpopulation and the Eastern subpopulation designated in the Pacific Stock Assessment Report (SAR) (Weller et al. 2013). Both DPSs could be present in the Action Area during their northward and southward migration (Sumich & Show 2011).

The Western North Pacific DPS is considered depleted (Weller et al. 2002; Cooke 2019). This subpopulation is endangered and should be very few in number in the Action Area given the small population and their known wintering areas in waters off Russia and Asia (Mate et al. 2015a). Analysis of the data available for 2005 through 2016 estimates the combined Sakhalin Island and Kamchatka populations are increasing (Cooke 2019). The Eastern North Pacific subpopulation has recovered and was delisted under the ESA in 1994 (Swartz et al. 2006; Carretta et al. 2020).

G.3.3.2 Occurrence in the Action Area

Gray whales of the Western North Pacific DPS primarily occur in shallow waters over the U.S. West Coast, Russian, and Asian continental shelfs and are considered to be one of the most coastal of the great whales (Jefferson et al. 2008; Jones & Swartz 2009). Feeding grounds for the population are the Okhotsk Sea off Sakhalin Island, Russia, and in the southeastern Kamchatka Peninsula (in the southwestern Bering Sea) in nearshore waters generally less than 225 ft. (68 m) deep (Jones & Swartz 2009). The breeding grounds consist of subtropical lagoons in Baja California, Mexico, and suspected wintering areas in southeast Asia (Urban-Ramirez et al. 2003). At least 12 members of the Western North Pacific DPS have been detected in waters off the Pacific Northwest (Weller & Brownell 2012; Mate 2013; Moore & Weller 2018). NMFS reported that 18 Western North Pacific gray whales have been identified in waters far enough south to have passed through Southern California waters (NMFS 2014).

Gray whales migrate along the Pacific coast twice a year between October and July (Calambokidis et al. 2015). Although they generally remain mostly over the shelf during migration, some gray whales may be found in more offshore waters to the west of San Clemente Island and the Channel Islands (Calambokidis et al. 2015; Schorr et al. 2019; Guazzo et al. 2019). In aerial surveys occurring in December and April each year, gray whales were the third-most encountered large cetacean in Southern California (Smultea 2014).

The main gray whale migrations that pass through the Action Area can be loosely categorized into three phases (Rugh et al. 2008; Calambokidis et al. 2015). Calambokidis et al. (2015) note these migration phases are not distinct, the timing for a phase may vary based on environmental variables, and a migration phase typically begins with a rapid increase in migrating whales, followed by moderate numbers over a period of weeks, and then slowly tapering off. A southward migration from summer feeding areas in the Chukchi Sea, Bering Sea, Gulf of Alaska, and the Pacific Northwest begins in the fall (Mate et al. 2013; Calambokidis et al. 2015; Mate et al. 2015a). This Southbound Phase includes all age classes as they migrate primarily to the nearshore waters and lagoons of Baja California, Mexico, as a destination. During this southward migration, the whales generally are within 10 km of the coast (Calambokidis et al. 2015), although there are documented exceptions where migrating gray whales have bypassed the coast by crossing sections of the open ocean (Rice & Wolman 1971; Mate & Urban-Ramirez 2003; Mate 2013; Mate et al. 2015a).

The northward migration for gray whales to the feeding grounds in Arctic waters, Alaska, the Pacific Northwest, and Northern California occurs in two phases (Calambokidis et al. 2015). Northbound Phase A consists mainly of adults and juveniles that lead the beginning of the north bound migration from late January through July, peaking in April through July. Newly pregnant females go first to maximize feeding time, followed by adult females and males, then juveniles (Jones & Swartz 2009). The Northbound Phase B consists primarily of cow-calf pairs that begin their northward migration later (March to July) remaining on the reproductive grounds longer to allow calves to strengthen and rapidly increase in size before the northward migration (Urban-Ramirez et al. 2003; Jones & Swartz 2009).

The gray whale migration corridors (north of Point Conception), the potential presence buffer area, and the months these four sections of the Pacific coastal waters were designated as cumulatively in use (October through July), were identified by Calambokidis et al. (2015) as BIAs for gray whales. A portion of the gray whale potential presence migration area and the migration routes off Southern California pass through the ROI.

G.3.3.3 Critical Habitat

There has been no designated critical habitat for the Western North Pacific gray whale DPS.

G.3.4 Humpback Whale (*Megaptera novaeangliae*), Mexico Distinct Population Segment and Central American Distinct Population Segment

G.3.4.1 Status

Humpback whales that are seasonally present in the Action Area are from two DPSs, given they represent populations that are both discrete from other conspecific populations and significant to the species of humpback whales to which they belong (NMFS 2016c). These DPSs are based on animals identified in breeding areas in Mexico and Central America (Bettridge et al. 2015; Muto et al. 2019). Humpback whales of the Mexico DPS are listed as threatened, and those from the Central America DPS are listed as endangered under the ESA (NMFS 2016c).

Although estimates show variable trends in the number of humpback whales along the U.S. West Coast, the overall trend in the estimates is consistent with growth rate of 6–7 percent for the California, Oregon, Washington stock and appears consistent with the highest-yet abundances of humpback whales in the most recent 2014 survey of that stock. For the DPSs in Mexico and in Central America, photo identification data collected between 2004 and 2006 are the main basis for the estimates for specific to those populations (Bettridge et al. 2015; NMFS 2016c; Wade et al. 2016). The new best overall estimate of abundance of humpback whales along the U.S. West Coast has been provided by photo identification data gathered between 2015 and 2018 along the U.S. West Coast (Calambokidis & Barlow 2020). This estimate, which includes the Mexico DPS and the Central America DPS, is 4,973, which is higher than the abundance (2,900) in the 2019 Pacific SAR (Calambokidis & Barlow 2020).

G.3.4.2 Occurrence in the Action Area

The habitat requirements of wintering humpbacks appear to be controlled by the conditions necessary for calving, such as warm water (75–80 °F) and relatively shallow, low-relief ocean bottom in protected areas, nearshore, or created by islands or reefs (Smultea 1994; Clapham 2000; Craig & Herman 2000). In breeding grounds, females with calves occur in significantly shallower waters than other groups of whales, and breeding adults use deeper, more offshore waters (Smultea 1994; Ersts & Rosenbaum 2003). Breeding and calving areas for the Mexico DPS and for the Central America DPS are both located within the ROI.

Off the U.S. West Coast, humpback whales are more abundant in shelf and slope waters (<2,000 m deep) and are often associated with areas of high productivity (Becker et al. 2010; Becker et al. 2012; Forney et al. 2012; Redfern et al. 2013; Campbell et al. 2015; Becker et al. 2016; Calambokidis et al. 2019). While most humpback whale sightings are in nearshore and continental shelf waters, humpback whales frequently travel through deep oceanic waters during migration (Dohl et al. 1983; Forney & Barlow 1998; Campbell et al. 2015). Humpback whales migrating from breeding grounds in Central America to feeding grounds at higher latitudes may cross the Action Area.

Peak occurrence during migration occurs in the Action Area from December through June (Calambokidis et al. 2015). In quarterly surveys undertaken in the 10-year period between 2004 and 2013 off Southern California, humpback whales were generally encountered in coastal and shelf waters, with the largest concentration occurring in relatively shallow waters, north of Point Conception (Campbell et al. 2015). During winter and spring, a substantially greater proportion of the humpback whale population is found farther offshore than during the summer, with (in all seasons) the majority of the population found north of the Channel Islands (Forney & Barlow 1998; Campbell et al. 2015; Becker et al. 2017; Calambokidis et al. 2017).

BIAs for humpback whales overlap the ROI. Passive acoustic monitoring at Monterey Bay California from 2015 to 2018 demonstrated that the timing of humpback whales feeding and migration in that area is variable, with detections generally occurring from September through May (Ryan et al. 2019). Location data from satellite tags also has demonstrated that, in some cases, the feeding BIAs do not represent the core area of humpback whale presence, at least for the time and sample of the population represented by humpback whales that were tagged and otherwise present in or around the area (Mate et al. 2018). In 2014, 2015, and 2016, humpback whales were more commonly sighted in coastal waters of Santa Monica Bay, and from Long Beach south to waters off Dana Point (Calambokidis et al. 2017). The variable use of the Santa Barbara Channel–San Miguel feeding BIA was also evident, corresponding to the 2014–2016 increase in ocean temperatures off California that resulted in the changes to the nominal distribution and availability of krill and anchovy (Zaba et al. 2018; Fiechter et al. 2020; Santora et al. 2020) and the distribution of humpback whales in 2014, resulting in a much higher density off Central California than a nominal year (Becker et al. 2018). Similar high ocean temperatures in 2016 also corresponded to a documented scarcity of healthy humpback whales in the Santa Barbara Channel–San Miguel feeding BIA and vicinity. However, more humpback whales were found further north off Central California and in better condition, which investigators suggested was indicative of good feeding areas that were likely to be sustained in that region in that anomalous year (Oregon State University 2017).

G.3.4.3 Critical Habitat

A final rule to designate critical habitat for humpback whales for the endangered Central America DPS and the threatened Mexico DPS was published on 21 April 2021 (75 FR 21082) pursuant to Section 4 of the ESA. This action followed a 9 October 2019 proposed rule to designate critical habitat for the humpback whales within the U.S. Exclusive Economic Zone (EEZ) in the Pacific for the endangered Central America DPS and the threatened Mexico DPS pursuant to section 4 of the ESA (84 FR 54378). In the proposal, NMFS considered 19 Regions/Units of habitat as critical habitat for the listed humpback whale DPSs.

These 19 areas include almost all coastal waters off California, Oregon, Washington, and Alaska in the Pacific. Humpback whale critical habitat is depicted in Figure 3.3-4; as shown, there is overlap between the Action Area and the critical habitat.

Region/Unit 17 has been referred to by NMFS in the proposed rule as the "Central California Coast Area," which covers an area of 6,697 square nm extending from 34° 30' to 36° 00' north latitude. Within those south and north boundaries, Region/Unit 17 begins at the 98 ft. (30 m) depth contour out to the 12,139 ft. (3,700 m) depth contour. This region's area includes waters off of southern Monterey, San Luis Obispo, and Santa Barbara counties. This region/unit of habitat is characterized by NMFS as having a very high conservation value (84 FR 54378).

The essential feature for the Central America DPS as defined by NMFS (2019b) is "Prey species, primarily euphausiids (Thysanoessa, Euphausia, Nyctiphanes, and Nematoscelis) and small pelagic schooling fishes, such as Pacific sardine (*Sardinops sagax*), northern anchovy (*Engraulis mordax*), and Pacific herring (*Clupea pallasii*), of sufficient quality, abundance, and accessibility within humpback whale feeding areas to support feeding and population growth. The Mexico DPS is very similar, but adds capelin (*Mallotus villosus*), juvenile walleye pollock (*Gadus chalcogrammus*), and Pacific sand lance (*Ammodytes personatus*) to the essential prey species lists. NMFS has noted that prey as an essential feature may require special management considerations or protections as a result of ecosystem shifts driven by climate change, commercial fisheries, and pollution (NMFS 2019b).

Humpback whales are generalists, taking a variety of prey while foraging and switching between target prey depending on what is most abundant in the system (Witteveen et al. 2014; Szabo 2015; Fleming et al. 2016). Consistent with the designated critical habitat, the humpback whales' diet is dominated by euphausiids and small pelagic fishes, such as northern anchovy, Pacific herring, Pacific sardine, and capelin (Santora et al. 2010; Szabo 2015; Fleming et al. 2016; Keen et al. 2017; Gabriele et al. 2017; Straley et al. 2017; Witteveen & Wynne 2017). Like other large mysticetes, they are a "lunge feeder," taking advantage of dense prey patches and engulfing as much food as possible in a single gulp. All feeding behavior seem to involve patches of prey with sufficient density to support feeding bouts (Mate et al. 2019; Frisch-Jordan et al. 2019). The size of individual krill seems to be an aspect of prey quality for the species (Santora et al. 2010; Szabo 2015; Burrows et al. 2016). For example, Santora et al. (2010) found that different species of baleen whales aggregated to krill hotspots that were differentiated by the size of individual krill, with humpback whales having preference for small (<35 mm) juvenile krill.

In the California Current Ecosystem, changing oceanographic factors (e.g., upwellings, temperatures, winds, salinity) result in seasonal, interannual, and decadal variability in the locations and density of krill and forage fish (Brinton & Townsend 2003; Keister et al. 2011; Santora et al. 2011; Deutsch et al. 2015; Santora et al. 2017a; Zaba et al. 2018; Cimino et al. 2020; Rockwood et al. 2020; Fiechter et al. 2020; Santora et al. 2020). As a result, the location, timing, and intensity of prey aggregations can vary greatly both seasonally and from year to year. Given that concentrations of prey tend to be spatially and temporally ephemeral at scales on the order of tens of meters to kilometers and hours to days (Zaba et al. 2018; Hazen et al. 2018; Rockwood et al. 2020; Fiechter et al. 2020; Santora et al. 2020), the presence of feeding humpback whales and prey as an essential feature of the critical habitat are also highly variable over these small spatial and temporal scales.

The critical habitat overlaps with the humpback whale feeding BIAs designated in 2015 (Calambokidis et al. 2015), but in the Action Area it extends farther offshore to incorporate the maximum extent of the predicted humpback abundance in cooler months (Becker et al. 2016; Becker et al. 2017) and farther inshore to incorporate distributions derived from satellite telemetry data for 13 humpback whales (Mate et al. 2018). Although the location, timing, and intensity of humpback whale prey vary greatly (Santora et al. 2011; Santora et al. 2017a; Zaba et al. 2018; Santora et al. 2020; Fiechter et al. 2020), static spatial management strategies such as the designation of critical habitat can effectively mitigate risks associated with fixed large and long-term actions such as established commercial vessel traffic lanes (associated with ship strikes) or within fishery regulations (associated with entanglement) (Rockwood et al. 2017; Moore & Weller 2018; Redfern et al. 2019; Redfern et al. 2020; Rockwood et al. 2020; Santora et al. 2020).

G.3.5 Killer Whale (*Orcinus orca*)

G.3.5.1 Status

NMFS listed the Southern Resident killer whale DPS as endangered in 2005 (70 FR 69903) and adopted a recovery plan in 2008 (73 FR 4176; NMFS 2008). There are 73 Southern Resident killer whales in the DPS (Couture et al. 2022). The Southern Resident DPS is divided into three pods identified as J, K, and L (Carretta et al. 2021).

Concerns over impacts on the population from several sources have been raised in recent years, including disturbance from whale watching vessels (Ferrara et al. 2017; Holt et al. 2017; Lacy et al. 2017; NMFS 2021), commercial shipping noise (Cominellli et al. 2018; McWhinnie et al. 2021), and prey availability (Hanson et al. 2021).

G.3.5.2 Occurrence in the Action Area

Southern Resident killer whales occur mainly along the outer coast and inland waters of Washington and British Columbia, Canada. In recent years the population has shifted and expanded its range to areas up to hundreds of miles from Washington waters both north (as far as Southeast Alaska) and south as far as central California (Cogan 2015; Dahlheim et al. 2008). Specifically, K-pod and L-pod have ranged widely along the coast and been sighted as far south as Monterey Bay in recent years; L-pod is known to have traveled as far north as Chatham Strait, Southeast Alaska. J-pod has largely remained in inland waters (Carretta et al. 2021).

Satellite-tag locations found that Southern Resident killer whales generally inhabit nearshore waters (Hanson et al. 2018; Hanson et al. 2017). Ninety-five percent of reported locations were within 18 nm (34 km) of shore, and 50 percent were within 5 nm (10 km) of shore. On the outer coast, 75 percent of tag locations were in a narrow corridor between 1.6 and 10 nm (3 and 19 km) offshore (Hanson et al. 2017). The proposed landing and fairing recovery area is in deep waters between approximately 46–400 nm off Rockport, California in the north to 158–910 nm off Baja California, Mexico in the south and no recovery activities would occur within 12 nm of islands. Therefore, relatively few killer whales are expected to occur in areas where these activities would be conducted.

G.3.5.3 Critical Habitat

NMFS amended and expanded the critical habitat designation for Southern Resident killer whales to include nearshore waters along the coasts of Washington, Oregon, and California in 2021. The elements of critical habitat essential for conservation of the Southern Resident killer whale are (1) water quality to support growth and development; (2) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth; and (3) passage conditions to allow for migration, resting, and foraging. The amended critical habitat designation extends along the entire Oregon coastline but is outside the ROI.

G.3.6 Sei Whale (*Balaenoptera borealis*)

G.3.6.1 Status

The sei whale is listed as endangered under the ESA and as depleted under the MMPA throughout its range. A recovery plan for the sei whale was completed in 2011 and provided a research strategy for obtaining data required to estimate population abundance and trends, and to identify factors that may be limiting the recovery of this species (NMFS 2011). Sei whales along the U.S. West Coast are assigned to the Eastern North Pacific stock within the U.S. EEZ (Carretta et al. 2020). NMFS has determined that an assessment of the sei whale population trend will likely require additional survey data and reanalysis of all datasets using comparable methods (Carretta et al. 2018b). There are no data on Eastern North Pacific sei whale trends in abundance (Carretta et al. 2020).

G.3.6.2 Occurrence in the Action Area

Sei whales have a worldwide distribution and are found primarily in cold temperate to subpolar latitudes. During the winter, sei whales are found in warm tropical waters. Sei whales are also encountered during the summer off California and the North America coast from approximately the latitude of the Mexican border to as far north as Vancouver Island, Canada (Masaki 1976; Horwood 2009; Smultea et al. 2010).

A total of 10 sei whale sightings were made during systematic ship surveys conducted off the U.S. West Coast in summer and fall between 1991 and 2008 (Barlow 2010), with an additional 14 groups sighted during a 2014 survey (Barlow 2016). Sei whales are expected to be present in offshore waters in the ROI.

G.3.6.3 Critical Habitat

There is no designated critical habitat for this species.

G.3.7 Sperm Whale (*Physeter macrocephalus*)

G.3.7.1 Status

The sperm whale has been listed as endangered since 1970 under the precursor to the ESA (NMFS 2009) and is depleted under the MMPA throughout its range. In the North Pacific sperm whales are divided into three stocks in the Pacific; one (California/Oregon/Washington) occurs within the Action Area (Carretta et al. 2020). Based on genetic analyses, Mesnick et al. (2011) found that sperm whales in the California Current are demographically independent from animals in the rest of the tropical Pacific. A Recovery Plan was completed for the sperm whale in 2010 (NMFS 2010b).

Line-transect surveys conducted off the U.S. West Coast from 1991 to 2014 include a high level of uncertainty but indicate that sperm whale abundance has appeared stable, with some evidence for an increasing number of sperm whales (Moore & Barlow 2014; Moore & Barlow 2017; Carretta et al. 2020).

G.3.7.2 Occurrence in the Action Area

This species is primarily found in the temperate and tropical waters of the Pacific (Rice 1989; Merkens et al. 2019). Its secondary range includes areas of higher latitudes up to and including the Gulf of Alaska (Whitehead & Weilgart 2000; Jefferson et al. 2008; Whitehead et al. 2008; Whitehead et al. 2009). This species appears to prefer deep waters and the continental shelf break and slope (Rice 1989; Whitehead 2003; Jefferson et al. 2008; Whitehead et al. 2008; Baird 2013). Typically, sperm whale concentrations also correlate with areas of high productivity, generally near drop offs and areas with strong currents and steep topography (Gannier & Praca 2007; Jefferson et al. 2008).

Sperm whales are found year-round in California waters, but their abundance is temporally variable, most likely due to the availability of prey species (Forney & Barlow 1993; Barlow 1995; Barlow & Forney 2007; Smultea 2014). Based on habitat models derived from line-transect survey data collected between 1991 and 2008 off the U.S. West Coast, sperm whales show an apparent preference for deep waters (Barlow et al. 2009; Becker et al. 2010; Becker et al. 2012; Forney et al. 2012). During quarterly ship surveys conducted off Southern California between 2004 and 2008, there were a total of 20 sperm whale sightings, the majority (12) occurring in summer in waters greater than 2,000 m deep (Douglas et al. 2014).

Sperm whales are somewhat migratory. General shifts in distribution occur during summer months for feeding and breeding, while in some tropical areas sperm whales appear to be largely resident (Rice 1989; Whitehead 2003; Whitehead et al. 2008; Whitehead et al. 2009). Pods of females with calves remain on breeding grounds throughout the year, between 40° North and 45° North (Rice 1989; Whitehead 2003), while males migrate between low-latitude breeding areas and higher-latitude feeding grounds (Pierce et al. 2007). In the northern hemisphere, "bachelor" groups (males typically 15 to 21 years old and bulls [males] not taking part in reproduction) generally leave warm waters at the beginning of summer and migrate to feeding grounds that may extend as far north as the perimeter of the arctic zone. In fall and winter, most return south, although some may remain in the colder northern waters during most of the year (Pierce et al. 2007).

G.3.7.3 Critical Habitat

There is no designated critical habitat for this species.

G.3.8 Southern Sea Otter (Federally Threatened Species)

G.3.8.1 Status

The USFWS listed the Southern sea otter (*Enhydra lutris nereis*) as federally threatened on 14 January 1977 (42 FR 2965) and published a Recovery Plan in 2003 (USFWS 2003). The USWFS completed a 5-year review of the species in 2015 (USFWS 2015).

G.3.8.2 Life History

The Southern sea otter is the smallest species of marine mammal in North America. It inhabits the nearshore marine environments of California from San Mateo County to Santa Barbara County with a small geographically isolated population around San Nicolas Island. On occasion, Southern sea otters have been observed beyond these limits and have been documented as far south as Baja, Mexico (USFWS 2015).

This species breeds and gives birth year-round and pups are dependent for 120–280 days (average 166 days; Riedman & Estes 1990). Sea otters are opportunistic foragers known to eat mostly abalones, sea urchins, crabs, and clams. They play a key ecological role in kelp bed communities by controlling sea urchin grazing.

G.3.8.3 Occurrence in the Action Area

Southern sea otters occur regularly off the coast of VSFB, with animals occasionally in the kelp beds offshore of Purisima Point on north VSFB, and frequently offshore of Sudden Flats on south VSFB. Transitory otters occasionally traverse the coast between SLC-4 and Point Arguello. This area is, however, not regularly occupied and no otters have been detected at this location during the last three annual spring census counts from 2011 to 2016 (U.S. Geological Survey Western Ecological Resource Center 2017, 2018, 2019, 2020).

G3.8.4 Critical Habitat

There is no designated critical habitat for this species.

G.3.9 California Sea Lion

G.3.9.1 Status

The California sea lion (*Zalophus californianus*) is not listed under the ESA, and the population has been designated as the U.S. stock by NMFS.

G.3.9.2 Life History

Typically, during the summer, California sea lions congregate near rookery islands and specific open-water areas. The primary rookeries off the coast of the United States are on San Nicolas, San Miguel, Santa Barbara, and San Clemente Islands (Le Boeuf & Bonnell 1980; Lowry et al. 1992; Carretta et al. 2000; Lowry & Forney 2005; Lowry et al. 2017). Haulout sites are also found on Richardson Rock, Santa Catalina Island, Santa Cruz Island, and Santa Rosa Island in the Southern California Bight (Le Boeuf 2002; Lowry et al. 2017).

In the nonbreeding season, beginning in late summer, adult and subadult males migrate northward along the coast of California to Washington and return south the following spring (Lowry & Forney 2005; Laake 2017). Females and juveniles also disperse somewhat but tend to stay in the Southern California area, although north and west of the Channel Islands (Melin & DeLong 2000; Lowry & Forney 2005; Thomas et al. 2010). Tagging results showed that lactating females foraging along the coast would travel as far north as Monterey Bay and offshore to the 1,000-meter isobath (Melin & DeLong 2000; Melin et al. 2008; Henkel & Harvey 2008; Kuhn & Costa 2014; McHuron et al. 2017). There is a general distribution shift northwest in fall and southeast during winter and spring, probably in response to changes in prey availability (DeLong et al. 2017a; DeLong et al. 2017b; Lowry et al. 2017). California sea lions are usually found in waters over the continental shelf and slope; they are also known to occupy locations far offshore in deep, oceanic waters, such as Guadalupe Island and Alijos Rocks off the Baja Peninsula, Mexico (Zavala-Gonzalez & Mellink 2000; Jefferson et al. 2008; Melin et al. 2008; Urrutia & Dziendzielewski 2012). California sea lions are the most frequently sighted pinnipeds offshore of Southern California during the spring, and peak abundance is during the May through August breeding season (Green et al. 1992; Keiper et al. 2005; Lowry et al. 2017). Overall, the California sea lion population is abundant and has been generally increasing (Jefferson et al. 2008; Carretta et al. 2010; Lowry et al. 2017; Carretta et al. 2020). Using count and resighting data gathered between 1975 and 2015, NMFS researchers showed that California sea lion population growth was above the maximum net productivity level and within the range of the optimal sustainable population (Laake et al. 2018).

G.3.9.3 Occurrence in the Action Area

California sea lions are common offshore of VSFB and haul out sporadically on rocks and beaches along the coastline of VSFB. This species hauls out at sites in the southern portion of VSFB, which are located approximately 3.6 mi (5.8 km) south of SLC-4, as well as the NCI (VSFB 2021). However, California sea lions rarely pup on the VSFB coastline (VSFB 2021) and one pup was observed in 2015 (VSFB, unpubl. data). California sea lions are the most abundant pinniped species in the Channel Islands (Lowry et al., 2017a). SMI is the northern extent of the species' breeding range; and, along with San Nicolas Island, it contains one of the largest breeding colonies of the species in the Channel Islands (Melin et al., 2010; Lowry et al., 2017a). Pupping occurs in large numbers on SMI at the rookeries found at Point Bennett on the west end of the island and at Cardwell Point on the east end of the island. During aerial surveys of the NCI conducted by NMFS in February 2010, 21,192 total California sea lions (14,802 pups) were observed at haulouts on San Miguel Island and 8,237 total (5,712 pups) at Santa Rosa Island (M. Lowry, NMFS, unpubl. data). During aerial surveys in July 2012, 65,660 total California sea lions (28,289 pups) were recorded at haulouts on SMI, 1,584 total (3 pups) at SRI, and 1,571 total (zero pups) at Santa Cruz Island (M. Lowry, NMFS, unpubl. data).

G.3.10 Northern Fur Seal

G.3.10.1 Status

The California stock of Northern fur seal (*Callorhinus ursinus*) that is present in the ROI is not considered depleted under the Marine Mammal Protection Act and is not listed under the ESA (Carretta et al. 2020). Animals from the California stock may remain on or near San Miguel Island throughout the year but after the breeding season in November generally move to the North Pacific in waters off Canada, Washington, Oregon, and Northern California to forage (Koski et al. 1998; Melin et al. 2012; Sterling et al. 2014; Adams et al. 2014; Lowry et al. 2017; Zeppelin et al. 2019).

G.3.10.2 Life History

Migrating seals and those along the U.S. West Coast are typically found over the edge of the continental shelf and slope (Kenyon & Wilke 1953; Sterling & Ream 2004; Gentry 2009; Adams et al. 2014). Their offshore distribution has been correlated with oceanographic features (e.g., eddies and fronts) where prey may be concentrated (Ream et al. 2005; Sterling et al. 2014). The abundance of northern fur seals at San Miguel Island, the primary rookery for the California stock, has increased steadily over the past four decades, except for two severe declines associated with El Niño-southern Oscillation events in 1993 and 1998 (DeLong & Stewart 1991; Melin et al. 2006; Melin et al. 2008; Orr et al. 2012; Carretta et al. 2020).

G.3.10.3 Occurrence in the Action Area

The California stock of Northern fur seal that is present in the project area is not considered depleted under the MMPA (Carretta et al. 2020). Animals from the California stock may remain in or near SMI throughout the year but, after the breeding season in November, generally move to the North Pacific in waters off Canada, Washington, Oregon, and Northern California to forage (Melin et al. 2012; Sterling et al. 2014; Adams et al. 2014; Lowry et al. 2017b; Zeppelin et al. 2019). Migrating seals and those along the U.S. West Coast are typically found over the edge of the continental shelf and slope (Kenyon & Wilke 1953; Sterling & Ream 2004; Gentry 2009; Adams et al. 2014). Their offshore distribution has been correlated with oceanographic features (e.g., eddies and fronts) where prey may be concentrated (Ream et al. 2005; Sterling et al. 2014). The abundance of northern fur seals at SMI, the primary rookery for the California stock, has increased steadily over the past four decades, except for two severe declines associated with El Niño-southern Oscillation events in 1993 and 1998 (DeLong & Stewart 1991; Melin et al. 2006; Melin et al. 2008; Orr et al. 2012; Carretta et al. 2017b; Carretta et al. 2020). Live northern fur seals have not been observed at any VSFB haulout location (VSFB 2021).

G.3.11 Guadalupe Fur Seal (Federally Listed Threatened Species)

G.3.11.1 Status

The Guadalupe fur seal is listed as threatened under the ESA and depleted under the Marine Mammal Protection Act throughout its range (Carretta et al. 2020). The population has been designated the Mexico to California stock (Carretta et al. 2020).

G.3.11.2 Life History

Guadalupe fur seals are most common at their primary breeding ground of Guadalupe Island, Mexico (Melin & DeLong 1999). A second rookery was found in 1997 at the San Benito Islands off the Baja Peninsula, Mexico (Maravilla-Chavez & Lowry 1999; Aurioles-Gamboa et al. 2010; Esperon-Rodriguez & Gallo-Reynoso 2012), and they have also been found in La Paz Bay in the southern Gulf of California (Elorriaga-Verplancken et al. 2016). Satellite tracking data from Guadalupe fur seals tagged at Guadalupe Island have demonstrated movements into the offshore waters between 31 and 186 miles (mi.). (50 and 300 kilometers [km]) from the U.S. West Coast (Norris et al. 2015; Norris 2017b, 2017a; Norris & Elorriaga-Verplancken 2020). Satellite tags have also documented the movement of females without pups at least as far as 800 mi. (1,300 km) north of Guadalupe Island (approximately Point Cabrillo in Mendocino County, California) (Norris 2019). Adult males have not been tagged but typically undertake some form of seasonal movement either after the breeding season or during the winter, when prey availability is reduced (Arnould 2009). The most recent stock assessment reports reflect the population of Guadalupe fur seals from a survey in 2010, which indicated a total estimated population size of approximately 20,000 animals and an average annual growth rate of 10.3 percent (Carretta et al. 2019). The ongoing Unusual Mortality Event involving Guadalupe fur seals (National Oceanic and Atmospheric Administration 2018; National Marine Fisheries Service 2019a) is likely to have impacted the recent population trend (Elorriaga-Verplancken et al. 2016; Ortega-Ortiz et al. 2019). However, based on counts off Mexico in 2018 at Guadalupe Island and the San Benito Archipelago, the minimum population estimate was 29,747 Guadalupe fur seals at those locations (Norris 2019). Valdivia et al. (2019) has noted that since being ESA-listed in 1985, the population of the Guadalupe fur seal increased about nine-fold at a rate of approximately 15 percent per year. The dispersion of Guadalupe fur seal from rookeries off Mexico may be an indicator of potential species recovery (Ortega-Ortiz et al. 2019).

G.3.11.3 Occurrence in the Action Area

Guadalupe fur seals are most common at their primary breeding ground of Guadalupe Island, Mexico (Melin & DeLong 1999). A second rookery was found in 1997 at the San Benito Islands off the Baja Peninsula, Mexico (Maravilla-Chavez & Lowry 1999; Aurioles-Gamboa et al. 2010; Esperon-Rodriguez & Gallo-Reynoso 2012), and they have also been found in La Paz Bay in the southern Gulf of California (Elorriaga-Verplancken et al. 2016a). Satellite tracking data from Guadalupe fur seals tagged at Guadalupe Island have demonstrated movements into the offshore waters between 50 and 300 km from the U.S. West Coast (Norris et al. 2015; Norris 2017b, 2017a; Norris & Elorriaga-Verplancken 2020). Based on that data, the seals can be expected to occur in both deeper waters of the open ocean and coastal waters within the project area. Adult and juvenile males have occasionally been observed at SMI since the mid-1960s; in the late 1990s, a pup was born on that island. Rare sightings of individuals have also occurred at Santa Barbara, San Nicolas, and San Clemente Islands (Stewart 1981; Stewart & Yochem 1984; Stewart et al. 1993; Stewart & Yochem n.d.). In NMFS aerial surveys between 2011 and 2015, Guadalupe fur seals were not observed on any of the Channel Islands other than at SMI (Lowry et al. 2017; Burke 2017). Guadalupe fur seals have not been observed at any VSFB haulout locations (VSFB 2021).

Satellite tags have documented the movement of females without pups at least as far as 808 mi (1,300 km) north of Guadalupe Island (to approximately Point Cabrillo in Mendocino County, California; Norris 2019). Adult males have not been tagged but typically undertake some form of seasonal movement either after the breeding season or during the winter, when prey availability is reduced (Arnould 2009). Based on counts off Mexico in 2018 at Guadalupe Island and the San Benito Archipelago, the minimum population estimate was 29,747 Guadalupe fur seals at those locations (Norris 2019). Valdivia et al. (2019)

has noted that, since being ESA-listed in 1985, the population of the Guadalupe fur seal increased about nine-fold at a rate of approximately 15 percent per year. The dispersion of Guadalupe fur seal from rookeries off Mexico may be an indicator of potential species recovery (Ortega-Ortiz et al. 2019).

G.3.12 Steller Sea Lion

G.3.12.1 Status

The Eastern U.S. stock (or DPS) of Steller sea lion (*Eumetopias jubatus*) is defined as the population occurring east of 144°W longitude, and it is not listed as threatened or endangered under the ESA (NMFS 2016; Muto et al. 2020; delisted 2013, see additional info below). The locations and distribution of the Eastern population's breeding sites along the U.S. Pacific coast have shifted northward, with fewer breeding sites in Southern California and more sites established in Washington and Southeast Alaska (Pitcher et al. 2007; Wiles 2015). Based on a 2017 survey, the Eastern U.S. stock has increased at a rate of approximately 4.25 percent per year over the last 40 years (Muto et al. 2020), but it remains uncertain how many and what trend there will be for Steller sea lions that are occasionally present in small numbers off Central and Southern California.

G.3.12.2 Life History

Steller sea lions range along the north Pacific from northern Japan to California (Perrin et al. 2009), with centers of abundance and distribution in the Gulf of Alaska and Aleutian Islands (Muto et al. 2020). There have also been reports of Steller sea lions in waters off Mexico as far south as the various islands off the port of Manzanillo in Colima, Mexico (Gallo-Reynoso et al. 2020). San Miguel Island and Santa Rosa Island were, in the past, the southernmost rookeries and haulouts for the Steller sea lions, but their range contracted northward in the 20th century, and now Año Nuevo Island off Central California is currently the southernmost rookery. Steller sea lions pups were known to be born at San Miguel Island up until 1981 (Pitcher et al. 2007; NMFS 2008; Muto et al. 2020), and so, as the population continues to increase, it is anticipated that the Steller sea lions may re-establish a breeding colony on San Miguel Island in the future. In the Channel Islands and vicinity and despite the species' general absence from the area, a consistent but small number of Steller sea lions (one to two individuals at a time) have been sighted in recent years. Approximately one to two adult and subadult male Steller sea lions have been seen hauled out at San Miguel Island each year during the fall and winter over the last decade, and adult and subadult males have occasionally been seen on rocks north of Northwest Point at San Miguel Island during the part of the summer in the past few years (Delong 2019). Aerial surveys for pinnipeds in the Channel Islands from 2011 to 2015 encountered a single Steller sea lion at San Nicolas Island in 2013 (Lowry et al. 2017). A lone adult female who gave birth to and reared a pup on San Miguel Island in the summer of 2017 (Delong 2019).

G.3.12.3 Occurrence in the Action Area

North Rocky Point was used in April and May 2012 by Steller sea lions (Marine Mammal Consulting Group and Science Applications International Corporation [MMCG and SAIC] 2012). This observation was the first time this species had been reported at VSFB during launch monitoring and monthly surveys conducted over the past two decades. Since 2012, Steller sea lions have been observed infrequently in routine monthly surveys, with as many as 16 individuals recorded. In 2014, up to 5 Steller sea lions were observed in the affected area during monthly marine mammal counts (MSRS 2015) and a maximum of 12 individuals were observed during monthly counts in 2015 (VSFB, unpublished data). However, up to 16 individuals were observed in 2012 (MMCG and SAIC 2012). Steller sea lions once had two small rookeries on SMI, but these were abandoned after the 1982–1983 El Niño event (DeLong and Melin 2000; Lowry

2002); however, occasional juvenile and adult males have been detected since then. These rookeries were once the southernmost colonies of the eastern stock of this species. The Eastern Distinct Population Segment of this species, which includes the California coastline as part of its range, was de-listed from the federal Endangered Species Act in November 2013.

G.3.13 Pacific Harbor Seal

G.3.13.1 Status

The harbor seal (*Phoca vitulina*) is not listed under the ESA and those present in the ROI have been assigned to the California stock of harbor seals (Carretta et al. 2020).

G.3.13.2 Life History

Harbor seals are generally not present in the deep waters of the open ocean, are rarely found more than 20 km from shore, and frequently occupy bays, estuaries, and inlets (Baird 2001; Harvey & Goley 2011; Jefferson et al. 2014). Data from 180 radio tagged harbor seals in California indicated most remained within 10 km of the location where they were captured and tagged (Harvey & Goley 2011).

Harbor seals generally haul out in greatest numbers at low tides and during the afternoon, when it is usually warmest. The period from late May to early June corresponds with the peak molt season when the maximum number of harbor seals are onshore (Lowry et al. 2017). The most recent (2012) statewide survey of California harbor seal rookeries has indicated that in the Channel Islands the count has been stable or trending as a slight increase since 1995 (Carretta et al. 2020).

G.3.12.3 Occurrence in the Action Area

Pacific harbor seals congregate on multiple rocky haulout sites along the VSFB coastline. Most haulout sites are located between the Boat House and South Rocky Point, where most of the pupping on VSFB occurs (VSFB 2021). Pups are generally present in the region from March through July. Within the affected area on VSFB, up to 332 adults and 34 pups have been recorded in monthly counts from 2013 to 2015 (MSRS 2014, 2015). During aerial pinniped surveys of haulouts located in the Point Conception area by NMFS in May 2002 and May and June of 2004, between 488 to 516 harbor seals were recorded (M. Lowry, NMFS, unpubl. data). Data on pup numbers were not provided. Harbor seals also haul out, breed, and pup in isolated beaches and coves throughout the coast of SMI. During aerial surveys conducted by NMFS in May 2002 and May and June of 2004, between 521 and 1,004 harbors seals were recorded at SMI, between 605 and 972 at SRI, and between 599 and 1,102 Santa Cruz Island (M. Lowry, NMFS, unpubl. data). Again, data on pup numbers were not provided. Lowry et al. (2017b) counted 1,367 Pacific harbor seals at the Channel Islands in July 2015.

G.3.14 Northern Elephant Seal

G.3.14.1 Status

The northern elephant seal (*Mirounga angustirostris*) is not listed under the ESA. There are two distinct populations of northern elephant seals: one that breeds in the Baja Peninsula, Mexico; and a population that breeds in California (Garcia-Aguilar et al. 2018). NMFS considers northern elephant seals in the ROI to be from the California Breeding stock, although elephant seals from the Baja Peninsula, Mexico, frequently migrate through the ROI (Aurioles-Gamboa & Camacho-Rios 2007; Carretta et al. 2020).

G.3.14.2 Life History

Northern elephant seals spend little time nearshore and migrate four times a year as they travel to and from breeding/pupping and molting areas, spending more than 80 percent of their annual cycle at sea (Robinson et al. 2012; Lowry et al. 2014; Lowry et al. 2017; Carretta et al. 2020). Peak abundance in California is during the January–February breeding season and during molting season from April to July (Lowry et al. 2014; Lowry et al. 2017). As presented in the 2019 Stock Assessment Report (Carretta et al. 2020), the population in California continues to increase Lowry et al. (2014).

G.3.14.3 Occurrence in the Action Area

Northern elephant seals haul out on rocks and beaches along the coastline of VSFB and observations of young of the year seals from May through November have represented individuals dispersing later in the year from other parts of the California coastline where breeding and birthing occur (VSFB 2021). Pupping of this species was observed on south VSFB in January 2017, for the first time in more than 40 years. Presence of all age classes have been closely recorded at VSFB, especially since 2018, with as many as 35 pups being born here. Researchers affiliated with the California Polytechnic State University, San Luis Obispo (Cal Poly) have flipper tagged nearly 200 pups since 2018 and satellite tagged 10 pups at VSFB and 5 pups at San Nicolas Island under authorization of NMFS permit 22187-04. Eleven northern elephant seals were observed during aerial surveys of the Point Conception area by NMFS in February of 2010 (M. Lowry, NMFS, unpubl. data). Northern elephant seals breed and pup at the rookeries found at Point Bennett on the west end of SMI and at Cardwell Point on the east end of the island (Lowry 2002). Northern elephant seals are abundant at the NCI from December to March (Lowry et al., 2017b). During aerial surveys of the Northern Channel Islands conducted by NMFS in February 2010, 21,192 total northern elephant seals (14,802 pups) were recorded at haulouts on SMI and 8,237 total (5,712 pups) were observed at SRI (M. Lowry, NMFS, unpubl. data). None were observed at Santa Cruz Island (M. Lowry, NMFS, unpubl. data). Lowry (2017b) stated that aerial surveys found 16,208 pups in SMI, 10,882 pups at San Nicolas Island, and 5,946 pups at SRI.

G.8 Bibliography

Abrahms, B., H. Welch, S. Brodie, M. H. Jacox, E. Becker, S. J. Bograd, L. Irvine, D. Palacios, B. Mate, and E. Hazen. 2019. Dynamic ensemble models to predict distributions and anthropogenic risk exposure for highly mobile species. Diversity and Distributions 00: 1–12.

Adams, J., J. Felis, J. W. Mason, and J. Y. Takekawa. 2014. Pacific Continental Shelf Environmental Assessment (PaCSEA): Aerial Seabird and Marine Mammal Surveys off Northern California, Oregon, and Washington, 2011–2012 (OCS Study BOEM 2014-003). Camarillo, CA: Bureau of Ocean Energy Management.

Alagona, P., S. Cooper, M. Capelli, M. Stocker, and P. H. Beedle. 2012. A History of Steelhead and Rainbow Trout (Oncorhynchus mykiss) in the Santa Ynez River Watershed, Santa Barbara County, California. Southern California Academy of Sciences Bulletin 111(3): 163–222.

Allen, L. H., and J. N. Cross. 2006. Surface waters. In. In L. H. Allen, D. J. Pondella, II & M. H. Horn (Eds.), The Ecology of Marine Fishes: California and Adjacent Waters (pp. 320–341). Berkeley, CA: University of California Press.

Arnould, J.P.Y. 2009. Southern fur seals, Arctocephalus spp. In W. F. Perrin, B. Würsig, & J. H. M. Thewissen (Eds.), Encyclopedia of Marine Mammals (2nd ed., pp. 1079–1084). Cambridge, MA: Academic Press.

Aurioles-Gamboa, D., and F.J. Camacho-Rios. 2007. Diet and feeding overlap of two otariids, Zalophus californianus and Arctocephalus townsendi: Implications to survive environmental uncertaintly. Aquatic Mammals 33(3): 315–326.

Aurioles-Gamboa, D., F. Elorriaga-Verplancken, and C. J. Hernandez-Camacho. 2010. The current population status of Guadalupe fur seal (*Arctocephalus townsendi*) on the San Benito Islands, Mexico. Marine Mammal Science 26(2): 402–408.

Azzellino, A., S. Gaspari, S. Airoldi, and B. Nani. 2008. Habitat use and preferences of cetaceans along the continental slope and the adjacent pelagic waters in the western Ligurian Sea. Deep Sea Research Part I: Oceanographic Research Papers 55(3): 296–323.

Bailey, H., B. R. Mate, D. M. Palacios, L. Irvine, S. J. Bograd, and D. P. Costa. 2009. Behavioral estimation of blue whale movements in the Northeast Pacific from state-space model analysis of satellite tracks. Endangered Species Research 10: 93–106.

Bailey, H., S. R. Benson, H. L. Shillinger, S. J. Bograd, P. H. Dutton, S. A. Eckert, S. J. Morreale, F. V. Paladino, T. Eguchi, D. H. Foley, B. A. Block, R. Piedra, C. Hitipeuw, R. F. Tapilatu, and J. R. Spotila. 2012. Identification of distinct movement patterns in Pacific leatherback turtle populations influenced by ocean conditions. Ecological Applications 22(3): 735–747.

Baird, R. 2013. Odontocete Cetaceans Around the Main Hawaiian Islands: Habitat Use and Relative Abundance from Small-Boat Sighting Surveys. Aquatic Mammals 39(3): 253–269.

Barlow, J. 1994. Abundance of large whales in California coastal waters: A comparison of ship surveys in 1979–1980 and in 1991. Report of the International Whaling Commission 44: 399–406.

Barlow, J. 1995. The abundance of cetaceans in California waters. Part I: Ship surveys in summer and fall of 1991. Fishery Bulletin 93: 1–14.

Barlow, J. 1997. Preliminary Estimates of Cetacean Abundance off California, Oregon and Washington based on a 1996 Ship Survey and Comparisons of Passing and Closing Modes. La Jolla, CA: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Barlow, J. 2010. Cetacean Abundance in the California Current Estimated from a 2008 Ship-Based Line-Transect Survey (NOAA Technical Memorandum NMFS-SWFSC-456). La Jolla, CA: Southwest Fisheries Science Center.

Barlow, J. 2016. Cetacean Abundance in the California Current Estimated from Ship-based Line-transect Surveys in 1991–2014. (NOAA Administrative Report NMFS-SWFSC-LJ-1601). La Jolla, CA: Southwest Fisheries Science Center.

Barlow, J., and K. A. Forney. 2007. Abundance and population density of cetaceans in the California Current ecosystem. Fishery Bulletin 105: 509–526.

Barlow, J., M. Ferguson, E. Becker, J. Redfern, K. Forney, I. Vilchis, P. Fiedler, T. Gerrodette, and L. Ballance. 2009. Predictive Modeling of Cetacean Densities in the Eastern Pacific Ocean (NOAA Technical Memorandum NMFS-SWFSC-444). La Jolla, CA: Southwest Fisheries Science Center.

Baum, J. K., R. A. Myers, D. H. Kehler, B. Worm, S. J. Harley, & P. A. Doherty. 2003. Collapse and conservation of shark populations in the northwest Atlantic. Science 299: 389-392.

Becker, E. A., K. A. Forney, D. H. Foley, and J. Barlow. 2012. Density and Spatial Distribution Patterns of Cetaceans in the Central North Pacific based on Habitat Models (NOAA Technical Memorandum NMFS-SWFSC-490). La Jolla, CA: Southwest Fisheries Science Center.

Becker, E. A., K. A. Forney, M. C. Ferguson, D. H. Foley, R. C. Smith, J. Barlow, and J. V. Redfern. 2010. Comparing California Current cetacean–habitat models developed using in situ and remotely sensed sea surface temperature data. Marine Ecology Progress Series 413: 163–183.

Becker, E. A., K. A. Forney, P. C. Fiedler, J. Barlow, S. J. Chivers, C. A. Edwards, A. M. Moore, and J. V. Redfern. 2016. Moving Towards Dynamic Ocean Management: How Well Do Modeled Ocean Products Predict Species Distributions? Remote Sensing 8(2): 149.

Bellinger, M. R., M. A. Banks, S. J. Bates, E. D. Crandall, C. H. Garza, and P. W. Lawson. 2015. Geo-Referenced, Abundance Calibrated Ocean Distribution of Chinook Salmon (*Oncorhynchus tshawytscha*) Stocks across the West Coast of North America. PLoS One 10(7): e0131276.

Bettridge, S., C. S. Baker, J. Barlow, P. J. Clapham, M. Ford, D. Gouveia, D. K. Mattila, R. M. Pace, III, P. E. Rosel, H. K. Silber, and P. R. Wade. 2015. Status Review of the Humpback Whale (Megaptera novaeangliae) under the Endangered Species Act (NOAA Technical Memorandum NMFS-SWFSC-540). La Jolla, CA: Southwest Fisheries Science Center.

Boughton, D. A., and H. Fish. 2003. New Data on Steelhead Distribution in Southern and South-Central California. La Jolla, CA: National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Bradford, A. L., K. A. Forney, E. A. Oleson, and J. Barlow. 2013. Line-transect abundance estimates of cetaceans in the Hawaiian EEZ (PIFSC Working Paper WP-13-004, PSRG-2013-18). Honolulu, HI: Pacific Islands Fisheries Science Center.

Brinton, E., and A. Townsend. 2003. Decadal variability in abundances of the dominant euphausiid species in southern sectors of the California Current. Deep Sea Research II 50: 2449–2472.

Burke, J.H. 2017. Pinniped Monitoring During Missile Launches on San Nicolas Island, California, December 2016–November 2017. Point Mugu, CA: Naval Air Warfare Center Weapons Division.

Burrows, J. A., D. W. Johnston, J. M. Straley, E. M. Chenoweth, C. Ware, C. Curtice, S. L. DeRuiter, and A. S. Friedlaender. 2016. Prey density and depth affect the fine-scale foraging behavior of humpback whales *Megaptera novaeangliae* in Sitka Sound, Alaska, USA. Marine Ecology Progress Series 561: 245–260.

Busby, P. J., T. C. Wainwright, H. J. Bryant, L. J. Lienheimer, R. S. Waples, F. W. Waknitz, and I. V. Lagomarsino. 1996. Status Review of West Coast Steelhead from Washington, Idaho, Oregon, and California (NOAA Technical Memorandum NMFS-NWFSC-27). Long Beach, CA: National Marine Fisheries Service, Southwest Region, Protected Species Management Division.

Calambokidis, J., and J. Barlow. 2004. Abundance of blue and humpback whales in the eastern North Pacific estimated by capture-recapture and line-transect methods. Marine Mammal Science 20(1): 63–85.

Calambokidis, J., and J. Barlow. 2013. Updated Abundance Estimates of Blue and Humpback Whales off the U.S. West Coast Incorporating Photo-Identifications from 2010 and 2011 (PSRG-2013-13R). Olympia, WA and La Jolla, CA: Cascadia Research and Southwest Fisheries Science Center.

Calambokidis, J., and J. Barlow. 2020. Updated abundance estimates for blue and humpback whales along the U.S. West Coast using data through 2018 (NOAA Technical Memorandum NMFS-SWFSC-634). La Jolla, CA: National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

Calambokidis, J., J. Barlow, K. Flynn, E. Dobson, and H. H. Steiger. 2017. Update on abundance, trends, and migrations of humpback whales along the U.S. West Coast (SC/A17/NP/13). Cambridge, United Kingdom: International Whaling Commission.

Calambokidis, J., J. Barlow, J. K. B. Ford, T. E. Chandler, and A. B. Douglas. 2009a. Insights into the population structure of blue whales in the Eastern North Pacific from recent sightings and photographic identification. Marine Mammal Science 25(4): 816–832.

Calambokidis, J., E. Falcone, A. Douglas, L. Schlender, and J. Huggins. 2009b. Photographic Identification of Humpback and Blue Whales off the U.S. West Coast: Results and Updated Abundance Estimates from 2008 Field Season. La Jolla, CA: Southwest Fisheries Science Center, and Olympia, WA: Cascadia Research Collective.

Calambokidis, J., H. H. Steiger, C. Curtice, J. Harrison, M. C. Ferguson, E. Becker, M. DeAngelis, and S. M. Van Parijs. 2015. Biologically Important Areas for Selected Cetaceans Within U.S. Waters – West Coast Region. Aquatic Mammals (Special Issue) 41(1): 39–53.

Calambokidis, J., J. A. Fahlbusch, A. R. Szesciorka, B. L. Southall, D. E. Cade, A. S. Friedlaender, and J. A. Goldbogen. 2019. Differential vulnerability to ship strikes between day and night for blue, fin, and humpback whales based on dive and movement data from medium duration archival tags. Frontiers in Marine Science 6: 11.

California Department of Fish and Wildlife. 2022a. Winter-Run Chinook Salmon. Retrieved October 4, 2022, from https://wildlife.ca.gov/Conservation/Fishes/Chinook-Salmon/Winter-run.

California Department of Fish and Wildlife. 2022b. Coho Salmon. Retrieved 6 October 2022, from https://wildlife.ca.gov/Conservation/Fishes/Coho-Salmon

Campbell, H. S., L. Thomas, K. Whitaker, A. B. Douglas, J. Calambokidis, and J. A. Hildebrand. 2015. Inter-annual and seasonal trends in cetacean distribution, density and abundance off southern California. Deep Sea Research Part II: Topical Studies in Oceanography 112: 143–157.

Carretta, J. V., K. A. Forney, E. M. Oleson, D. W. Weller, A. R. Lang, J. Baker, M. M. Muto, B. Hanson, A. J. Orr, H. Huber, M. S. Lowry, J. Barlow, J. E. Moore, D. Lynch, L. Carswell, and R. L. Brownell Jr. 2019. Draft U.S. Pacific Marine Mammal Stock Assessments: 2019 (NOAA Technical Memorandum). La Jolla, CA: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center

Carretta, J. V., K. A. Forney, E. M. Oleson, D. W. Weller, A. R. Lang, J. Baker, M. M. Muto, B. Hanson, A. J. Orr, H. Huber, M. S. Lowry, J. Barlow, J. E. Moore, D. Lynch, L. Carswell, and R. L. Brownell Jr. (2020). U.S. Pacific Marine Mammal Stock Assessments: 2019 (NOAA-TM-NMFS-SWFSC-629). La Jolla, CA: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center

Carretta, J. V., K. A. Forney, E. M. Oleson, D. W. Weller, A. R. Lang, J. Baker, M. M. Muto, B. Hanson, A. J. Orr, H. Huber, M. S. Lowry, J. Barlow, J. E. Moore, D. Lynch, L. Carswell, and R. L. Brownell, Jr. (2018a). U.S. Pacific Marine Mammal Stock Assessments: 2017. La Jolla, CA: Southwest Fisheries Science Center.

Carretta, J. V., K. A. Forney, E. M. Oleson, D. W. Weller, A. R. Lang, J. Baker, M. M. Muto, B. Hanson, A. J. Orr, H. Huber, M. S. Lowry, J. Barlow, J. E. Moore, D. Lynch, L. Carswell, and R. L. Brownell, Jr. (2018b). U.S. Pacific Draft Marine Mammal Stock Assessments: 2018 (NOAA Technical Memorandum NMFS-SWFSC-XXX). La Jolla, CA: National Marine Fisheries Service, Southwest Fisheries Science Center.

Carretta, J. V., M. M. Muto, J. Greenman, K. Wilkinson, D. Lawson, J. Viezbicke, and J. Jannot. (2017a). Sources of Human-Related Injury and Mortality for U.S. Pacific West Coast Marine Mammal Stock Assessments, 2011–2015 (NOAA Technical Memorandum NMFS-SWFSC-579). La Jolla, CA: Southwest Fisheries Science Center.

Carretta, J. V., E. M. Oleson, K. A. Forney, M. M. Muto, D. W. Weller, A. R. Lang, J. Baker, B. Hanson, A. J. Orr, J. Barlow, J. E. Moore, and R. L. J. Brownell. (2021). U.S. Pacific Marine Mammal Stock Assessments: 2020 (NMFS-SWFSC-646). La Jolla, CA: National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center

Carretta, J. V., E. M. Oleson, J. Baker, D. W. Weller, A. R. Lang, K. A. Forney, M. M. Muto, B. Hanson, A. J. Orr, H. Huber, M. S. Lowry, J. Barlow, J. E. Moore, D. Lynch, L. Carswell, and R. L. Brownell, Jr. (2017b). U.S. Pacific Marine Mammal Stock Assessments: 2016 (NOAA Technical Memorandum NMFS-SWFSC-561). La Jolla, CA: Southwest Fisheries Science Center.

Carretta, J. V., E. Oleson, D. W. Weller, A. R. Lang, K. A. Forney, J. Baker, M. M. Muto, B. Hanson, A. J. Orr, H. Huber, M. S. Lowry, J. Barlow, J. Moore, D. Lynch, L. Carswell, and R. L. Brownell. (2015). U.S. Pacific Marine Mammal Stock Assessments: 2014 (NOAA Technical Memorandum NMFS-SWFSC-549). La Jolla, CA: Southwest Fisheries Science Center.

Cimino, M. A., J. A. Santora, I. Schroeder, W. Sydeman, M. H. Jacox, E. L. Hazen, and S. J. Bogard. 2020. Essential krill species habitat resolved by seasonal upwelling and ocean circulation models within the large marine ecosystem of the California Current System. Ecography 43: 1–15.

Clapham, P. J. 2000. The humpback whale: Seasonal feeding and breeding in a baleen whale. In J. Mann, R. C. Connor, P. L. Tyack, & H. Whitehead (Eds.), Cetacean Societies: Field Studies of Dolphins and Whales (pp. 173–196). Chicago, IL: University of Chicago Press.

Clark, R., A. Ott, M. Rabe, D. Vincent-Lang, and D. Woodby. 2010. The Effects of a Changing Climate on Key Habitats in Alaska. Anchorage, AK: Alaska Department of Fish and Game.

Cliffton, K., D.O. Cornejo, and R.S. Felger. 1995. Sea turtles of the Pacific coast of Mexico. In K. A. Bjorndal (Ed.), Biology and Conservation of Sea Turtles (Revised ed., pp. 199-209). Washington, DC: Smithsonian Institution Press.

Cogan, J. 2015. 2015 Whale Sightings in the Salish Sea: Central Salish Sea and Puget Sound (Southern Resident Killer Whale Project). Friday Harbor, WA: Center for Whale Research.

Cominellli, S., R. Sevillers, H. Yurk, A. MacGillivray, L. McWhinnie, and R. Canessa. 2018. Noise exposure from commercial shipping for the southern resident killer whale population. Marine Pollution Bulletin 136(1): 177–200.

Compagno, L. J. V. 1984. FAO Species Catalogue. Sharks of the World. An Annotated and Illustrated Catalogue of Shark Species Known to Date. Part 2. Carcharhiniformes (FAO Fisheries Synopsis No. 125). Tiburon, CA: San Francisco State University.

Conant, T. A., P. H. Dutton, T. Eguchi, S. P. Epperly, C. C. Fahy, M. H. Godfrey, S. L. MacPherson, E. E. Possardt, B. A. Schroeder, J. A. Seminoff, M. L. Snover, C. M. Upite, and B. E. Witherington. 2009.

Loggerhead sea turtle (*Caretta caretta*) 2009 status review under the U.S. Endangered Species Act (Report of the loggerhead biological review team to the National Marine Fisheries Service, August 2009). Silver Spring, MD: Loggerhead Biological Review Team.

Cooke, J. 2019. Western gray whale population assessment update with reference to historic range and recovery prospects. Western Gray Whale Advisory Panel 19(22): 1–15.

Couture, F., H. Oldford, V. Christensen, L. Barrett-Lennard, and C. Walters. 2022. Requirements and availability of prey for northeastern pacific southern resident killer whales. Plos one 17(6).

Craig, A.S., and L.M. Herman. 2000. Habitat preferences of female humpback whales, Megaptera novaeangliae, in the Hawaiian Islands are associated with reproductive status. Marine Ecology Progress Series 193: 209–216.

Dahlheim, M. E., A. Schulman-Janiger, N. Black, R. Ternullo, D. K. Ellifrit, and K. C. Balcomb, III. 2008. Eastern temperate North Pacific offshore killer whales (*Orcinus orca*): Occurrence, movements, and insights into feeding ecology. Marine Mammal Science 24(3): 719–729.

Daly-Engel, T. S., K. D. Seraphin, K. N. Holland, J. P. Coffey, H. A. Nance, R. J. Toonen, & B. W. Bowen. 2012. Global phylogeography with mixed-marker analysis reveals male-mediated dispersal in the endangered scalloped hammerhead shark (*Sphyrna lewini*). PLoS One 7(1): e29986.

DeLong, R.L., & S.R. Melin. 2000. Thirty years of pinniped research at San Miguel Island. Proceedings of the Fifth California Islands Symposium. U.S. Department of the Interior, Minerals Management Service, Pacific OCS Region. February 2000, pp. 401-406.

DeLong, R. L., and B. S. Stewart. 1991. Diving patterns of northern elephant seal bulls. Marine Mammal Science 7(4): 369–384.

Delong, R. 2019. [Personal communication on characterization of Steller Sea Lion sightings in Southern California in support of the PMSR EIS (R. DeLong {National Oceanic and Atmospheric Administration}, H. Sanders {U.S. Navy, NAVAIR}, T. Orr {National Oceanic and Atmospheric Administration}, C. Erkelens {Mantech}, M. Zickel {Mantech})].

DeLong, R. L., S. J. Jeffries, S. R. Melin, A. J. Orr, and J. L. Laake. 2017a. Satellite Tag Tracking and Behavioral Monitoring of Male California Sea Lions in the Pacific Northwest to Assess Haul-out Behavior on Puget Sound Navy Facilities and Foraging Behavior in Navy Testing and Training Areas. Seattle, WA: National Marine Fisheries Service and the Washington Department of Fish and Wildlife.

DeLong, R. L., S. R. Melin, J. L. Laake, P. A. Morris, A. J. Orr, and J. D. Harris. 2017b. Age- and sex-specific survival of California sea lions (*Zalophus californianus*) at San Miguel Island, California. Marine Mammal Science 33(4): 1097–1125.

Deutsch, C., A. Ferrel, B. Seibel, H. O. Portner, and R. B. Huey. 2015. Climate change tightens a metabolic constraint on marine habitats. Science 348(6239): 1132–1135.

Dohl, T. P., R. C. Guess, M. L. Duman, and R. C. Helm. 1983. Cetaceans of Central and Northern California, 1980-1983: Status, Abundance, and Distribution (OCS Study MMS 84–005). Los Angeles, CA: U.S. Department of the Interior, Minerals Management Service, Pacific Outer Continental Shelf Region.

Douglas, A. B., J. Calambokidis, L. M. Munger, M. S. Soldevilla, M. C. Ferguson, A. M. Havron, D. L. Camacho, H. S. Campbell, and J. A. Hildebrand. 2014. Seasonal distribution and abundance of cetaceans off Southern California estimated from CalCOFI cruise data from 2004 to 2008. Fishery Bulletin 112(2–3): 198–220.

Duncan, K. M., & K. N. Holland. 2006. Habitat use, growth rates and dispersal patterns of juvenile scalloped hammerhead sharks, *Sphyrna lewini*, in a nursery habitat. Marine Ecology Progress Series 312: 211–221.

Eckert, K. L. 1995. Anthropogenic threats to sea turtles. In K. A. Bjorndal (Ed.), Biology and Conservation of Sea Turtles (Revised ed., pp. 611–612). Washington, DC: Smithsonian Institution Press.

Eguchi, T., J. Seminoff, R. Leroux, P. Dutton, and D. Dutton. 2010. Abundance and survival rates of green sea turtles in an urban environment coexistence of humans and an endangered species. Marine Biology 157: 1869-1877. doi: 10.1007/s00227-010-1458-9

Elorriaga-Verplancken, F. R., H. Rosales-Nanduca, and R. Robles-Hernández. 2016. Unprecedented records of Guadalupe fur seals in La Paz Bay, Southern Gulf of California, Mexico, as a possible result of warming conditions in the Northeastern Pacific. Aquatic Mammals 42(3): 261–267.

Erickson, D. L. and J. E. Hightower. 2007. Oceanic distribution and behavior of green sturgeon. American Fisheries Society Symposium 56: 197–211.

Ersts, P. J., and H. C. Rosenbaum. 2003. Habitat preference reflects social organization of humpback whales (*Megaptera novaeangliae*) on a wintering ground. Journal of Zoology 260(4): 337–345.

Esperon-Rodriguez, M., and J.P. Gallo-Reynoso. 2012. Analysis of the re-colonization of San Benito Archipelago by Guadalupe fur seals (*Arctocephalus townsendi*). Latin American Journal of Aquatic Research 40(1): 213–223.

Ferguson, M. C. 2005. Cetacean Population Density in the Eastern Pacific Ocean: Analyzing Patterns With Predictive Spatial Models. (Unpublished Doctoral Dissertation). University of California, San Diego, La Jolla, CA. Retrieved from http://daytonlab.ucsd.edu.

Ferguson, M. C., C. Curtice, J. Harrison, and S. M. Van Parijs. 2015. Biologically important areas for cetaceans within U.S. waters – Overview and rationale. Aquatic Mammals (Special Issue) 41(1): 2–16.

Ferrara, H. A., T. M. Mongillo, and L. M. Barre. 2017. Reducing Disturbance from Vessels to Southern Resident Killer Whales: Assessing the Effectiveness of the 2011 Federal Regulations in Advancing Recovery Goals. Seattle, WA: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, and National Marine Fisheries Service.

Fiechter, J., J. A. Santora, F. Chavez, D. Northcott, and M. Messié. 2020. Krill hotspot formation and phenology in the California current ecosystem. Geophysical Research Letters 47.

Fisher, J. P., L. A. Weitkamp, D. J. Teel, S. A. Hinton, J. A. Orsi, E. V. Farley Jr., J. F. T. Morris, M. E. Thiess, R. M. Sweeting, and M. Trudel. (2014). Early Ocean Dispersal Patterns of Columbia River Chinook and Coho Salmon. Transactions of the American Fisheries Society 143(1): 252–272.

Fleming, A. H., C. T. Clark, J. Calambokidis, and J. Barlow. 2016. Humpback whale diets respond to variance in ocean climate and ecosystem conditions in the California Current. Global Change Biology 22(3): 1214–1224.

Forney, K. A., and J. Barlow. 1993. Preliminary winter abundance estimates for cetaceans along the California coast based on a 1991 aerial survey. Reports of the International Whaling Commission 43: 407–415.

Forney, K. A., and J. Barlow. 1998. Seasonal patterns in the abundance and distribution of California cetaceans, 1991–1992. Marine Mammal Science 14(3): 460–489.

Forney, K. A., J. Barlow, and J. V. Carretta. 1995. The abundance of cetaceans in California waters. Part II: Aerial surveys in winter and spring of 1991 and 1992. Fishery Bulletin 93: 15–26.

Forney, K. A., M. C. Ferguson, E. A. Becker, P. C. Fiedler, J. V. Redfern, J. Barlow, I. L. Vilchis, and L. T. Ballance. 2012. Habitat-based spatial models of cetacean density in the eastern Pacific Ocean. Endangered Species Research 16(2): 113–133.

Frisch-Jordan, A., N. L. Ransome, O. Aranda-Mena, and F. Romo-Sirvent. 2019. Intensive feeding of humpback whales (*Megaptera novaeangliae*) in the breeding ground of Banderas Bay, Mexico. Latin American Journal of Aquatic Mammals 14(1): 27–33.

Froese, R., & D. Pauly. 2016. FishBase. World Wide Web electronic publication. Retrieved from www.fishbase.orH.

Gabriele, C. M., J. L. Neilson, J. M. Straley, C. S. Baker, J. A. Cedarleaf, and J. F. Saracco. 2017. Natural history, population dynamics, and habitat use of humpback whales over 30 years on an Alaska feeding ground. Ecosphere 8(1): e01641.

Gallo-Reynoso, J. P., A. L. Figueroa-Carranza, I. D. Barba-Acuña, D. Borjes-Flores, and I. J. Pérez-Cossío. 2020. Stellar sea lions (*Eumetopias jubatus*) along the western coast of Mexico. Aquatic Mammals 46(4): 411–416.

Gannier, A., and E. Praca. 2007. SST fronts and the summer sperm whale distribution in the north-west Mediterranean Sea. Journal of the Marine Biological Association of the United Kingdom 87(01): 187.

Garcia-Aguilar, M. C., C. Turrent, F. R. Elorriaga-Verplancken, A. Arias-Del-Razo, and Y. Schramm. 2018. Climate change and the northern elephant seal (*Mirounga angustirostris*) population in Baja California, Mexico. PLoS ONE 13(2): e0193211.

Gaspar, P., and M. Lalire. 2017. A model for simulating the active dispersal of juvenile sea turtles with a case study on western Pacific leatherback turtles. PLoS ONE 12(7): e0181595.

Gentry, R. L. 2009. Northern fur seal, *Callorhinus ursinus*. In W. F. Perrin, B. Wursig, & J. H. M. Thewissen (Eds.), Encyclopedia of Marine Mammals (2nd ed., pp. 788–791). Cambridge, MA: Academic Press.

Goldbogen, J. A., E. L. Hazen, A. S. Friedlaender, J. Calambokidis, S. L. DeRuiter, A. K. Stimpert, B. L. Southall, and D. Costa. 2015. Prey density and distribution drive the three-dimensional foraging strategies of the largest filter feeder. Functional Ecology 29(7): 951–961.

Good, T. P., R. S. Waples, and P. Adams, (Eds.). 2005. Updated Status of Federally Listed ESUs of West Coast Salmon and Steelhead. Seattle, WA: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Fisheries Science Center.

Green, H. A., J. J. Brueggeman, R. A. Grotefendt, C. E. Bowlby, M. L. Bonnell, and K. C. Balcomb, III. 1992. Cetacean Distribution and Abundance off Oregon and Washington, 1989–1990. Los Angeles, CA: U.S. Department of the Interior, Minerals Management Service.

Guazzo, R. A., A. Schulman-Janiger, M. H. Smith, J. Barlow, H. L. D'Spain, D. B. Rimington, and J. A. Hildebrand. 2019. Gray whale migration patterns through the Southern California Bight from multi-year visual and acoustic monitoring. Marine Ecology Progress Series 625: 181–203.

Hamilton, T. A., J. V. Redfern, J. Barlow, L. T. Ballance, T. Gerrodette, R. S. Holt, K. A. Forney, and B. L. Taylor. 2009. Atlas of Cetacean Sightings for Southwest Fisheries Science Center Cetacean and Ecosystem Surveys: 1986–2005 (NOAA Technical Memorandum NMFS-SWFSC-440). La Jolla, CA: Southwest Fisheries Science Center.

Hanson, M. B., C. K. Emmons, M. J. Ford, M. Everett, K. Parsons, L. K. Park, J. Hempelmann, D. M. V. Doornik, H. S. Schorr, J. K. Jacobsen, M. F. Sears, M. S. Sears, J. H. Sneva, R. W. Baird, and L. Barre. 2021. Endangered predators and endangered prey: Seasonal diet of Southern Resident killer whales. PLoS ONE 16(3).

Hanson, M. B., E. J. Ward, C. K. Emmons, and M. M. Holt. 2018. Modeling the occurrence of endangered killer whales near a U.S. Navy Training Range in Washington State using satellite-tag locations to improve acoustic detection data. Seattle, WA: National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Fisheries Science Center.

Hanson, M. B., E. J. Ward, C. K. Emmons, M. M. Holt, and D. M. Holzer. 2017. Assessing the Movements and Occurrence of Southern Resident Killer Whales Relative to the U.S. Navy's Northwest Training Range Complex in the Pacific Northwest. Seattle, WA: National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Fisheries Science Center.

Harvey, J. T., and D. Goley. 2011. Determining a correction factor for aerial surveys of harbor seals in California. Marine Mammal Science 27(4): 719–735.

Hazen, E. L., and J. Goldbogen. 2015. Blue whales (*Balaenoptera musculus*) optimize foraging efficiency by balancing oxygen use and energy gain as a function of prey density. Science Advances 1(9): e1500469.

Hazen, E. L., K. L. Scales, S. M. Maxwell, D. K. Briscoe, H. Welch, S. J. Bograd, H. Bailey, S. R. Benson, T. Eguchi, H. Dewar, S. Kohin, D. P. Costa, L. B. Crowder, and R. L. Lewison. 2018. A dynamic ocean management tool to reduce bycatch and support sustainable fisheries. Science Advances 4(5): 1–7.

Helmbrecht, D., and D. A. Boughton. 2005. Recent Efforts to Monitor Anadromous Oncorhynchus Species in the California Coastal Region: A Complication of Metadata. La Jolla, CA: National Marine Fisheries Service, Southwest Fisheries Science Center.

Hendrix, N., A.-M. K. Osterback, E. Jennings, E. Danner, V. Sridharan, C. M. Greene, and S. T. Lindley. 2019. Model Description for the Sacramento River Winter-run Chinook Salmon Life Cycle Model. Seattle, WA: National Marine Fisheries Service.

Henkel, L. A., and J. T. Harvey. 2008. Abundance and distribution of marine mammals in nearshore waters of Monterey Bay, California. California Fish and Game 94(1): 1–17.

Heironimus, L. B., M. T. Sturza, and S. S. M. 2022. Tagging Green Sturgeon with Acoustic Transmitters for Evaluation of Habitat Use Along the Washington Coast. Seattle, WA: Washington Department of Fish and Wildlife.

Holt, M. M., M. B. Hanson, D. A. Giles, C. K. Emmons, and J. T. Hogan. 2017. Noise levels received by endangered killer whales Orcinus orca before and after implementation of vessel regulations. Endangered Species Research 34: 15–26.

Horwood, J. 2009. Sei whale, *Balaenoptera borealis*. In W. F. Perrin, B. Wursig, & J. H. M. Thewissen (Eds.), Encyclopedia of Marine Mammals (2nd ed., pp. 1001–1003). Cambridge, MA: Academic Press.

Huff, D. D., S. T. Lindley, P. S. Rankin, and E. A. Mora. 2011. Green sturgeon physical habitat use in the coastal Pacific Ocean. PLoS ONE 6(9): e25156.

Huff, D. D., S. T. Lindley, B. K. Wells, and F. Chai. 2012. Green sturgeon distribution in the Pacific Ocean estimated from modeled oceanographic features and migration behavior. PLoS ONE 7(9): e45852.

INP. 2006. Sustentabilidad y Pesca Responsable en México. Instituto Nacional de la Pesca.

Israel, J. A., K. J. Bando, E. C. Anderson, and B. May. 2009. Polyploid microsatellite data reveal stock complexity among estuarine North American green sturgeon (*Acipenser medirostris*). Canadian Journal of Fish Aquatic Science 66: 1491–1504.

Jefferson, T. A., M. A. Webber, and R. L. Pitman. 2008. Marine Mammals of the World: A Comprehensive Guide to Their Identification. London, United Kingdom: Elsevier.

Jefferson, T. A., M. A. Smultea, and C. E. Bacon. 2014. Southern California Bight marine mammal density and abundance from aerial survey, 2008–2013. Journal of Marine Animals and Their Ecology 7(2): 14–30.

Jones, M. L., and S. L. Swartz. 2009. Gray whale, *Eschrichtius robustus*. In W. F. Perrin, B. Wursig, & J. H. M. Thewissen (Eds.), Encyclopedia of Marine Mammals (2nd ed., pp. 503–511). Cambridge, MA: Academic Press.

Keen, E. M., J. Wray, H. Meuter, K.-L. Thompson, J. P. Barlow, and C. R. Picard. 2017. 'Whale Wave': Shifting strategies structure the complex use of critical fjord habitat by humpbacks. Marine Ecological Progress Series 567: 211–233.

Keiper, C. A., D. H. Ainley, S. H. Allen, and J. T. Harvey. 2005. Marine mammal occurrence and ocean climate off central California, 1986 to 1994 and 1997 to 1999. Marine Ecology Progress Series 289: 285–306.

Keister, J. E., E. Di Lorenzo, C. A. Morgan, V. Combes, and W. T. Peterson. 2011. Zooplankton species composition is linked to ocean transport in the Northern California Current. Global Change Biology 17(7): 2498-2511.

Kenyon, K. W., and F. Wilke. 1953. Migration of the Northern Fur Seal, *Callorhinus ursinus*. Journal of Mammalogy 34(1): 86–98.

Klinck, H., S. L. Nieukirk, S. Fregosi, D. K. Mellinger, S. Lastuka, H. B. Shilling, and J. C. Luby. 2015. Cetacean Studies on the Hawaii Range Complex in December 2014–January 2015: Passive Acoustic Monitoring of Marine Mammals using Gliders. Final Report. Honolulu, HI: HDR Inc.

Kohler, N. E., & P. A. Turner. 2001. Shark tagging: A review of conventional methods and studies. Environmental Biology of Fishes 60(1-3): 191–223.

Koski, W. R., J. W. Lawson, D. H. Thomson, and W. J. Richardson. 1998. Point Mugu Sea Range Marine Mammal Technical Report. San Diego, CA: Naval Air Warfare Center, Weapons Division and Southwest Division, Naval Facilities Engineering Command.

Kuhn, C. E., and D. P. Costa. 2014. Interannual variation in the at-sea behavior of California sea lions (*Zalophus californianus*). Marine Mammal Science 30(4): 1297–1319.

Laake, J. 2017. [Personal Communication between Dr. Jeff Laake, Statistician (California Current Ecosystems Program at National Oceanic and Atmospheric Administration) and John Ugoretz (U.S. Navy, NAVAIR Sustainability Office) regarding 2016 surveys that found better growth and body condition for sea lions at both San Nicolas and San Miguel Islands].

Laake, J. L., M. S. Lowry, R. L. DeLong, S. R. Melin, and J. V. Carretta. 2018. Population Growth and Status of California Sea Lions. Journal of Wildlife Management 82(3): 583–595.

Lacy, R. C., R. Williams, E. Ashe, K. C. Balcomb, III, L. J. N. Brent, C. W. Clark, D. P. Croft, D. A. Giles, M. Macduffee, and P. C. Paquet. 2017. Evaluating anthropogenic threats to endangered killer whales to inform effective recovery plans. Scientific Reports 7(14119): 1–12.

Le Boeuf, B. J. 2002. Status of pinnipeds on Santa Catalina Island. Proceedings of the California Academy of Sciences 53(2): 11–21.

Le Boeuf, B. J., and M. L. Bonnell. 1980. Pinnipeds of the California Islands: Abundance and distribution. In D. M. Power (Ed.), The California Islands: Proceedings of a Multidisciplinary Symposium (pp. 475–493). Santa Barbara, CA: Santa Barbara Museum of Natural History.

Lowry, M.S. 2002. Counts of northern elephant seals at rookeries in the Southern California Bight: 1981-2001. NOAA Technical Memorandum NMFS. NOAA-TM-NMFS-SWFSC-345. 63 pp.

Lowry, M. S., P. Boveng, R. J. DeLong, C. W. Oliver, B. S. Stewart, H. DeAnda, and J. Barlow. 1992. Status of the California sea lion (*Zalophus californianus californianus*) population in 1992. Silver Spring, MD: National Marine Fisheries Service.

Lowry, M. S., and K. A. Forney. 2005. Abundance and distribution of California sea lions (*Zalophus californianus*) in central and northern California during 1998 and summer 1999. Fishery Bulletin 103(2): 331–343.

Lowry, M. S., R. Condit, B. Hatfield, S. H. Allen, R. Berger, P. A. Morris, B. J. Le Boeuf, and J. Reiter. 2014. Abundance, distribution, and population growth of the northern elephant seal (*Mirounga angustirostris*) in the United States from 1991 to 2010. Aquatic Mammals 40(1): 20–31.

Lowry, M. S., S. E. Nehasil, and E. M. Jaime. 2017a. Distribution of California Sea Lions, Northern Elephant Seals, Pacific Harbor Seals, and Steller Sea Lions at the Channel Islands During July 2011–2015 (National Oceanic and Atmospheric Administration Technical Memorandum NMFS-SWFSC-578). Springfield, VA: Southwest Fisheries Science Center.

Lowry, M.S., S.R. Melin, & J.L. Laake. 2017b. Breeding Season Distribution and Population Growth of California Sea Lions, *Zalophus californianus*, in the United States During 1964-2014. NOAA-TM-NMFS-SWFSC-574. April 2017.

ManTech SRS Technologies, Inc. 2014. Marine Mammal Surveys 2013 Annual Report, Vandenberg Air Force Base, California. Prepared for 30th Space Wing Installation Management Flight, Environmental Conservation, Vandenberg Air Force Base.

ManTech SRS Technologies, Inc. 2015. Marine Mammal Surveys 2014 Annual Report, Vandenberg Air Force Base, California. Prepared for 30th Space Wing Installation Management Flight, Environmental Conservation, Vandenberg Air Force Base.

Maravilla-Chavez, M.O., and M.S. Lowry. 1999. Incipient breeding colony of Guadalupe fur seals at Isla Benito del Este, Baja California, Mexico. Marine Mammal Science 15(1): 239–241.

Marine Mammal Consulting Group and Science Applications International Corporation (MMCG and SAIC). 2012. Technical report: population trends and current population status of harbor seals at Vandenberg Air Force Base, California. 1993-2012. September 2012

Masaki, Y. 1976. Biological studies on the North Pacific sei whale. Bulletin of the Far Seas Fisheries Research Laboratory 14: 1–104.

Mate, B. 2013. Offshore Gray Whale Satellite Tagging in the Pacific Northwest. Silverdale, WA: Naval Facilities Engineering Command Northwest.

Mate, B. R., A. Bradford, H. A. Tsidulko, V. Vertankin, and V. Ilyashenko. 2013. Late feeding season movements of a western North Pacific gray whale off Sakhalin Island, Russia and subsequent migration into the eastern North Pacific (Paper SC/63/BRG23). Washington, DC: International Whaling Commission.

Mate, B. R., and J. Urban-Ramirez. 2003. A note on the route and speed of a gray whale on its northern migration from Mexico to central California, tracked by satellite-monitored radio tag. Journal of Cetacean Research and Management 5(2): 155–157.

Mate, B. R., D. M. Palacios, C. S. Baker, B. A. Lagerquist, L. M. Irvine, T. Follett, D. Steel, C. Hayslip, and M. H. Winsor. 2016. Baleen (Blue and Fin) Whale Tagging in Southern California in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas. Final Report. Pearl Harbor, HI: Naval Facilities Engineering Command, Pacific.

Mate, B. R., D. M. Palacios, C. S. Baker, B. A. Lagerquist, L. M. Irvine, T. Follett, D. Steel, C. E. Hayslip, and M. H. Winsor. 2018. Humpback Whale Tagging in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas in the Pacific Ocean: Final Report for Feeding Areas off the US West Coast in Summer-Fall 2017, Including Historical Data from Previous Tagging Efforts. San Diego, CA: Naval Facilities Engineering Command Southwest.

Mate, B. R., D. M. Palacios, C. S. Baker, B. A. Lagerquist, L. M. Irvine, T. Follett, D. Steel, C. E. Hayslip, and M. H. Winsor. 2019. Humpback Whale Tagging in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas in the Pacific Ocean. Final Report. Corvallis, OR: Oregon State University.

Mate, B. R., D. M. Palacios, C. S. Baker, B. A. Lagerquist, L. M. Irvine, T. Follett, D. Steel, C. Hayslip, and M. H. Winsor. 2017. Baleen Whale Tagging in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas Covering the Years 2014, 2015, and 2016. Final Report. Pearl Harbor, HI: Naval Facilities Engineering Command, Pacific.

Mate, B. R., D. M. Palacios, L. M. Irvine, B. A. Lagerquist, T. Follett, M. H. Winsor, and C. Hayslip. 2015b. Baleen (Blue & Fin) Whale Tagging in Southern California in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas (SOCAL, NWTRC, GOA); Final Report. Pearl Harbor, HI: U.S. Pacific Fleet.

Mate, B. R., V. Y. Ilyashenko, A. L. Bradford, V. V. Vertyankin, H. A. Tsidulko, V. V. Rozhnov, and L. M. Irvine. 2015a. Critically endangered western gray whales migrate to the eastern North Pacific. Biology Letters 11(4): 1–4.

McHuron, E. A., S. H. Peterson, L. A. Hückstädt, S. R. Melin, J. D. Harris, and D. P. Costa. 2017. The energetic consequences of behavioral variation in a marine carnivore. Ecology and Evolution 8(8): 4340–4351.

McWhinnie, L. H., P. D. O'Hara, C. Hilliard, N. Le Baron, L. Smallshaw, R. Pelot, and R. Canessa. 2021. Assessing vessel traffic in the Salish Sea using satellite AIS: An important contribution for planning, management and conservation in southern resident killer whale critical habitat. Ocean & Coastal Management 200.

Melin, S. R., and R. L. DeLonH. 1999. Observations of a Guadalupe fur seal (*Arctocephalus townsendi*) female and pup at San Miguel Island, California. Marine Mammal Science 15(3): 885–887.

Melin, S. R., and R. L. DeLonH. 2000. At-sea distribution and diving behavior of California sea lion females from San Miguel Island, California (Proceedings of the Fifth California Islands Symposium). Santa Barbara, CA: U.S. Department of the Interior, Minerals Management Service.

Melin, S. R., A.J. Orr, J.D. Harris, J.L. Laake, & R.L. Delong. 2010. Unprecedented Mortality of California Sea Lion Pups. CalCOFI Rep, Vol. 51, 182-194.

Melin, S. R., R. R. Ream, and T. K. Zeppelin. 2006. Report of the Alaska Region and Alaska Fisheries Science Center Northern Fur Seal Tagging and Census Workshop: 6–9 September 2005. Seattle, WA: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center.

Melin, S. R., R. L. DeLong, and D. B. Siniff. 2008. The effects of El Niño on the foraging behavior of lactating California sea lions (*Zalophus californianus californianus*) during the nonbreeding season. Canadian Journal of Zoology 86(3): 192–206.

Melin, S.R., J.T. Sterling, R.R. Ream, R.H. Towell, T. Zeppelin, A.J. Orr, B. Dickerson, N. Pelland, and C.E. Kuhn. 2012. A Tale of Two Stocks: Studies of Northern Fur Seals Breeding at the Northern and Southern Extent of the Range. (0008-4301; 1480-3283). Seattle, WA: Alaska Fisheries Science Center.

Merkens, K., A. Simonis, and E. Oleson. 2019. Geographic and temporal patterns in the acoustic detection of sperm whales Physeter macrocephalus in the central and western North Pacific Ocean. Endangered Species Research 39: 115–133.

Mesnick, S. L., B. L. Taylor, F. I. Archer, K. K. Martien, S. E. Trevino, B. L. Hancock-Hanser, S. C. M. Medina, V. L. Pease, K. M. Robertson, J. M. Straley, R. W. Baird, J. Calambokidis, H. S. Schorr, P. Wade, V. Burkanov, C. R. Lunsford, L. Rendell, and P. A. Morin. 2011. Sperm whale population structure in the eastern and central North Pacific inferred by the use of single-nucleotide polymorphisms, microsatellites and mitochondrial DNA. Molecular Ecology Resources 11 (Supplement 1): 278–298.

Mizroch, S. A., D. W. Rice, D. Zwiefelhofer, J. M. Waite, and W. L. Perryman. 2009. Distribution and movements of fin whales in the North Pacific Ocean. Mammal Review 39(3): 193–227.

Moore, J., and J. Barlow. 2017. Population Abundance and Trend Estimates for Beaked Whales and Sperm Whales in the California Current from Ship-Based Visual Line-Transect Survey Data, 1991–2014

(National Oceanic and Atmospheric Administration Technical Memorandum NMFS-SWFSC-585). La Jolla, CA: Southwest Fisheries Science Center.

Moore, J. E., and J. Barlow. 2011. Bayesian state-space model of fin whale abundance trends from a 1991–2008 time series of line-transect surveys in the California Current. Journal of Applied Ecology 48(5): 1195–1205.

Moore, J. E., and J. P. Barlow. 2014. Improved abundance and trend estimates for sperm whales in the eastern North Pacific from Bayesian hierarchical modelinH. Endangered Species Research 25(2): 141–150.

Moore, J. E., and D. W. Weller. 2013. Probability of taking a western North Pacific gray whale during the proposed Makah hunt (NOAA Technical Memorandum NMFS-SWFSC-506). La Jolla, CA: Southwest Fisheries Science Center.

Moore, J. E., and D. W. Weller. 2018. Updated Estimates of the Probability of Striking a Western North Pacific Gray Whale during the Proposed Makah Hunt (Technical Memorandum NOAA-TM-NMFS-SWFSC-605). Silver Spring, MD: National Oceanic and Atmospheric Administration.

Moyle, P. B. 2002. Inland Fishes of California. Los Angeles, CA: University of California Press.

Muto, M. M., V. T. Helker, B. J. Delean, R. P. Angliss, P. L. Boveng, J. M. Breiwick, B. M. Brost, M. F. Cameron, P. J. Clapham, S. P. Dahle, M. E. Dahlheim, B. S. Fadely, M. C. Ferguson, L. W. Fritz, R. C. Hobbs, Y. V. Ivashchenko, A. S. Kennedy, J. M. London, S. A. Mizroch, R. R. Ream, E. L. Richmond, K. E. W. Shelden, K. L. Sweeney, R. H. Towell, P. R. Wade, J. M. Waite, and A. N. Zerbini. 2020. Alaska Marine Mammal Stock Assessments, 2019 (NOAA Technical Memorandum NMFS-AFSC-404). Juneau, AK: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Alaska Fisheries Science Center.

Myers, A. E., and H. C. Hays. 2006. Do leatherback turtles, Dermochelys coriacea, forage during the breeding season? A combination of data-logging devices provide new insights. Marine Ecology Progress Series 322: 259–267.

National Marine Fisheries Service. 1997. Endangered and Threatened Species: Listing of Several Evolutionary Significant Units (ESUs) of West Coast Steelhead. Washington, DC: U.S. Government Publishing Office. Retrieved from https://www.gpo.gov/fdsys/granule/FR-1997-08-18/97-21661.

National Marine Fisheries Service. 2005. Green Sturgeon (*Acipenser medirostris*) Status Review Update. La Jolla, CA: National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.

National Marine Fisheries Service. 2008. Recovery Plan for the Steller Sea Lion. Silver Spring, MD: National Marine Fisheries Services, Office of Protected Resources.

National Marine Fisheries Service. 2016. Steller Sea Lion (*Eumetopias jubatus*). Accessed On: 10/13/2017, Retrieved from https://www.fisheries.noaa.gov/species/steller-sea-lion.

National Marine Fisheries Service. 2009. Sperm Whale (*Physeter macrocephalus*): 5-Year Review: Summary and Evaluation. Silver Spring, MD: National Marine Fisheries Service Office of Protected Resources.

National Marine Fisheries Service 2010a. Recovery plan for the fin whale (*Balaenoptera physalus*). National Marine Fisheries Service, Silver Spring, MD. 121 pp.

National Marine Fisheries Service 2010b. Recovery plan for the sperm whale (*Physeter macrocephalus*). National Marine Fisheries Service, Silver Spring, MD. 165 pp.

National Marine Fisheries Service. 2011. Final Recovery Plan for the Sei Whale (*Balaenoptera borealis*). Silver Spring, MD: National Marine Fisheries Service Office of Protected Resources.

National Marine Fisheries Service. 2012. Southern California Steelhead Recovery Plan. Long Beach, CA: National Marine Fisheries Service, Southwest Regional Office.

National Marine Fisheries Service. 2014. Deepwater Horizon Oil Spill 2010: Sea Turtles, Dolphins, and Whales. Accessed On, Retrieved from https://www.fisheries.noaa.gov/national/marine-life-distress/deepwater-horizon-oil-spill-2010-sea-turtles-dolphins-and-whales.

National Marine Fisheries Service. 2016a. 5-year Review: Summary and Evaluation of Southern California Coast Steelhead Distinct Population Segment. Long Beach, CA: National Oceanic and Atmospheric Administration, National Marine Fisheries Service, West Coast Region, California Coastal Office.

National Marine Fisheries Service. 2016b. Species in the Spotlight: Pacific Leatherback 5-Year Action Plan. Silver Spring, MD: National Marine Fisheries Service.

National Marine Fisheries Service. 2016c. Endangered and Threatened Species; Identification of 14 Distinct Population Segments of the Humpback Whale (*Megaptera novaeangliae*) and Revision of Species-Wide ListinH. Federal Register 81(174): 62260–62320.

National Marine Fisheries Service. 2019. 2015–2019 Guadalupe Fur Seal Unusual Mortality Event in California. Accessed On, Retrieved from www.fisheries.noaa.gov/national/marine-life-distress/2015-2018-guadalupe-fur-seal-unusual-mortality-event-california

National Marine Fisheries Service. 2019a. Life History Information for Pacific Salmonids. Seattle, WA: National Marine Fisheries Service, Office of Science and Technology.

National Marine Fisheries Service. 2019b. Draft Biological Report for the Proposed Designation of Critical Habitat for the Central America, Mexico, and Western North Pacific Distinct Population Segments of Humpback Whales (Megaptera novaeangliae). Silver Spring, MD: National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

National Marine Fisheries Service 2020. Recovery Plan for the Blue Whale (*Balaenoptera musculus*) - First Revision. National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD. 188 pp.

National Marine Fisheries Service. 2021. Nearby Vessels Interrupt Feeding of Southern Resident Killer Whales, Especially Females. Retrieved January 14, 2021, from https://www.fisheries.noaa.gov/feature-story/nearby-vessels-interrupt-feeding-southern-resident-killer-whales-especially-females?utm_medium=email&utm_source=govdelivery.

National Marine Fisheries Service, and U.S. Fish and Wildlife Service. 1998a. Recovery Plan for U.S. Pacific Populations of the Green Turtle (*Chelonia mydas*). Silver Spring, MD: National Marine Fisheries Service.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 1998b. Recovery Plan for U.S. Pacific Populations of the Olive Ridley Turtle (*Lepidochelys olivacea*). (pp. 52). Silver Spring, MD: National Marine Fisheries Service.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 2007a. Green Sea Turtle (*Chelonia mydas*) 5-year Review: Summary and Evaluation. (pp. 102). Silver Spring, MD: National Marine Fisheries Service.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 2007b. Olive Ridley Sea Turtle (*Lepidochelys olivacea*) 5-year Review: Summary and Evaluation. (pp. 64). Silver Spring, MD: National Marine Fisheries Service.

National Marine Fisheries Service, and U.S. Fish and Wildlife Service. 2013a. Hawksbill sea turtle (*Eretmochelys imbricata*) 5-year review: summary and evaluation. Jacksonville, FL: Jacksonville Ecological Services Field Station.

National Marine Fisheries Service, and U.S. Fish and Wildlife Service. 2013b. Leatherback Turtle (*Dermochelys coriacea*) 5-Year Review: Summary and Evaluation. Silver Spring, MD: National Marine Fisheries Service Office of Protected Resources and U.S. Fish and Wildlife Service Southeast Region.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 2014. Olive Ridley Sea Turtle (*Lepidochelys olivacea*) 5-Year Review : Summary and Evaluation. Jacksonville, FL: Jacksonville Ecological Services Field Station.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 2020. Endangered Species Act status review of the leatherback turtle (*Dermochelys coriacea*). Report to the National Marine Fisheries Service Office of Protected Resources and U.S. Fish and Wildlife Service.

National Oceanic and Atmospheric Administration. 2016. Oceanic Whitetip Shark (*Carcharhinus longimanus*). Retrieved from http://www.fisheries.noaa.gov/pr/species/fish/oceanicwhitetipshark.html.

National Oceanic and Atmospheric Administration. 2018. 2015–2018 Guadalupe Fur Seal Unusual Mortality Event in California. Accessed On, Retrieved from https://www.fisheries.noaa.gov/national/marine-life-distress/2015-2018-guadalupe-fur-seal-unusual-mortality-event-california.

Nehlsen, W., J. E. Williamsm, and J. A. Lichatowich. 1991. Pacific salmon at the crossroads: Stocks at risk from California, Oregon, Idaho, and Washington. Fisheries 16(2): 4–21.

Norris, T. 2017a. [Personal communication via email between Tenaya Norris (The Marine Mammal Center) and Conrad Erkelens (Mantech International Corporation) on Guadalupe fur seal abundance and distribution].

Norris, T. 2017b. [Updated abundance estimate for Guadalupe fur seals. Personal communication on August 18, 2017, between Tenaya Norris (The Marine Mammal Center) and Michael Zickel (Mantech International) via email].

Norris, T. 2019. Guadalupe Fur Seal Population Census and Tagging in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas in the Pacific Ocean. Sausalito, CA: The Marine Mammal Center.

Norris, T., H. DeRango, R. DiGiovanni, and C. Field. 2015. Distribution of and threats to Guadalupe fur seals off the California coast. San Francisco, CA: Society of Marine Mammalogy.

Norris, T.A., and F.R. Elorriaga-Verplancken. 2020. Guadalupe Fur Seal Population Census and Tagging in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas in the Pacific Ocean. Sausalito, CA: The Marine Mammal Center

Oregon State University. 2017. Southern and Central California 2016 Whale Approach Summary from Bruce Mate regarding body condition of blue and fin whales off Southern and Central California. Corvallis, OR: Oregon State University.

Orr, A. J., S. D. Newsome, J. L. Laake, H. R. VanBlaricom, and R. L. DeLonH. 2012. Ontogenetic dietary information of the California sea lion (*Zalophus californianus*) assessed using stable isotope analysis. Marine Mammal Science 28(4): 714–732.

Ortega-Ortiz, C. D., M. H. Vargas-Bravo, A. Olivos-Ortiz, M. H. V. Zapata, and F. R. Elorriaga-Verpancken. 2019. Short Note: Guadalupe fur seal encounters in the Mexican Central Pacific during 2010–2015: Dispersion related to the species recovery? Aquatic Mammals 45(2): 246–254.

Palacios, D. M., H. Bailey, E. A. Becker, S. J. Bograd, M. L. DeAngelis, K. A. Forney, E. L. Hazen, L. M. Irvine, and B. R. Mate. 2019. Ecological correlates of blue whale movement behavior and its predictability in the California Current Ecosystem during the summer-fall feeding season. Movement Ecology 7(1).

Panigada, S., M. Zanardelli, M. Mackenzie, C. Donovan, F. Melin, and P. S. Hammond. 2008. Modelling habitat preferences for fin whales and striped dolphins in the Pelagos Sanctuary (Western Mediterranean Sea) with physiographic and remote sensing variables. Remote Sensing of Environment 112(8): 3400–3412.

Payne, J., D. L. Erickson, M. Donnellan, and S. T. Lindley. 2015. Project to Assess Potential Impacts of the Reedsport Ocean Power Technologies Wave Energy Generation Facility on Migration and Habitat use of Green Sturgeon (*Acipenser medirostris*). Portland, OR: Oregon Wave Energy Trust.

Perrin, W. F., B. Würsig, and J. H. M. Thewissen. 2009. *Encyclopedia of Marine Mammals* (2nd ed.). Cambridge, MA: Academic Press.

Peterson, W. T., R. Emmett, R. Goericke, E. Venrick, A. Mantyla, S. J. Bograd, F. B. Schwing, R. Hewitt, N. Lo, W. Watson, J. Barlow, M. Lowry, S. Talston, K. A. Forney, B. E. Lavaniegos, W. J. Sydeman, D. Hyrenbach, R. W. Bradley, P. Warzybok, F. Chavez, K. Hunter, S. Benson, M. Weise, and J. Harvey. 2006. The State of the California Current, 2005–2006: Warm in the North, Cool in the South. In S. M. Shoffler (Ed.), California Cooperative Oceanic Fisheries Investigations (Vol. 47, pp. 30–74). La Jolla, CA: California Department of Fish and Game, University of California, Scripps Institute of Oceanography, and the National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Pierce, H. J., M. B. Santos, C. Smeenk, A. Saveliev, and A. F. Zuur. 2007. Historical trends in the incidence of strandings of sperm whales (*Physeter macrocephalus*) on North Sea coasts: An association with positive temperature anomalies. Fisheries Research 87(2–3): 219–228.

Pitcher, K. W., P. F. Olesiuk, R. F. Brown, M. S. Lowry, S. J. Jeffries, J. L. Sease, W. L. Perryman, C. E. Stinchcomb, and L. F. Lowry. 2007. Abundance and distribution of the eastern North Pacific Steller sea lion (*Eumetopias jubatus*) population. Fisheries Bulletin 107: 102–115.

Polovina, J. J., D. R. Kobayashi, D. M. Parker, M. P. Seki, and H. H. Balazs. 2000. Turtles on the edge: Movement of loggerhead turtles (*Caretta caretta*) along oceanic fronts, spanning longline fishing grounds in the central North Pacific, 1997–1998. Fisheries Oceanography 9(1): 71–82.

Quinn, T. P. and K. W. Myers. 2005. Anadromy and the marine migrations of Pacific salmon and trout: Rounsefell revisited. Reviews in Fish Biology and Fisheries 14: 421–442.

Ream, R.R., J.T. Sterling, and T.R. Loughlin. 2005. Oceanographic features related to northern fur seal migratory movements. Deep-Sea Research II 52: 823–843.

Reavis, B. 1991. International Symposium on Steelhead Trout Management. Portland, OR: Pacific States Marine Fisheries Commission Association of Northwest Steelheaders.

Redfern, J. V., E. A. Becker, and T. J. Moore. 2020. Effects of Variability in Ship Traffic and Whale Distributions on the Risk of Ships Striking Whales. Frontiers in Marine Science 6: 14.

Redfern, J. V., M. F. McKenna, T. J. Moore, J. Calambokidis, M. L. Deangelis, E. A. Becker, J. Barlow, K. A. Forney, P. C. Fiedler, and S. J. Chivers. 2013. Assessing the risk of ships striking large whales in marine spatial planning. Conservation Biology 27(2): 292–302.

Redfern, J. V., T. J. Moore, E. A. Becker, J. Calambokidis, S. P. Hastings, L. M. Irvine, B. R. Mate, D. M. Palacios, and L. Hawkes. 2019. Evaluating stakeholder-derived strategies to reduce the risk of ships striking whales. Diversity and Distributions 00: 1–11.

Reeves, R. R., T. D. Smith, R. L. Webb, J. Robbins, and P. J. Clapham. 2002. Humpback and fin whaling in the Gulf of Maine from 1800 to 1918. Marine Fisheries Review 64(1): 1–12.

Rice, A. C., S. Baumann-Pickering, A. Sirovic, J. A. Hildebrand, M. Rafter, B. J. Thayre, J. S. Trickey, and S. M. Wiggins. 2018. Passive Acoustic Monitoring for Marine Mammals in the SOCAL Range Complex April 2016–June 2017. La Jolla, CA: Marine Physical Laboratory, Scripps Institution of Oceanography.

Rice, D. W. 1989. Sperm whale Physeter macrocephalus Linnaeus, 1758. In S. H. Ridgway & R. Harrison (Eds.), Handbook of Marine Mammals (Vol. 4, pp. 177–234). San Diego, CA: Academic Press.

Rice, D. W., and A. A. Wolman. 1971. The Life History and Ecology of the Gray Whale (Vol. 3). Lawrence, KS: The American Society of Mammalogists.

Riedman, M. L., and J. A. Estes. 1990. The Sea Otter (*Enhydra lutris*): Behavior, Ecology, and Natural History. Washington, DC: U.S. Department of the Interior, Fish and Wildlife Service.

Robinson, P. W., D. P. Costa, D. E. Crocker, J. P. Gallo-Reynoso, C. D. Champagne, M. A. Fowler, C. Goetsch, K. T. Goetz, J. L. Hassrick, L. A. Huckstadt, C. E. Kuhn, J. L. Maresh, S. M. Maxwell, B. I. McDonald, S. H. Peterson, S. E. Simmons, N. M. Teutschel, S. Villegas-Amtmann, and K. Yoda. 2012. Foraging behavior and success of a mesopelagic predator in the northeast Pacific Ocean: Insights from a data-rich species, the northern elephant seal. PLoS ONE 7(5): e36728.

Rockwood, R. C., J. Calambokidis, and J. Jahncke. 2017. High mortality of blue, humpback and fin whales from modeling of vessel collisions on the U.S. West Coast suggests population impacts and insufficient protection. PLoS ONE 12(8): e0183052.

Rockwood, R. C., M. L. Elliott, B. Saenz, N. Nur, and J. Jahncke. 2020. Modeling predator and prey hotspots: Management implications of baleen whale co-occurrence with krill in Central California. PLoS ONE 15(7).

Ryan, J. P., D. E. Cline, J. E. Joseph, T. Margolina, J. A. Santora, R. M. Kudela, F. P. Chavez, J. T. Pennington, C. Wahl, R. Michisaki, K. Benoit-Bird, K. A. Forney, A. K. Stimpert, A. DeVogelaere, N. Black, and M. Fischer. 2019. Humpback whale song occurrence reflects ecosystem variability in feeding and migratory habitat of the northeast Pacific. PLoS ONE 14(9): e0222456.

Santora, J. A., C. S. Reiss, V. J. Loeb, and R. R. Veit. 2010. Spatial association between hotspots of baleen whales and demographic patterns of Antarctic krill Euphausia superba suggests size-dependent predation. Marine Ecology Progress Series 405: 255–269.

Santora, J. A., E. L. Hazen, I. D. Schroeder, S. J. Bograd, K. M. Sakuma, and J. C. Field. 2017b. Impacts of ocean climate variability on biodiversity of pelagic forage species in an upwelling ecosystem. Marine Ecology Progress Series 580: 205–220.

Santora, J. A., J. H. Dorman, and W. J. Sydeman. 2017a. Modeling spatiotemporal dynamics of krill aggregations: Size, intensity, persistence, and coherence with seabirds. Ecography 40(11): 1300–1314.

Santora, J. A., N. J. Mantua, I. D. Schroeder, J. C. Field, E. L. Hazen, S. J. Bograd, W. J. Sydeman, B. K. Wells, J. Calambokidis, L. Saez, D. Lawson, and K. A. Forney. 2020. Habitat compression and ecosystem shifts as potential links between marine heatwave and record whale entanglements. Nature Communications 11(1): 536.

Santora, J. A., W. J. Sydeman, I. D. Schroeder, B. K. Wells, and J. C. Field. 2011. Mesoscale structure and oceanographic determinants of krill hotspots in the California Current: Implication for trophic transfer and conservation. Progress in Oceanography 91: 397–409.

Sarti-Martinez, L., S. A. Eckert, N. Garcia T., and A. R. Barragan. 1996. Decline of the world's largest nesting assemblage of leatherback turtles. Marine Turtle Newsletter 74: 2–5.

Satterthwaite, W. H., J. Ciancio, E. D. Crandall, M. L. Palmer-Zwahlen, A. M. Grover, M. R. O'Farrell, E. C. Anderson, M. S. Mohr, and C. Garza. 2015. Stock composition and ocean spatial distribution inference from California recreational Chinook salmon fisheries using genetic stock identification. Fisheries Research 170: 166-178.

Scales, K. L., H. S. Schorr, E. L. Hazen, S. J. Bograd, P. I. Miller, R. D. Andrews, A. N. Zerbini, and E. A. Falcone. 2017. Should I stay or should I go? Modelling year-round habitat suitability and drivers of residency for fin whales in the California Current. Biodiversity Research 23(10): 1204–1215.

Schorr, H. S., E. A. Falcone, B. K. Rone, and E. L. Keene. 2019. Distribution and demographic of Cuvier's beaked whales and fin whales in the Southern California Bight. Seabeck, WA: Marine Ecology and Telemetry Research.

Shapovalov, L., and A. C. Taft. 1954. The Life Histories of the Steelhead Rainbow Trout (Salmo gairdneri gairdneri) and Silver Salmon (Oncorhynchus kisutch) With Special Reference to Waddell Creek, California, and Recommendations Regarding Their Management. San Diego, CA: University of California San Diego.

Shane, M. A. 2001. Records of Mexican Barracuda, *Sphyraena ensis*, and Scalloped Hammerhead, *Sphyrna lewini*, from Southern California Associated with Elevated Water Temperatures. Southern California Academy of Sciences Bulletin, 7.

Sharma, R. 2009. Survival, Maturation, Ocean Distribution and Recruitment of Pacific Northwest Chinook Salmon (*Oncorhynchus tshawytscha*) in Relation to Environmental Factors, and Implications for Management. (Unpublished doctoral dissertation). University of Washington, Seattle, WA.

Širović, A., A. Rice, E. Chou, J. A. Hildebrand, S. M. Wiggins, and M. A. Roch. 2015. Seven years of blue and fin whale call abundance in the Southern California Bight. Endangered Species Research 28: 61–76.

Širović, A., E. M. Oleson, J. Buccowich, A. Rice, and A. R. Bayless. 2017. Fin whale song variability in southern California and the Gulf of California. Scientific Reports 7(1): 10126.

Širović, A., J. A. Hildebrand, S. M. Wiggins, M. A. McDonald, S. E. Moore, and D. Thiele. 2004. Seasonality of blue and fin whale calls and the influence of sea ice in the Western Antarctic Peninsula. Deep Sea Research II 51(17–19): 2327–2344.

Smultea, M.A. 1994. Segregation by humpback whale (Megaptera novaeangliae) cows with a calf in coastal habitat near the island of Hawaii. Canadian Journal of Zoology 72: 805–811.

Smultea, M.A. 2014. Changes in Relative Occurrence of Cetaceans in the Southern California Bight: A Comparison of Recent Aerial Survey Results with Historical Data Sources. Aquatic Mammals 40(1): 32–43.

Smultea, M. A., T. A. Jefferson, and A. M. Zoidis. 2010. Rare sightings of a Bryde's whale (Balaenoptera edeni) and Sei whales (*B. borealis*) (Cetacea: Balaenopteridae) northeast of Oahu, Hawaii. Pacific Science 64(3): 449–457.

Spotila, J. R. 2004. Sea Turtles: A Complete Guide to Their Biology, Behavior, and Conservation. Baltimore, MD: John Hopkins University Press.

Stafford, K. M., D. R. Bohnenstiehl, M. Tolstoy, E. Chapp, D. K. Mellinger, and S. E. Moore. 2004. Antarctic-type blue whale calls recorded at low latitudes in the Indian and eastern Pacific Oceans. Deep Sea Research Part I: Oceanographic Research Papers 51(10): 1337–1346.

Stafford, K. M., S. L. Nieukirk, and C. H. Fox. 2001. Geographic and seasonal variation of blue whale calls in the North Pacific. Journal of Cetacean Research Management 3(1): 65–76.

Sterling, J. T., and R. R. Ream. 2004. At-sea behavior of juvenile male northern fur seals (*Callorhinus ursinus*). Canadian Journal of Zoology 82(10): 1621–1637.

Sterling, J. T., A. M. Springer, S. J. Iverson, S. P. Johnson, N. A. Pelland, D. S. Johnson, M. A. Lea, and N. A. Bond. 2014. The sun, moon, wind, and biological imperative-shaping contrasting wintertime migration and foraging strategies of adult male and female northern fur seals (*Callorhinus ursinus*). PLoS ONE 9(4): e93068.

Stewart, B. 1981. The Guadalupe fur seal (*Arctocephalus townsendi*) on San Nicolas Island, California. Bulletin of the Southern California Academy of Sciences 80(3): 134–136.

Stewart, B. S., and P. K. Yochem. (n.d.). Community Ecology of California Channel Islands Pinnipeds. San Diego, CA: Hubbs-Sea World Research Institute.

Stewart, B. S., and P. K. Yochem. 1984. Seasonal Abundance of Pinnipeds at San Nicolas Island, California, 1980-1982. Southern California Academy of Sciences Bulletin 83(3): 121-132.

Stewart, B. S., P. K. Yochem, R. L. DeLong, and H. A. Antonelis. 1993. Trends in abundance and status of pinnipeds on the southern California Channel Islands. In F. H. Hochberg (Ed.), Third California Islands Symposium: Recent Advances in Research on the California Islands (pp. 501–516). Santa Barbara, CA: Santa Barbara Museum of Natural History.

Stinson, M.L. 1984. Biology of Sea Turtles in San Diego Bay, California, and in the Northeastern Pacific Ocean. San Diego State University, San Diego, CA.

Straley, J. M., J. R. Moran, K. M. Boswell, J. J. Vollenweider, R. A. Heintz, T. J. Quinn II, B. H. Witteveen, and S. D. Rice. 2017. Seasonal presence and potential influence of humpback whales on wintering Pacific herring populations in the Gulf of Alaska. Deep Sea Research Part II.

Sumich, J. L., and I. T. Show. 2011. Offshore migratory corridors and aerial photogrammetric body length comparisons of southbound gray whales, *Eschrichtius robustus*, in the Southern California Bight, 1988–1990. Marine Fisheries Review 73(1): 28–34.

Szabo, A. 2015. Immature euphausiids do not appear to be prey for humpback whales (Megaptera novaeangliae) during spring and summer in Southeast Alaska. Marine Mammal Science 31(2): 677–687.

Teel, D. J., B. J. Burke, D. R. Kuligowski, C. A. Morgan, and D. M. Van Doornik. 2015. Genetic Identification of Chinook Salmon: Stock-Specific Distributions of Juveniles along the Washington and Oregon Coasts. Marine and Coastal Fisheries 7(1): 274-300.

Thomas, K., J. Harvey, T. Goldstein, J. Barakos, and F. Gulland. 2010. Movement, dive behavior, and survival of California sea lions (*Zalophus californianus*) posttreatment for domoic acid toxidosis. Marine Mammal Science 26(1): 36–52.USFWS. 2003. Final Revised Recovery Plan for the Southern Sea Otter (*Enhydra lutris nereis*). Portland OR: U.S. Fish and Wildlife Service.

Urban-Ramirez, J., L. Rojas-Bracho, H. Perez-Cortes, A. Gomez-Gallardo, S. L. Swartz, S. Ludwig, and R. L. Brownell, Jr. 2003. A review of gray whales (*Eschrichtius robustus*) on their wintering grounds in Mexican waters. Journal of Cetacean Research and Management 5(3): 281–295.

Urrutia, Y. S., and H. H. Dziendzielewski. 2012. Diagnóstico de la vulnerabilidad de las cuatro especies de pinnípedos (lobo marino, lobo fino, foca de Puerto y elefante marino) en México, frente al cambio climático global. Ensenada, Mexico: Fonsec Semarnat-Conacyt.

U.S. Bureau of Reclamation. 2013. 2010 Annual Monitoring Report and Trend Analysis for the Biological Opinion for the Operation and Maintenance of the Cachuma Project on the Santa Ynez River in Santa Barbara County, California. Long Beach, CA: Report prepared for the National Marine Fisheries Service.

U.S. Fish and Wildlife Service. 2003. Final Revised Recovery Plan for the Southern Sea Otter (Enhydra lutris nereis). Portland, Oregon.

U.S. Fish and Wildlife Service. 2015. Southern Sea Otter (*Enhydra lutris nereis*) 5-Year Review: Summary and Evaluation. Portlan OR: U.S. Fish and Wildlife Service.

U.S. Geological Survey Western Ecological Resource Center. 2017. Annual California Sea Otter Census: 2017 Census Summary Shapefile. Retrieved from https://www.sciencebase.gov/catalog/item/5601b6dae4b03bc34f5445ec.

U.S. Geological Survey Western Ecological Resource Center. 2018. Annual California Sea Otter Census: 2018 Census Summary Shapefile. Retrieved from https://www.sciencebase.gov/catalog/item/5601b6dae4b03bc34f5445ec.

U.S. Geological Survey Western Ecological Resource Center. 2019. Annual California Sea Otter Census: 2019 Census Summary Shapefile. Retrieved from https://www.sciencebase.gov/catalog/item/5601b6dae4b03bc34f5445ec.

U.S. Geological Survey Western Ecological Resource Center. 2020. Annual California Sea Otter Census: 2019 Census Summary Shapefile. Retrieved 16 October 2020, from https://www.sciencebase.gov/catalog/item/5601b6dae4b03bc34f5445ec.

Valdivia, A., S. Wolf, and K. SucklinH. 2019. Marine mammals and sea turtles listed under the U.S. Endangered Species Act are recoverinH. PLoS ONE 14(1): e0210164.

Vandenberg Space Force Base. 2021. Annual Report. Letters of Authorization: Taking marine mammals incidental to space vehicle and missile launches and aircraft test flight and helicopter operations at Vandenberg Air Force Base, California. 1 January to 31 December 2020. Vandenberg Space Force Base, CA: U.S. Department of the Air Force.

Ward-Paige, C. A., D. M. Keith, B. Worm, & H. K. Lotze. (2012). Recovery potential and conservation options for elasmobranchs. Journal of Fish Biology 80(5): 1844–1869.

Weller, D. W., and R. L. Brownell, Jr. 2012. A re-evaluation of gray whale records in the western North Pacific (SC/64/BRG10). La Jolla, CA: Southwest Fisheries Science Center.

Weller, D. W., S. Bettridge, R. L. Brownell, J. L. Laake, M. J. Moore, P. E. Rosel, B. L. Taylor, and P. R. Wade. (2013). Report of the National Marine Fisheries Service Gray Whale Stock Identification Workshop (NOAA Technical Memorandum NMFS-SWFSC-507). La Jolla, CA: Southwest Fisheries Science Center.

Whitehead, H. 2003. Sperm Whales Social Evolution in the Ocean. Chicago, IL: University of Chicago Press.

Whitehead, H., A. Coakes, N. Jaquet, and S. Lusseau. 2008. Movements of sperm whales in the tropical Pacific. Marine Ecology Progress Series 361: 291–300.

Whitehead, H., and L. Weilgart. 2000. The sperm whale; Social females and roving males. In J. Mann, R. C. Connor, P. L. Tyack, & H. Whitehead (Eds.), Cetacean Societies; Field Studies of Dolphins and Whales (pp. 154–172). Chicago, IL: University of Chicago Press.

Windell, S., P. L. Brandes, J. L. Conrad, J. W. Ferguson, P. A. L. Goertler, B. N. Harvey, J. Heublein, J. A. Israel, D. W. Kratville, J. E. Kirsch, R. W. Perry, J. Pisciotto, W. R. Poytress, K. Reece, B. H. Swart, and R. C. Johnson. 2017. Scientific framework for assessing factors influencing endangered Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*) across the life cycle. National Marine Fisheries Service.

Weller, D. W., A. M. Burdin, B. Würsig, B. L. Taylor, and R. L. Brownell, Jr. (2002). The western gray whale: A review of past exploitation, current status and potential threats. Journal of Cetacean Research and Management 4(1): 7–12.

Weller, D. W., A. Klimek, A. L. Bradford, J. Calambokidis, A. R. Lang, B. Gisborne, A. M. Burdin, W. Szaniszlo, J. Urbán, A. Gomez-Gallardo Unzueta, S. Swartz, and R. L. Brownell. 2012. Movements of gray whales between the western and eastern North Pacific. Endangered Species Research 18(3): 193–199.

Wiles, H. J. 2015. Periodic Status Review for the Steller Sea Lion. Olympia, WA: Washington Department of Fish and Wildlife.

Williams, T. H., S. T. Lindley, B. C. Spence, and D. A. Boughton. 2011. Status Review Update for Pacific Salmon and Steelhead Listed under the Endangered Species Act: Southwest. Santa Cruz, CA: National Marine Fisheries Service, Southwest Fisheries Science Center.

Witteveen, B. H., A. D. Robertis, L. Guo, and K. M. Wynne. 2014. Using dive behavior and active acoustics to assess prey use and partitioning by fin and humpback whales near Kodiak Island, Alaska. Marine Mammal Science.

Witteveen, B. H., and K. M. Wynne. 2017. Site fidelity and movement of humpback whales (Megaptera novaeangliae) in the western Gulf of Alaska as revealed by photo-identification. The Canadian Journal of Zoology 95: 169–175.

Young, C. N., J. Carlson, C. Hutt, D. Kobayashi, C. T. McCandless, & J. Wraith. 2016. Status review report: oceanic whitetip shark (*Carcharhinius longimanus*) (Final Report to the National Marine Fisheries Service, Office of Protected Resources).

Zaba, K. D., D. L. Rudnick, B. D. Cornuelle, H. Gopalakrishnan, and M. R. Mazloff. 2018. Annual and interannual variability in the California current system: Comparison of an ocean state estimate with a network of underwater gliders. Journal of Physical Oceanography 48: 2965–2988.

Zavala-Gonzalez, A., and E. Mellink. 2000. Historical exploitation of the California sea lion, Zalophus californianus, in Mexico. Marine Fisheries Review 62(1): 35–40.

Zeppelin, T., N. Pelland, J. Sterling, B. Brost, S. Melin, D. Johnson, M. A. Lea, and R. Ream. 2019. Migratory strategies of juvenile northern fur seals (*Callorhinus ursinus*): Bridging the gap between pups and adults. Scientific Reports 9.

Appendix H
Airspace

H.1 Introduction

Airspace management considers how airspace is designated, used, and administered to best accommodate the individual and common needs of military, commercial, and general aviation. The FAA considers multiple and sometimes competing demands for airspace in relation to airport operations, federal airways, jet routes, military flight training activities, commercial space operations, and other special needs to determine how the National Airspace System (NAS) can be best structured to address all user requirements.

The FAA designs and manages the NAS based on the Code of Federal Regulations (CFR) (14 CFR Part 71). The FAA has designated four types of airspace above the United States: controlled airspace, Special Use Airspace (SUA), other airspace, and uncontrolled airspace.

- **Controlled airspace** is a generic term that covers the different classifications of airspace and defined dimensions within which air traffic control service is provided in accordance with the airspace classification. Controlled airspace consists of five classes: A, B, C, D, and E (Figure H-1).

- **Class A** airspace is generally the airspace from 18,000 feet mean sea level (MSL) up to and including flight level 600, including the airspace overlying the waters within 12 nautical miles of the coast of the 48 contiguous states and Alaska. Unless otherwise authorized, all operation in Class A airspace is conducted under instrument flight rules (IFR).

- **Class B** airspace is generally airspace from the surface to 10,000 feet MSL surrounding the nation's busiest airports in terms of airport operations or passenger enplanements.

- **Class C** airspace is generally airspace from the surface to 4,000 feet above the airport elevation (charted in MSL) surrounding those airports that have an operational control tower, are serviced by a radar approach control, and have a certain number of IFR operations or passenger enplanements.

- **Class D** airspace is generally airspace from the surface to 2,500 feet above the airport elevation (charted in MSL) surrounding those airports that have an operational control tower.

- **Class E** airspace is the controlled airspace not classified as Class A, B, C, or D airspace. A large amount of the airspace over the United States is designated as Class E airspace.

- **SUA** is the designation for airspace in which certain activities must be confined, or where limitations may be imposed on aircraft operations that are not part of those activities. The FAA has designated SUA areas that are listed in FAA Order 7400.10C and 7400.2N. SUA usually consists of prohibited areas, restricted areas, warning areas, military operation areas, alert areas, and controlled firing areas. Most SUA areas have specific hours of operations, and users must remain clear of or obtain permission from the using agency or the controlling agency before flight through the defined areas.

- **Other airspace area** is a general term referring to the majority of the remaining airspace. Examples include local airport advisory areas, military training routes, temporary flight restriction (TFR) areas, parachute jump aircraft operations areas, published visual flight rules routes, terminal radar service areas, and national security areas.

- **Uncontrolled airspace or Class G airspace** is the portion of the airspace that has not been designated as Class A, B, C, D, or E. Class G airspace extends from the surface to the base of the overlying Class E airspace.

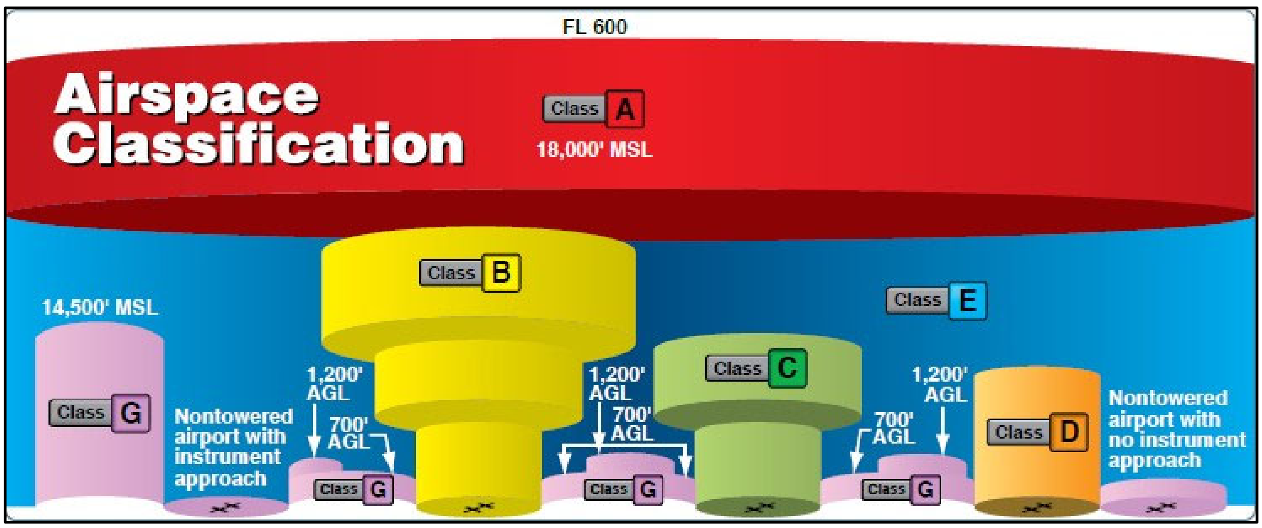

Figure H-1. Airspace Profile

H.2 Study Area

The airspace study area includes the airspace above Vandenberg Space Force Base (VSFB), the airspace surrounding the launch trajectory, and the airspace associated with any hazard areas that must be protected to ensure public safety. All launch trajectories would be over the Pacific Ocean. The study area's airspace is controlled primarily by the Los Angeles Air Route Traffic Control Center (ARTCC), and for northern trajectories, both Los Angeles and Oakland Centers.

Additionally, for missions involving reentry of the launch vehicle's second stage, the study area includes a downrange airspace hazard area (e.g., south Pacific Ocean or Indian Ocean). These airspaces could be controlled by the FAA, such as Los Angeles ARTCC, or another air navigation service provider.

H.3. Existing Conditions

The study area consists of airspace made up of SUA (Warning Areas and Restricted Areas) as well as an Altitude Reservation (ALTRV) area (Figure H-2). The SLD 30 is the using agency for the Warning Areas and Restricted Areas when these areas are activated by a Notice to Air Missions (NOTAM). The Los Angeles ARTCC controls the airspace around the Warning Areas, Restricted Areas, and the ALTRV. An ARTCC does not allow any air traffic they are controlling to enter these areas when active. The study area contains published aviation routes (Figures H-3 and H-4). The specific routes that would be impacted are identified prior to each launch and vary by mission.

Range Special Use Airspace and Published Aviation Routes

Table H-1: Restricted Areas, Warning Areas, and Altitude Reservation Area (Reference Figure H-2)

Designation	Altitude	Active Time
R-2517	Unlimited	Continuous
R-2534A	500 feet above the surface to unlimited	Intermittent by NOTAM at least 4 hours in advance
R-2534B	500 feet above the surface to unlimited	Intermittent by NOTAM at least 4 hours in advance
R-2535A	Surface to 100,000 feet MSL	0600-2200 local time Monday-Friday; other times by NOTAM at least 24 hours in advance
R-2535B	Surface to 100,000 feet MSL	0600-2200 local time Monday-Friday; other times by NOTAM at least 24 hours in advance
W-537	Surface to unlimited	Intermittent by NOTAM
W-289N	Surface to FL240	Intermittent by NOTAM
W-289	Surface to unlimited	Intermittent by NOTAM
W-412	Surface to 3,000 feet MSL	Intermittent by NOTAM
W-532	Surface to unlimited	Intermittent by NOTAM
ALTRAV (Southern Trajectory)	Surface to unlimited	Intermittent by NOTAM

Note: FL = Flight level; MSL = Mean Sea Level; NOTAM = Notice to Air Missions

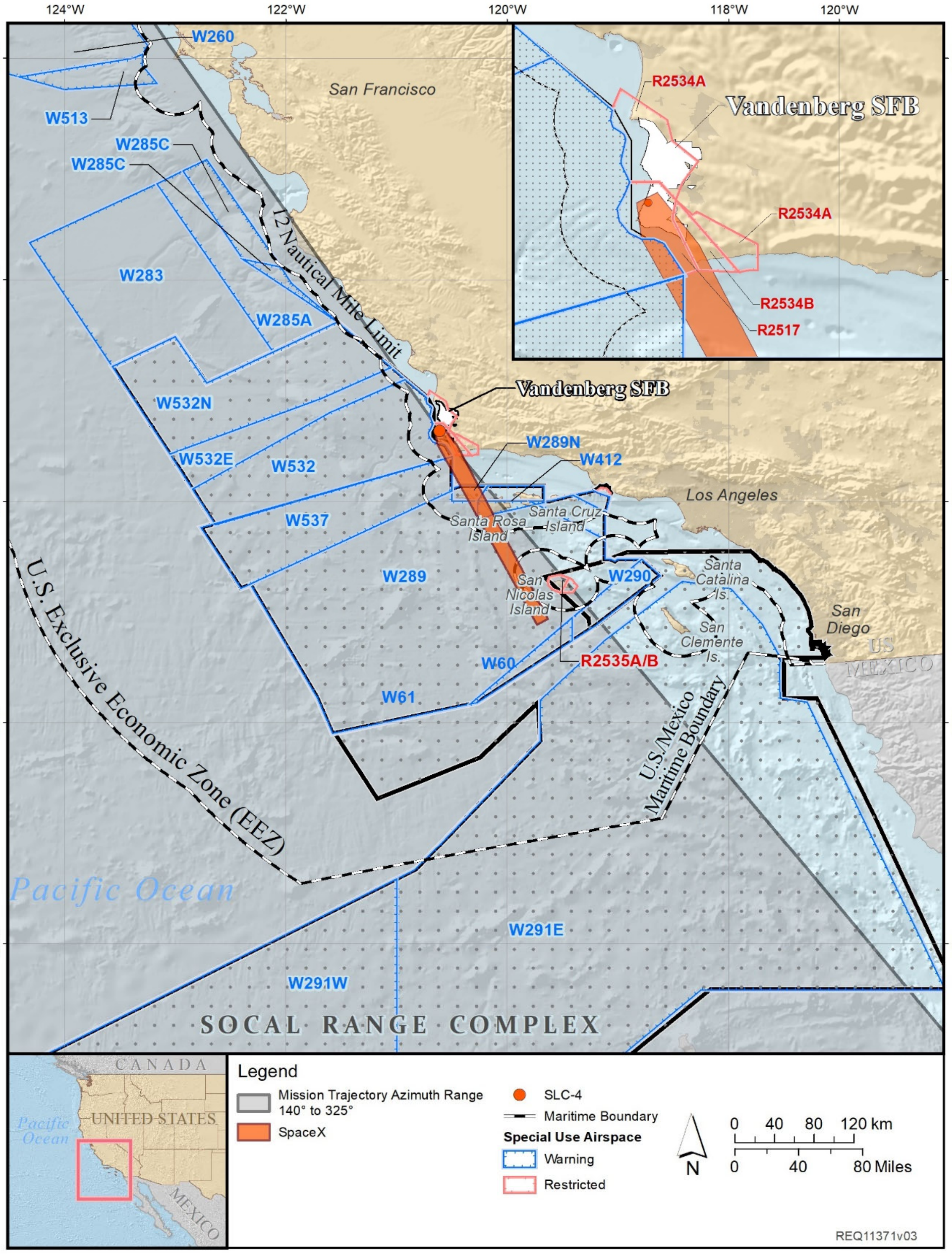

Figure H-2 Restricted Areas, Warning Areas, and Altitude Reservation Area

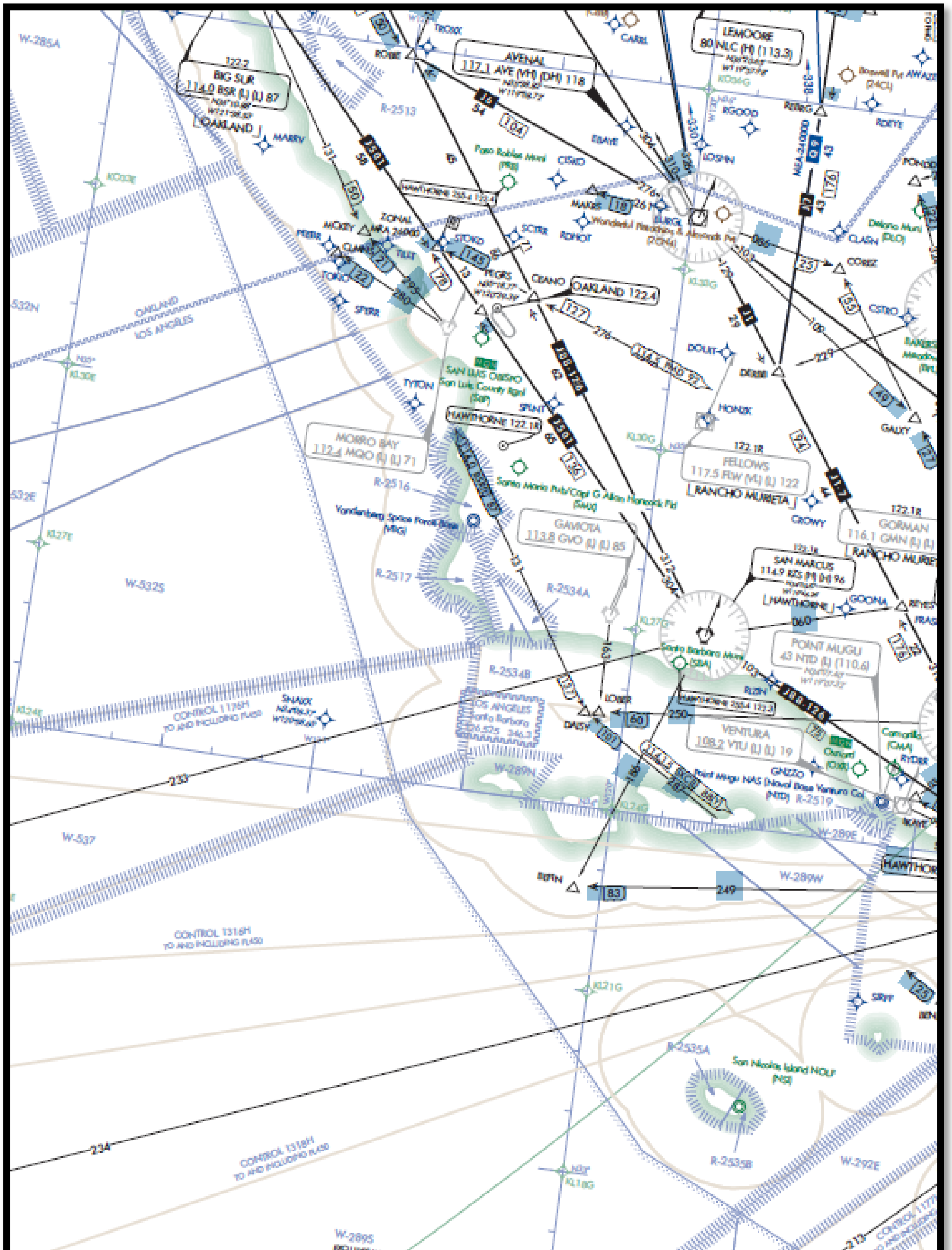

Figure H-3 Published Aviation Routes (Enroute High Altitude, Panel H-4)

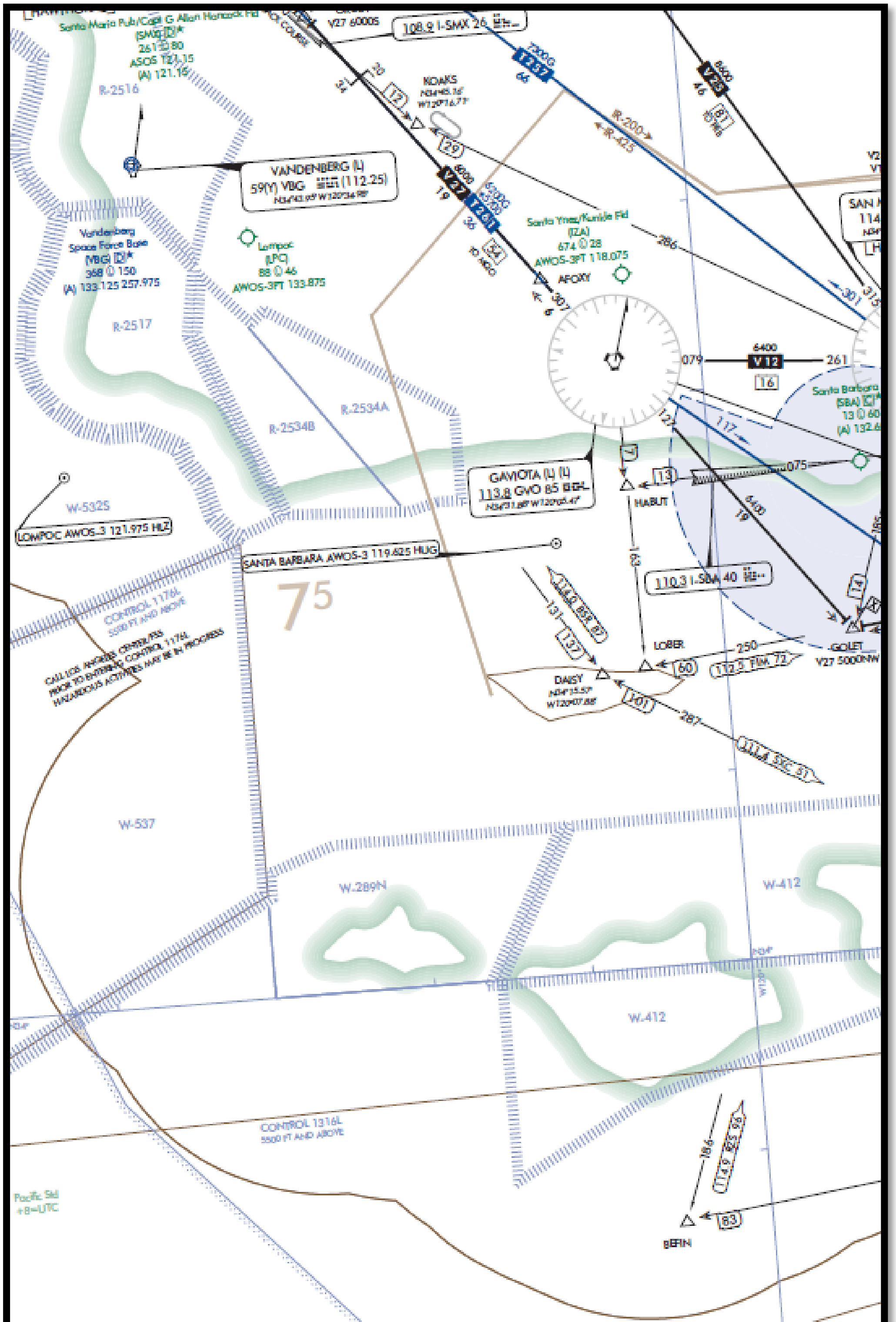

Figure H-4 Published Aviation Routes (Enroute Low Altitude, Panel L-4)

Oakland Air Route Traffic Control Center (ZOA), Los Angeles Air Route Traffic Control Center (ZLA), Santa Barbara Terminal Radar Approach Control Facility (SBA), Air Traffic Control System Command Center (ATCSCC), 30th Space Wing (30 SW)

LETTER OF AGREEMENT

EFFECTIVE: 07 APR 2020

SUBJECT: Vandenberg Space Vehicle Launch/Reentry Communications and Coordination

1. PURPOSE: This agreement establishes communication, coordination between the Federal Aviation Administration (FAA), and the 30th Space Wing (30 SW) for launch and/or reentry operations in to or through the national airspace system in accordance with 14 CFR Part 400-1199, AFI 13-201, and FAA JO 7610.4. Procedures defined in this Letter of Agreement (LOA) are part of and supplemental to all Air Force Safety requirements and agreements and are not intended to circumvent the terms or conditions of a space operator license.

2. CANCELLATION: The agreement between Western Space and Missile Center and FAA Oakland Air Route Traffic Control Center, subject "Interagency Coordination for Western Space and Missile Center Operations", is cancelled with the implementation of this agreement.

3. DISTRIBUTION: This agreement is distributed to the signatories, FAA office of Commercial Space and the Western Service Area.

4. RESPONSIBILITIES:

a. All signatories must ensure personnel operating within the scope of this agreement are knowledgeable of, understand, and comply with the provisions of this agreement.

b. 30 SW will notify ATCSCC, ZLA and ZOA of mission status at 3 hours and at 60 minutes prior to launch/deorbit burn. SBA must be notified according to this timeline when operational.

c. 30 SW will notify ATCSCC, ZLA ZOA and SBA, of any freezes or changes to launch times, or deorbit burn prior to T -30 minutes.

d. All signatories and the contracting space operator will communicate on the mission hotline, hosted by ATCSCC, no less than Target Launch Time T-30 minutes or Deorbit Burn -30 minutes. The hotline will remain active at least until the vehicle has entered earth orbit, returned to earth, completed the mission, or the mission is cancelled. The 30 SW will notify the participants to the hotline of any changes to hotline start times.

e. Deviations from responsibilities or procedures, established in this agreement must be effected only after prior coordination is accomplished, and responsibilities are clearly defined in each case.

Oakland Air Route Traffic Control Center (ZOA), Los Angeles Air Route Traffic Control Center (ZLA), Santa Barbara Terminal Radar Approach Control Facility (SBA), Air Traffic Control System Command Center (ATCSCC), 30th Space Wing (30 SW)

5. PROCEDURES:

a. 30th Space Wing must:

(1) Email the Altitude Reservation (ALTRV) request (per FAA Directives) to Central Altitude Reservation Function (CARF), no less than 12 days prior to a scheduled space operation (with cc. addresses, ZOA, ZLA, Fleet Area Control and Surveillance Facility (FACSFAC), ATCSCC Space Operations, Pacific Military Altitude Reservation Function (PACMARF), and others as appropriate.

(a) Include an operation name/number.

(b) Scheduled Primary and Backup dates/times of commencement and completion in Coordinated Universal Time (UTC).

(c) The altitudes requested.

(d) When aircraft hazard areas are contained in more than one area, the areas will be identified by name(s)/number(s)/letters.

(e) Request non-published airspace described by at least four fixes based on latitude and longitude (Degrees, Minutes).

(f) When the hazard areas fall in several Flight Information Regions (FIR), the portion CARF is responsible for will be indicated in a separate paragraph. In the event the hazard area falls within a FIR (ex. Auckland) which has an LOA with CARF, they will be included as an addressee in the message, and an additional paragraph indicating EUCARFs portion of the hazard area will be included in the message.

(2) Provide ZOA, ZLA, SBA and ATCSCC Space Ops a copy of the "Launch Airspace Safety Sheet" & "FOUO -11 Safety Sheet", at least 12 days prior to the planned launch.

(3) 30 minutes prior to launch (L-30)/or deorbit burn start (DB-30), participate on the ATC real-time hotline. Be prepared to communicate the following information:

(a) Launch status, delays or other information affecting the launch/reentry/fly-back time.

(b) Countdown status, delays or other information affecting the liftoff/deorbit burn ignition time.

(c) Verbal confirmation of critical mission events, including "Lift off" declaration.

(d) Vehicle health until the vehicle has entered earth orbit, returned to earth, touched down or otherwise completed the mission.

(4) For any unplanned events, particularly those which could produce debris, immediately advise via mission hotline which areas are affected, which are not, provide last known position and vector (if available), and provide the airspace opening times of the hazard areas if they differ from times included in the Launch Airspace Safety Sheet.

(5) Notify CARF of mission completion, cancellation, and/or the time per the Hazard Safety Sheet when the ALTRV(s) and/or Backup ALTRV(s) are no longer necessary. When CARF is closed, notify the ATCSCC National Operations Manager (NOM) 540-359-3100. Verbal notification on the hotline is preferred; however, verbal notification must be followed in writing, to include all identified areas of the ALTRV.

b. ZOA and ZLA must:

(1) Collaborate and formulate the airspace management plan and intended Notice to Airmen (NOTAMs) with ATCSCC Space Ops in advance of the space operation in accordance with JO 7400.2.

(2) Notify local facilities and other appropriate affected agencies of the proposed space operation and the pre-planned airspace mitigation strategies as required.

(3) Issue and distribute required local NOTAMs, as appropriate or required.

NOTE – *Local NOTAMs may be issued based on CARF ALTRV approval request and may need to be modified based on revisions from CARF.*

(4) Cancel local NOTAMs when the mission is complete, cancelled, or the airspace is no longer required.

c. ATCSCC must:

(1) Share appropriate mission data including the operational impact analysis and collaborate with ATC facilities to develop the airspace management plan.

(2) Publish requested traffic management initiatives, not issued by NOTAMs, via Command Center Advisories, when necessary.

(3) Activate and host the mission hotline, no less than 30 minutes prior to the scheduled target launch time or reentry deorbit burn.

NOTE *- Activation of the hotline could occur more than 30 minutes prior to mission, if so requested by 30SW/or Space Operator designee. Supporting air traffic facilities will not be required to be on the call until 30 minutes prior to launch time or deorbit burn.*

(4) Coordinate any additional safety or hazard mitigations relevant to the launch or reentry vehicle as needed.

Oakland Air Route Traffic Control Center (ZOA), Los Angeles Air Route Traffic Control Center (ZLA), Santa Barbara Terminal Radar Approach Control Facility (SBA), Air Traffic Control System Command Center (ATCSCC), 30th Space Wing (30 SW)

d. CARF must:

(1) Upon receipt of an ALTRV, coordinate the request in accordance with current FAA Orders.

(2) Coordinate ALTRVs with foreign countries in which CARF has written agreements, for missions which depart from the U.S.

(3) Approve ALTRVs at all altitudes for the space operation. Airspace requests that lie wholly within activated SUA will not be included in the ALTRV approval.

(4) Issue the approved ALTRV to 30SW, and applicable air traffic facilities, no less than three business days prior the proposed operation.

(5) Process updates and changes per FAA Orders.

(6) Issue CARF NOTAMs for the approved ALTRV airspace.

(7) Cancel ALTRV NOTAMS upon notification from the Project Officer, Range Scheduling Representative, or designee.

6. ATTACHMENT: Contact Information

JEFF B HUBERT
Digitally signed by JEFF B HUBERT
Date: 2020.02.13 14:21:41 -08'00'

Jeff B. Hubert
Air Traffic Manager
Oakland ARTCC

LISA MARIE JONES
Digitally signed by LISA MARIE JONES
Date: 2020.02.18 17:04:02 -08'00'

Lisa Jones
Air Traffic Manager
Los Angeles ARTCC

Oakland Air Route Traffic Control Center (ZOA), Los Angeles Air Route Traffic Control Center (ZLA), Santa Barbara Terminal Radar Approach Control Facility (SBA), Air Traffic Control System Command Center (ATCSCC), 30th Space Wing (30 SW)

CARRIE L DRAPER Digitally signed by CARRIE L DRAPER Date: 2020.02.19 10:01:37 -08'00'

Carrie Draper
Air Traffic Manager
Santa Barbara ATC/TRACON

JENNIFER A ROSS Digitally signed by JENNIFER A ROSS Date: 2020.03.03 08:59:06 -05'00'

Jennifer Ross
Acting Air Traffic Manager
Air Traffic Control System Command Center

MASTALIR.ANTHONY.J.1101714930 Digitally signed by MASTALIR.ANTHONY.J.1101714930 Date: 2020.04.07 14:10:45 -07'00'

Anthony J. Mastalir
Col., USAF
Commander, 30 SW

MARK G KUCK Digitally signed by MARK G KUCK Date: 2020.02.19 10:29:43 -08'00'

Mark Kuck
FAA Air Traffic Representative
Western Service Center

Oakland Air Route Traffic Control Center (ZOA), Los Angeles Air Route Traffic Control Center (ZLA), Santa Barbara Terminal Radar Approach Control Facility (SBA), Air Traffic Control System Command Center (ATCSCC), 30th Space Wing (30 SW)

Attachment

Contact Information

Name/Office/Function	Email	Phone
Oakland Center Operations Manager Oakland Center MOS	 9-AWP-ZOA-MOS@faa.gov	 510 745-3331 510 745-3334
Los Angeles Center MOS Los Angeles Center Traffic Management Los Angeles Center Operations Manager	9-AWP-ZLA-MOS@faa.gov 9-AWP-ZLA-TMU@faa.gov	661-265-8249 661-575-2066 661 265-8205
Santa Barbara TRACON (SBA) SBA Airspace Spec.	AJT-SBA-ATM@faa.gov AJT-SBA-OS@faa.gov	805 681-0166 Recorded Line 805 681-0116 805 681-0534 ask for Airspace
30 Space Wing/2ROPS Airspace/Offshore Mgmt 30 SW Scheduling Office	 2ROPS.DON@us.af.mil 2ROPS.DOS@us.af.mil	 805-606-0002 805-606-8825
ATCSCC Space Operations Central Altitude Reservation Function (CARF) Challenger Space Operations Room Launch/Reentry Hotline National Operations Manager (NOM) (after hours, weekends and holidays)	 9-AWA-AJR-Space.Ops@faa.gov 7-AWA-CARF@faa.gov	 540-422-4212 540-422-4053 540-359-3200, 2456# 540-359-3100 540-422-4100

APPENDIX I
Housing Impact Study

DRAFT

Housing Impact Study

Vandenberg Space Force Base

FEBRUARY 2024

Prepared for:

SPACE EXPLORATION TECHNOLOGIES, INC.
PO Box 568
Lompoc, CA 93458

Prepared by:

DUDEK

605 Third Street
Encinitas, California 92024
Contact: Elizabeth Dickson

Table of Contents

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TABLE(S)

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Acronyms and Abbreviations

Acronym/Abbreviation	Definition
VSFB	Vandenberg Space Force Base
SBCAG	Santa Barbara County Association of Governments
RHNA	Regional Housing Needs Allocation
RGF	Regional Growth Forecast
UC Santa Barbara	University of California, Santa Barbara
SLC	Space Launch Complex
County	County of Santa Barbara (unincorporated county)

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1 Background

1.1 Site Description

The Vandenberg Space Force Base (VSFB) is a space launch base that launches spacecrafts, conducts missile testing, and supports launch activities for the United States Air Force, Department of Defense, National Aeronautics and Space Administration, as well as private contractors. It encompasses 99,604 acres and is located along the coastline in Santa Barbara County within the unincorporated County of Santa Barbara (County) near the Cities of Lompoc and Santa Maria.

1.2 Project Description

The proposed Project (Project) is to increase the annual Falcon launch cadence at VSFB through launches at Space Launch Complex (SLC)-4 and SLC-6 and the modification of SLC-6 for Falcon launch vehicles to support future commercial and U.S. government launch service needs. To support the Falcon 9 annual launch cadence increase at VSFB, it is anticipated that 400 new permanent staff roles will be added. This increase in staff would occur over time and would consist of local and non-local hires.

2 Housing Impact

To assess the housing impact of the 400 new staff roles at VSFB created by the Project, this section assesses the proposed job growth through the lens of the regional housing need and available capacity to accommodate needed housing.

2.1 Housing Needs

Every eight years, the State of California determines the anticipated number of housing units needed in each region across California. The methodology for determining the housing need considers factors such as the makeup and condition of the existing housing stock, existing and forecasted jobs, the projected population, and the availability of housing. Specifically, the State allocates the housing need by region and regional agencies work with jurisdictions to develop a methodology for divvying up the allocated housing need per jurisdiction.

As determined by the State, the Santa Barbara County Association of Governments (SBCAG), which is the Metropolitan Planning Organization responsible for regional planning activities for all incorporated and unincorporated areas in Santa Barbara County, has an anticipated housing need of 24,856 additional housing units to be built between 2023-2031. SBCAG's Regional Housing Needs Allocation (RHNA) Plan, establishes the methodology for allocating shares of the 24,856 needed housing units between each local government in the region[1].

SBCAG's RHNA Plan objectives for the housing need allocation include the following:

1. Increase supply and mix of housing types, tenure, and affordability.

[1] Santa Barbara County Association of Governments. "Regional Housing Needs Allocation Plan 6th Cycle 2023-2031". July 15, 2021.

2. Promote infill development and socioeconomic equity.
3. Promote improved relationship between jobs and housing.
4. Seek to balance income strata across the region.
5. Affirmatively further fair housing.

As stated in SBCAG's RHNA Plan, the first step of SBCAG's methodology factors existing and forecasted jobs to address the jobs and housing imbalance. The housing need methodology for each jurisdiction directly corresponds with existing and projected jobs in the region for the 2023-2031 projection period.

SBCAG's RHNA Plan relies on SBCAG's Regional Growth Forecast (RGF), which serves as a tool for long range regional planning. Specifically, the RGF provides input for the State Department of Housing and Community Development RHNA for the Santa Barbara County region. The RFG captures existing and projected population, housing, and job growth for various industries in Santa Barbara County, its eight incorporated cities, and its major economic and demographic regions (i.e. Vandenberg SFB), through 2050. Because the RGF forms the basis of the RHNA, job growth for the 2023-2031 RHNA projection period in all job industries are reflected in the calculation of the RHNA.

Further, the RGF specifically projects anticipated employment at VSFB. In 2017, VSFB supplied an estimated amount of 6,250 jobs, accounting for about 3-percent of the region's total jobs.[2] The RGF projects a total of 850 new jobs to be added in VSFB between 2017 and 2030, increasing the total to 7,100 jobs by 2030. The increase of 850 new jobs at the VSFB falls within SBCAG's RHNA Plan projection period of 2023-2031. This job growth at VSFB is captured by the SBCAG RGF and has been used to help determine and allocate housing needs in the region through the methodology used in the RHNA Plan.[3]

2.2 Housing Capacity

SBCAG's RHNA Plan divides the region into two subareas, the South Coast Housing Market Area and the North County Housing Market Area. The North County Housing Market Area includes the cities of Buellton, Guadalupe, Lompoc, Santa Maria, and Solvang, as well as the unincorporated areas of Orcutt, Guadalupe, Cuyama Valley, Lompoc Valley, and Santa Ynez within the jurisdiction of the County. Given the proximity to the base, many off-base employees of VSFB are likely to reside in the North County Housing Market Area. SBCAG's RHNA Plan has allocated portions of the regional housing need to each local jurisdiction in the region, including those in the North County Housing Market Area. Each of these jurisdictions has identified capacity to accommodate its housing need, demonstrating that there are sufficient development opportunities to meet the housing need. The allocation of the RHNA and identified housing capacity for each jurisdiction in the North County Housing Market Area are provided below.

2.2.1 North County Housing Market Area Housing Capacity

In accordance with State law, local governments must demonstrate in their General Plan Housing Elements how they will accommodate their share of the regional housing need by identifying sites that are zoned for housing and can reasonably accommodate housing development. It should be noted that jurisdictions are only responsible for

[2] *Regional Growth Forecast 2050 Santa Barbara County.*
[3] Santa Barbara County Association of Governments. *RHNA Supplemental Report*. June 18, 2020. rhna_supplemental_report.pdf (sbcag.org)

creating opportunities for the private market to build units specified in their RHNA and are not responsible for the actual construction of such units.

The County's RHNA share is 5,664 total units for the 2023-2031 planning period.[4] The County has divided its housing need of 5,664 into two subregions, the South Coast subregion and the North County subregion. Nearly three-quarters of the housing need (4,142 units) have been allocated to the South Coast subregion of the County, while the rest (1,522) were allocated to the North County subregion. Factoring in all vacant sites, future ADU development, pending projects, County-owned sites, and potential site rezones, the County's Housing Element identifies capacity for 13,986 units, far exceeding the total housing need. Of the County's identified housing capacity, capacity for 4,991 units is identified in the North County subregion. VSFB is located in the County's North County subregion and likely employes more households in the North County subregion than the South Coast subregion.

The City of Lompoc is the closest city to VSFB, with many of its residents being employed by the base. The City of Lompoc's housing need for the 2023-2031 planning period is 2,248 units.[5] Their Housing Element identifies capacity through planned and approved projects, projected ADU development, and vacant and underutilized sites. Their total identified capacity is 2,407 units, an additional 7-percent beyond their housing need.

The City of Santa Maria is the most populous city in the North County Housing Market Area and has a housing need of 5,418 units for the 2023-2031 planning period. The City of Santa Maria's Housing Element identifies capacity to accommodate 5,819 new housing units, which is 401 units beyond their housing need.[6]

Other cities in the North County Housing Market Area, including Buellton, Guadalupe, and Solvang were allocated much fewer housing units due to their size. Buellton's capacity of 761 units, which includes both built and potential units, exceeds their housing need of 165 new housing units for the 2023-2031 period.[7] Solvang's housing need for the same period is 191 housing units and their Housing Element identifies capacity for 343 units, which is 128 units beyond their need.[8] The City of Guadalupe's Housing Element identified housing need is 431 new housing units for the same period, but the housing capacity is currently unknown as the City is in process of updating its housing element. If the City of Guadalupe is unable to identify adequate housing capacity, they are required by State law to rezone sites to ensure that adequate capacity will be made available to accommodate the entirety of the housing need.

As indicated in **Table 1: Housing Capacity in North County Housing Market Area,** all jurisdictions in the North County Housing Market Area with an approved housing element for the 2023-2031 planning period have identified adequate housing capacity that not only meets but and exceeds the identified housing need. The County's North County subregion and Buellton in particular have identified housing capacity that is more than triple and quadruple the respective housing needs. In general, the North County Housing Market Area has more than enough housing capacity to meet the housing need. Not only have these jurisdictions provided capacity that captures expected growth at VSFB, as identified by the SBCAG RHNA Plan, but the jurisdictions that house the largest numbers of those employed at VSFB have capacity well beyond the housing need.

[4] County of Santa Barbara. 2023-2031 Housing Element Update. December 2023. https://cosantabarbara.app.box.com/s/afflk9pjqz2wbgq6t70yfz7o73z6prz0
[5] City of Lompoc. *2023-2031 Housing Element Update.* November 21, 2023. 638372841321100000 (cityoflompoc.com)
[6] City of Santa Maria. *Sixth Cycle Housing Element Update 2023-2031.* December 5, 2023. 638379843679470000 (cityofsantamaria.org)
[7] City of Buellton. *2023-2031 Housing Element.* July 24, 2023. Buellton Housing Element - CLEAN - 7.24.23.pdf (cityofbuellton.com)
[8] City of Solvang. *Housing Element.* September 2023. plansolvang.com/images/docs/SovGPU_HEU_Full_RevHCD_2023 09 26 RL.pdf

Table 1: Housing Capacity in North County Housing Market Area

Jurisdiction[1]	Total RHNA	Total Identified Capacity	Surplus	% of RHNA Planned
County of Santa Barbara - North County Subregion	1,522	4,991	3,469	327.9%
Lompoc	2,248	2,407	159	107.1%
Santa Maria	5,418	5,819	401	107.4%
Buellton	165	761	596	461.2%
Solvang	191	343	152	179.6%
Total	**9,544**	**13,321**	**4,777**	**139.6%**

[1] The City of Guadalupe is not included in this table since it has not updated its housing element to reflect the 6th Cycle RHNA.

3 Conclusions

The SBCAG RHNA Plan identifies the 2023-2031 housing need for all of Santa Barbara County. The SBCAG RHNA Plan considers an anticipated growth at VSFB of 850 new jobs by 2030 in the determination of the housing need. Further, local jurisdictions surrounding the VSFB have identified adequate housing capacity to meet and far exceed the 2023-2031 housing need. The anticipated increase of 400 new permanent staff roles needed to support the Project will not have a housing impact beyond the Santa Barbara County existing and projected housing need, and further will not create a housing need beyond identified capacity.

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APPENDIX J
United States Space Force, Space Launch Delta 30 and United States Coast Guard Memorandum of Agreement

MEMORANDUM OF AGREEMENT

BETWEEN THE

U.S. SPACE FORCE, SPACE LAUNCH DELTA 30

AND

U.S. COAST GUARD DISTRICT ELEVEN

FOR

SPACE VEHICLE AND MISSILE LAUNCH SUPPORT

APPROVED FOR SPACE LAUNCH DELTA 30:

STEVENS.THOMAS.E.1230451784 Digitally signed by STEVENS.THOMAS.E.1230451784 Date: 2022.12.08 16:46:59 -08'00'

THOMAS E. STEVENS
NH-04, DAF, USSF
Executive Director, SLD 30

Date: 8 Dec 22

APPROVED FOR U.S. COAST GUARD DISTRICT ELEVEN:

Andrew Sugimoto

ANDREW M. SUGIMOTO
Rear Admiral, USCG
Commander, Eleventh CG District

Date: 19 Sept 2022

1. PURPOSE:

This Memorandum of Agreement (MOA) between the Space Launch Delta 30 (SLD 30) and the U.S. Coast Guard (USCG) District Eleven, contains the provisions, procedures for implementing USCG liaison, patrol, and maritime warning assistance in support of space vehicle and missile launches on the Western Launch and Test Range (WR). The USCG District Eleven support mission to aid in mitigating risk on the high seas for marine traffic within the SLD 30 identified launch hazard areas. USCG support also includes broadcast notice to mariners (BNM), local notice to mariners (LNM), and limited access areas (LAA) authority under Captain of the Port. This MOA does not alter the jurisdiction or responsibilities of any agency. The MOA is intended only to improve the internal management of existing responsibilities within each agency and enhance interagency coordination and communication. Neither this MOA, nor any actions to implement it, shall be construed to create any right or benefit, substantive or procedural, legally enforceable by any party or person. The Parties retain discretion to deviate from the provisions of the MOA after prior notification to the other Party.

2. AUTHORITY:

The USCG's authority to enter into this Agreement can be found in the following sources: 14 U.S.C. § 504(a), 14 CFR § 431.75, 14 CFR § 450.147, 14 CFR § 417.111 and USCG Commandant Instruction 5216.18.

3. PARTIES:

The SLD 30 is responsible for the safe conduct of launch and test operations from the WR. The Launch Risk Analysis Section within the SLD 30 Launch Safety Office (SLD 30/SEL) is responsible for determining the launch hazard areas for each launch from the WR. The 2nd Range Operations Squadron (2 ROPS) conducts air and sea surveillance of these launch hazard areas for each launch from the WR. The 2 ROPS Area Surveillance Officer (ASO) is responsible for the conduct of surveillance operations within the identified launch hazard area and for reporting the location of any seaborne vessels to the SLD 30/SEL Surveillance Control Officer (SCO) and Sea Surveillance Officer (SSO). The SCO and SSO are responsible for determining the launch risk to seaborne vessels and providing vessel redirect instructions, as required, to the ASO in order to minimize the hazards to the general public and remain within established risk criteria (individual and collective).

USCG District Eleven (D11) represents the U.S. Government on matters of maritime control. They are also the interface for all USCG/USCG Auxiliary launch support for safety and security operations within the USCG District Eleven area of responsibility.

4. POINTS OF CONTACT (POC):

a. The SLD 30 Points of Contact are the 2 ROPS/DON Flight Chief, 805-606-4761 or 805-606-0002, 1602 California Blvd STE 248, Vandenberg SFB, CA 93437 and SLD 30/SE 805-605-7168.

b. The USCG POC is the District Waterways Management Office (dpw), U.S. Coast Guard District Eleven, (510) 437-5984, Coast Guard Island, Bldg. 50-2, Alameda, CA 94501-5100.

5. RESPONSIBILITIES:

Space Launch Delta 30 agrees to the following:

a. Contingency Plans: SLD 30 will provide, or ensure commercial entities provide current copies of the following plans to the Coast Guard:

(1) Ship Hazard Areas as defined through RCC-321 section 3.4 to match 14 CFR 450.135 and 14 CFR 417.111(i) requirements:

(a) A Ship Hazard Area accounting for the impact area of l debris fragments in a catastrophic failure event;

(2) Mishap Investigation Plan as prepared IAW 14 CFR 450.173(d) and 14 CFR 417.111 (h) including the following provision:

(a) Immediate notification to the National Response Center (800) 424-8802 and Coast Guard Pacific Area / District Eleven Command Center (510) 437-3701 in the event of a launch site accident over or adjacent to navigable waters.

b. Response Plans: SLD 30 will provide, or ensure commercial entities provide current copies of the following plan to Coast Guard District Eleven, Sector LA/LB, and Sector San Diego:

(1) Response Plan as prepared IAW 14 CFR 450.173(c) and 14 CFR 417.111 (h) including the following provision:

(a) The plan should include procedures to ensure the consequences of a launch accident, launch incident, reentry accident, reentry incident, or other mishap occurring in the conduct of a reusable launch vehicle mission are contained and minimized so that it does not affect a navigable waterway. The plan should include response measures for impacts that cannot be avoided, including procedures to mitigate hazards to public health and safety, and the contamination of waterways.

c. Scheduling and Notification Activities:

(1) SLD 30 will provide D11 an annual launch schedule forecast for the fiscal year by 30 September each year.

(2) (L-30 days) SLD 30 will submit launch information to D11 to request a LNM article via D11-SMB-D11-LNM@uscg.mil with a goal of at least 30 days prior to scheduled launch. It is understood that with the emerging commercial launch industry, some launch programs may provide flight trajectory updates to accommodate late breaking launch

vehicle performance reviews requiring revisions to hazardous areas or provide launch trajectory data within 30 days because of a high frequency of launch.

SLD 30 shall provide all updates as received from launch developers due to modification or changes.

Launch information should include the following:

(a) Operation Number;
(b) Vehicle type and launch description;
(c) Primary and secondary launch date and time in local and GMT;
(d) Launch Hazard Areas, perimeter coordinates in degrees, minutes, and seconds to three decimal places, if applicable;
(e) Launch/Re-entry risk evaluation, type of debris, pollution risk, safety POC's;
(f) Perimeter coordinates shall be minimized to 4 coordinate positions per area box to limit maritime confusion and charting requirements.

(3) At L-20 days or as soon as SLD30 receives the launch inf ormation, BNM request is sent: D11SPACE@uscg.mil

(4) (L-72 hours) SLD 30 shall contact the following:

(a) D11 to confirm launch information for the LNM and Local Sector BNM, NAVTEX, and SMIB notifications are scheduled and distributed.

(b) National Geospatial-Intelligence Agency (NGA) to request Navigation Area XII warning notifications for launch activities occurring over water from 150 nautical miles offshore to deep-ocean. Launch information should be sent to navsafety@nga.mil and/or (571) 557-5455.

(c) Launch information shall be sent to D11SPACE@uscg.mil and RCCAlameda1@uscg.mil.

Coast Guard District Eleven agrees to the following:

a. Scheduling and Notification Activities:

(1) Review annual forecast of scheduled launches and provisions of this agreement each year;

(2) (L-90 days) Review scheduled launch operations, coordinate waterways risk, and make determination if LAA is recommended;

(3) (L-15 days) Publish launch information in the Local Notice to Mariners;

(4) (L-72 hours) Coordinate Local Broadcast Notice to Mariners (BNM) and NAVTEX prior to launch with respective operational USCG Sector;

(5) (L-day) Confirm local Safety Marine Information Broadcast (SMIB) via VHF-FM is scheduled to be distributed 3 hours before and during launch;

(6) Fulfill any other statutory responsibility pertaining to USCG jurisdiction and authorities;

(7) Coast Guard may communicate directly with the various providers launching out of Vandenberg in support of meeting its statutory obligations to the maritime community.

6. EFFECTIVE DATE AND TERMINATION:

This MOA becomes effective upon signature by an authorized agent from each organization. It may be terminated at any time by mutual agreement or by one party upon giving the other 180 days written notice.

7. MODIFICATIONS AND REVIEW:

This MOA may be modified by mutual agreement at any time. It will be reviewed triennially to determine whether it should be continued as is, modified, or terminated.

8. OTHER FEDERAL AGENCIES:

This MOA does not bind any federal agency, other than the Parties, nor waive required compliance with any law or regulation.

9. FINANCIAL DETAILS:

This MOA does not authorize the expenditure or reimbursement of any funds, nor does it obligate the partners to expend appropriations or enter into any contract or other obligation. All obligations of the partners under this MOA shall be subject to the availability of funds and resources for such purposes. No provision in this MOA will be interpreted to require obligation or payment of funds in violation of the Anti-Deficiency Act, Section 1341 of Title 31, United States Code.

10. OTHER PROVISIONS:

Nothing in this MOA is intended to conflict with current laws or regulations or the directives of the PARTIES. If a term of this MOA is inconsistent with such authority, then that term shall be invalid, but the remaining terms and conditions of this MOA shall remain in full force and effect.

Distribution:

SLD 30 SW/FM, JA, SE
SLD 30 MSG/CC (CES, CONS, FSS/MOF, SFS, Det 1)
SLD 30/CV (RANS, SCS, WS, 2 SLS)
HQ AFSPC(A4/A7 USSF SPOC SpOC/S3/6RA, AFSOC/A3OU, HAF/A3, AF/A3T /A3)
USCG District Eleven (DXO, DRMC, DRE, DL, DM, and DMF)
USCG Sector Los Angeles/Long Beach
USCG Sector San Diego

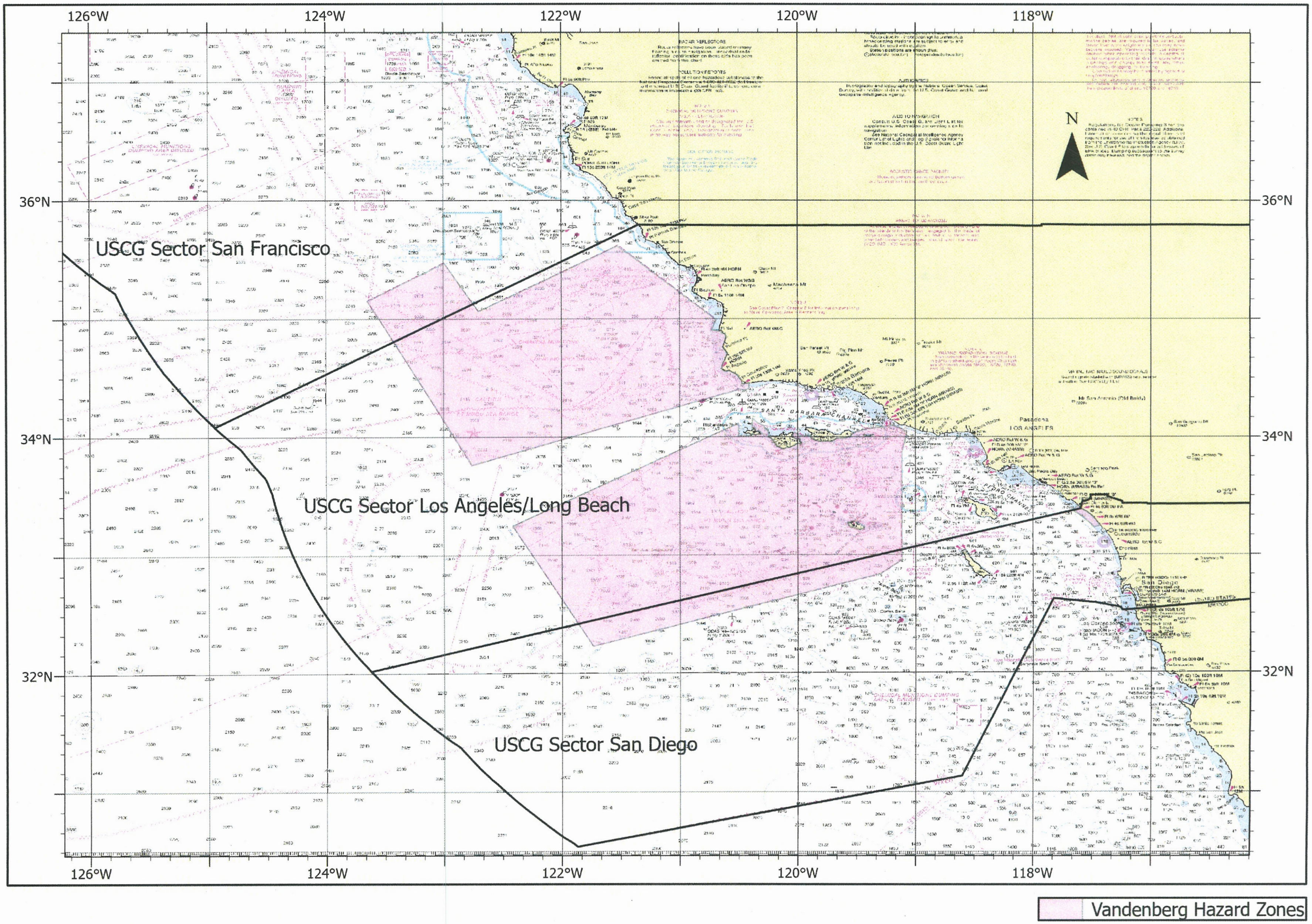
Appendix A – Specific Points of Contact

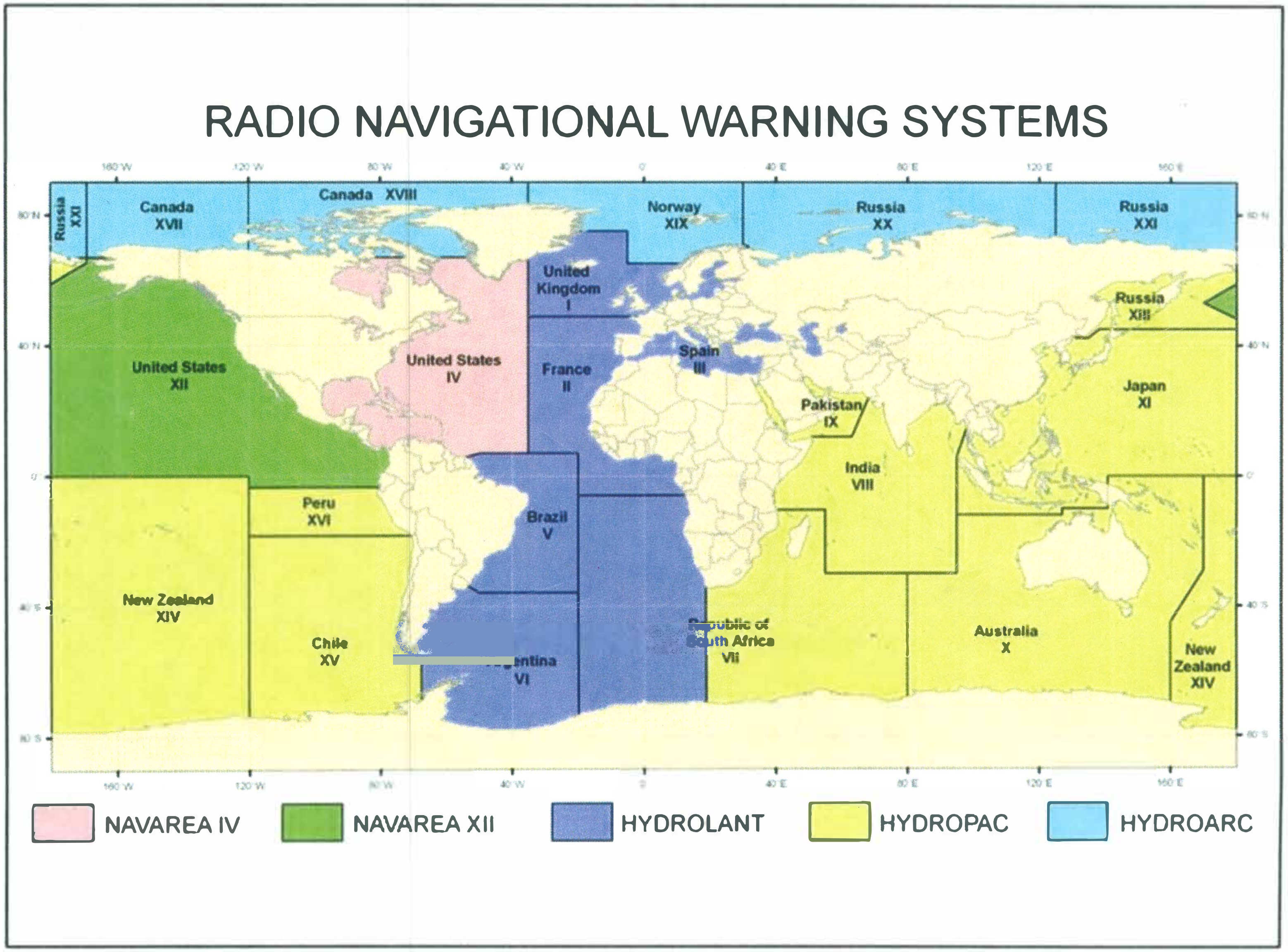
OFFICE	NUMBER	RESPONSIBILITY
Coast Guard District Eleven Waterways Management D11-DG-D11-Waterways@uscg.mil	510-437-2968	Chief, Waterways Management
Coast Guard District Eleven Marine Transportation System Officer D11-DG-D11-Waterways@uscg.mil	510-437-5984	Space Liaison Officer
Space Launch Delta 30 2ROPSDOSMailbox@us.af.mil	805-605-8011	Operations
Coast Guard District Eleven LNM Editor D11-SMB-D11-LNM@uscg.mil	510-437-2929	Publication of Local Notice to Mariners
Coast Guard Sector LA-LB Command Center D11-SMB-SECTORLALB-SCC@uscg.mil	310-521-3801	Emergency contact number for all Search and Rescue in COTP zone
Coast Guard Sector San Diego Command Center jhoc@uscg.mil	619-278-7033	Emergency contact number for all Search and Rescue in COTP zone
Coast Guard District Eleven Command Center RCCAlameda1@uscg.mil	510-437-3701	Emergency contact number for all Search and Rescue in D11

Appendix B – List of Acronyms

2ROPS 2nd Range Operations Squadron
ASO Area Surveillance Officer
BNM broadcast notice to mariners
CFR Code of Federal Regulations
COTP Captain of the Port
D11 Coast Guard District Eleven
DPW District Waterways Management Office
IAW In accordance with
LA/LB Los Angeles/Long Beach
LAA limited access areas
LNM local notice to mariners
MOA Memorandum of Agreement
NAVTEX Navigational Telex
POC Point of contact
SLD Space Launch Delta
SMIB Safety Marine Information Broadcast
SSO Sea Surveillance Officer
USCG United States Coast Guard
USSF Unites States Space Force
WR Western Launch and Test Range

Appendix C – Vandenberg Hazard Zones




RADIO NAVIGATIONAL WARNING SYSTEMS
Russia XXI
Canada XVII
Canada XVIII
Norway XIX
Russia XX
Russia XXI
United Kingdom I
Russia XIII
United States XII
United States IV
France II
Spain III
Japan XI
Pakistan IX
India VIII
Peru XVI
Brazil V
New Zealand XIV
Chile XV
entina VI
Australia X
Africa Vii
New Zealand XIV
NAVAREA IV
NAVAREA XII
HYDROLANT
HYDROPAC
HYDROARC

3.3.3 Aircraft Hazard Volumes for Planned Debris Releases

The range must confirm that Notices to Airmen are issued that encompass the volume and duration necessary to protect aircraft from debris capable of causing an aircraft accident due to all planned events.[22]

NOTE	Federal law[23] defines an aircraft accident as "an occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight and all such persons have disembarked, and in which any person suffers death or serious injury, or in which the aircraft receives substantial damage." As described in the glossary, federal law also defines death, serious injury, and substantial damage for the purposes of accident reporting.

3.3.4 Mishap Response

The range must coordinate with the FAA to ensure timely notification[24] of any expected air traffic hazard associated with range activities. In the event of a mishap, the range must immediately inform the FAA of the volume and duration of airspace where an aircraft hazard is predicted.

3.4 Ship Protection[25]

The term "ship" includes boats and watercraft of all sizes.

3.4.1 Non-Mission Ship Criteria

a. Ship Warning Areas. Notices to Mariners (NOTMARs) shall be issued to warn non-mission ships of regions defined by one of the following approaches:[26]

(1) where the probability of debris capable of causing a casualty impacting on or near a vessel exceeds 10E−6 (1E−5), accounting for all relevant hazards; or

(2) the union of the areas where the individual probability of casualty for any person onboard exceeds the criteria in a of Subsection 3.2.1, the collective casualty expectation for an individual ship would exceed the criterion in b of Subsection 3.2.1, and the catastrophic risk for an individual ship would exceed the provisional criteria outlined in Section 3.8.

In some situations, warnings may be optional when expected ship traffic in the affected area is low and adequate observation will be performed.

b. Non-Mission Ship Risk Criteria. People on observed non-mission ships shall be included[27] in the determination of compliance with collective risk criteria in b of

[22] Planned debris releases include intercept debris, jettison stages, nozzle covers, fairings, inter-stage hardware, etc.
[23] 49 C.F. R. 830.2. 1 October 2011.
[24] This may be accomplished through preflight analyses and coordination as described in Chapter 4 of the supplement.
[25] Chapter 4 of the supplement provides important guidelines on the proper implementation of ship protection measures.
[26] The warning area may be expanded to provide additional mitigation so that risk criteria (3.2.1) are met, as discussed in Chapter 4 of the supplement.
[27] Mission risk shall include all members of the GP on land, on ships, and on aircraft.

Subsection 3.2.1 and provisional catastrophic criteria in c of Subsection 3.2.1. Observation to locate non-mission ships is an acceptable method to ensure compliance, provided that suitable observation techniques are used to include the region(s):

(1) where the individual probability of casualty exceeds the criteria in a of Subsection 3.2.1; and

(2) where the collective casualty expectation or provisional catastrophic risk criteria (b or c of Subsection 3.2.1, respectively) would be exceeded given a conservative estimate of typical ship traffic.

3.4.2 Mission-Essential Ship Criteria

a. Mission-Essential Ship Hazard Areas. Mission-essential ships will be restricted from hazard areas defined by either:

(1) the region where the probability of debris capable of causing a casualty impacting on or near a vessel exceeds 100E−6 (1E−4), accounting for all relevant hazards; or

(2) The union of the areas where the individual probability of casualty for an exposed person onboard exceeds the criteria in a of Subsection 3.2.2, the collective risk criteria in b of Subsection 3.2.2, or the catastrophic risk criteria in c of Subsection 3.2.2.

b. Mission-Essential Ship Risk Criteria. Ship-board MEP shall be included in the assessment of compliance with the collective risk criteria in b of Subsection 3.2.2 and catastrophic risk criteria in c of Subsection 3.2.2.

3.4.3 Ship Hazard Areas for Debris Releases

The range must confirm that NOTMARs are issued for each planned debris release event that encompasses the areas and durations necessary to satisfy the risks as described in a of Subsection 3.4.1 or contain, with 99% probability of containment, all resulting debris impacts capable of causing a casualty.[28]

3.4.4 Mishap Response

The range must coordinate with the United States Coast Guard or other appropriate authorities to ensure timely notification of any ship traffic hazard associated with range activities. In the event of a mishap, the range must promptly inform the appropriate authority(s) of the area and duration of navigable waters where a ship hazard is predicted.

3.5 Infrastructure Protection

3.5.1 Mission-Essential Infrastructure Criteria

Mission-essential infrastructure (such as radar equipment) is treated separately as critical assets.

[28] This 99% probability of containment region corresponds to a 3-sigma dispersion region for a single impact if the impact uncertainty can be characterized by a bivariate normal impact probability distribution.

APPENDIX K
NOTICE OF AVAILABILITY FOR PUBLIC REVIEW, PROOF OF DELIVERY/PUBLICATION, PUBLIC COMMENTS RECEIVED ON FINAL DRAFT, AND RESPONSES

DEPARTMENT OF THE AIR FORCE
UNITED STATES SPACE FORCE
SPACE LAUNCH DELTA 30

16 September 2024

MEMORANDUM FOR ALL INTERESTED GOVERNMENT AGENCIES, PUBLIC OFFICIALS, ORGANIZATIONS, AND INDIVIDUAL PARTIES

FROM: 30 CES/CEI
1028 Iceland Avenue
Vandenberg SFB, CA 93437-6010

SUBJECT: Draft Environmental Assessment (EA) and Finding of No Significant Impact (FONSI) for the Falcon 9 Launch Cadence Increase at Vandenberg Space Force Base, California.

1. Attached as public and agency notification, to comply with the National Environmental Policy Act of 1969, and the President's Council on Environmental Quality's implementing regulations, Space Launch Delta 30 (SLD 30) prepared the Draft EA/FONSI for Falcon 9 Cadence Increase at Vandenberg Space Force Base, California.

2. The Proposed Action is to increase Falcon 9 annual launch cadence from 36 to 50 launches per year at Space Launch Complex 4 (SLC-4) on VSFB, increase Falcon 9 first stage and fairing recovery activities, and expand the recovery area in the Pacific Ocean. Up to 12 boosters per year would continue to land at SLC-4. The purpose of the Proposed Action is to provide greater mission capability to the Department of Defense (DOD), National Aeronautics and Space Administration, and commercial customers by increasing Falcon 9's flight opportunities. This is in furtherance of United States policy to ensure capabilities necessary to launch and insert necessary national security payloads into space. The current launch capacity is insufficient to meet critical DOD and key commercial launch missions. Resources and matters analyzed in the Draft EA include air quality, climate, sound (airborne), biological resources, water resources, cultural resources, coastal zone resources, Department of Transportation Act Section 4(f) properties, utilities, socioeconomics, transportation, human health and safety, hazardous materials and waste management, and solid waste management. The Draft EA/FONSI concludes there will be no significant environmental impacts resulting from the Proposed Action.

3. The public comment period for this Draft EA/FONSI will be from 17 September 2024 through 17 October 2024. This Draft EA/FONSI is available at: the Lompoc, Santa Maria, and Santa Barbara Public Libraries, and the VSFB Library, Ojai Public Library, Avenue Library (Ventura), E.P. Foster Library (Ventura), and South Oxnard Branch Library and electronically on the Vandenberg SFB website at https://www.vandenberg.spaceforce.mil/About-Us/Environmental/EAS/. During this time, comments may be sent to Space Launch Delta 30, Installation Management Flight Environmental Assets, Building 11146, Vandenberg SFB, California 93437, attention of Ms. Tiffany Whitsitt-Odell, e-mailed to tiffany.whitsitt-odell@spaceforce.mil, or faxed to (805) 606-6137. If you have any questions, please contact Ms. Tiffany Whitsitt-Odell at (805) 606-4198.

Recoverable Signature

X Beatrice L Kephart

Beatrice L Kephart

Signed by: KEPHART.BEATRICE.LINDA.1166122291

BEATRICE L KEPHART
Chief, Installation Management Flight

Attachment:

Draft EA/FONSI for Falcon 9 Cadence Increase at Vandenberg Space Force Base (VSFB), California. Available at: https://www.vandenberg.spaceforce.mil/About-Us/Environmental/EAS/

DEPARTMENT OF THE AIR FORCE
UNITED STATES SPACE FORCE
SPACE LAUNCH DELTA 30

16 de septiembre de 2024

MEMORANDUM PARA TODAS LAS AGENCIAS GUBERNAMENTALES, FUNCIONARIOS PÚBLICOS, ORGANIZACIONES Y PARTES INDIVIDUALES INTERESADAS

DE: 30 CES/CEI
1028 Iceland Avenue
Vandenberg SFB, CA 93437-6010

ASUNTO: Borrador de la evaluación ambiental (EA) y determinación de que no hubo impacto significativo (FONSI, por sus siglas en inglés) por el aumento de la cadencia de lanzamiento del Falcon 9 en la base de la fuerza espacial Vandenberg, California.

1. Adjunto como notificación pública y de agencia, para cumplir con la Ley Nacional de Política Ambiental de 1969 y las regulaciones de implementación del Consejo Presidencial sobre Calidad Ambiental, Space Launch Delta 30 (SLD 30) preparó el Borrador de EA/FONSI para el Aumento de Cadencia del Falcon 9 en la Base de la Fuerza Espacial Vandenberg, California.

2. La Acción Propuesta consiste en aumentar la cadencia de lanzamiento anual del Falcon 9 de 36 a 50 lanzamientos por año en el Complejo de Lanzamiento Espacial 4 (SLC-4) en la Base de la Fuerza Aérea de los Estados Unidos (VSFB, por sus siglas en inglés), aumentar las actividades de recuperación de la primera etapa y el carenado del Falcon 9 y ampliar el área de recuperación en el Océano Pacífico. Hasta 12 cohetes propulsores por año seguirían aterrizando en el SLC-4. El propósito de la Acción Propuesta es proporcionar una mayor capacidad de misión al Departamento de Defensa (DOD, por sus siglas en inglés), la Administración Nacional de Aeronáutica y del Espacio y los clientes comerciales al aumentar las oportunidades de vuelo del Falcon 9. Esto se hace en cumplimiento de la política de los Estados Unidos de garantizar las capacidades necesarias para lanzar e insertar en el espacio las cargas útiles de seguridad nacional necesarias. La capacidad de lanzamiento actual es insuficiente para cumplir con las misiones críticas del DOD y las misiones de lanzamiento comerciales clave. Los recursos y asuntos analizados en el Borrador de la EA incluyen la calidad del aire, el clima, el sonido (aéreo), los recursos biológicos, los recursos hídricos, los recursos culturales, los recursos de la zona costera, las propiedades de la Sección 4(f) de la Ley del Departamento de Transporte, los servicios públicos, la socioeconomía, el transporte, la salud y seguridad humanas, la gestión de materiales y desechos peligrosos y la gestión de desechos sólidos. El Borrador de la EA/FONSI concluye que no habrá impactos ambientales significativos como resultado de la Acción Propuesta.

3. El período de comentarios públicos para este borrador de EA/FONSI será del 17 de septiembre de 2024 al 17 de octubre de 2024. Este borrador de EA/FONSI está disponible en: las bibliotecas públicas de Lompoc, Santa María y Santa Bárbara, y en la biblioteca VSFB, la biblioteca pública de Ojai, la biblioteca Avenue (Ventura), la biblioteca E.P. Foster (Ventura) y la biblioteca South Oxnard Branch, y electrónicamente en el sitio web de Vandenberg SFB en https://www.vandenberg.spaceforce.mil/About-Us/Environmental/EAS/. Durante este tiempo, los comentarios pueden enviarse a Space Launch Delta 30, Installation Management Flight Environmental Assets, Building 11146, Vandenberg SFB, California 93437, a la atención de la Sra. Tiffany Whitsitt-Odell, por correo electrónico a tiffany.whitsitt-odell@spaceforce.mil o por fax al (805) 606-6137. Si tiene alguna pregunta, por favor comuníquese con la Sra. Tiffany Whitsitt-Odell al (805) 606-4198.

Recoverable Signature

X Beatrice L Kephart

Beatrice L Kephart

Signed by: KEPHART.BEATRICE.LINDA.1166122291

BEATRICE L KEPHART
Jefa de Gestión de Instalación de Vuelo

Adjunto:

Borrador de EA/FONSI para el aumento de cadencia del Falcon 9 en la Base de la Fuerza Espacial Vandenberg (VSFB), California.
Disponible en: https://www.vandenberg.spaceforce.mil/About-Us/Environmental/EAS/

https://santamariatimes.com/tncms/asset/editorial/2fc7ebde-7479-11ef-9111-0f2126fded3b/

Increased VSFB launch assessment finds 'no significant impact,' public comment period opens Tuesday

Lisa André landre@syvnews.com
Sep 16, 2024

Vandenberg Space Force Base on Monday issued results from a a draft environmental assessment conducted by the U.S. Space Force on the environmental impacts of increased launch activity from the West Coast. In this photo a SpaceX Falcon 9 rocket lifts off from Vandenberg Space Force Base on June 28.

Contributed, SpaceX

Vandenberg Space Force Base on Monday issued results from a draft environmental assessment conducted and released by the U.S. Space Force on the environmental impacts of increased launch activity from the West Coast.

Space Force evaluated the impacts of increasing the annual number of Falcon 9 launches from Space Launch Complex 4 at Vandenberg, from 36 (or roughly three each month) to 50 launches (one weekly).

According to base officials, the assessment returned with "finding of no

This comes after the California Coastal Commission in August reluctantly agreed to increasing SpaceX activity at Vandenberg to 36 launches and 12 landings per year, with conditions.

The first three conditions, however, were not agreed to by the Space Force, according to Commission staff in August.

Conditions include: providing an enhanced on-base biological monitoring program to address gaps and shortcomings in the existing programs; submitting a sonic boom minimization plan for limiting the spatial extent and severity for launches; and developing improved and enhanced biological monitoring “if avoidance cannot be achieved.”

To read the full story, go to lompocrecord.com/news/local/military/vandenberg/california-coastal-commission-agrees-to-spacex-launch-increase-with-conditions/article_088bab8f-b463-5f84-8422-14457665c6ce.html

As a result of the recent assessment, Vandenberg and SpaceX will proceed to ramp up launch cadence as well as increase Falcon 9 first stage and fairing recovery activities, and expanding the recovery area in the Pacific Ocean.

Up to 12 boosters per year would continue to land at SLC-4, officials noted, which typically results in a series of audible sonic booms.

In a statement, Space Force explained that the purpose of the Proposed Action "is to provide greater mission capability to the Department of Defense DOD, National Aeronautics and Space Administration, and commercial customers by increasing Falcon 9’s flight opportunities."

This is in furtherance of United States policy to ensure capabilities necessary to launch and insert necessary national security payloads into space, they said.

A public comment period opens on the draft environmental assessment and FONSI Sept. 17 and runs through Oct. 17.

Comments may be sent to Space Launch Delta 30, Installation Management Flight Environmental Assets, 1028 Iceland Ave., Building 11146, Vandenberg Space Force Base, California, 93437; Attention: Ms. Tiffany Whitsitt-Odell; or email to tiffany.whitsitt-odell@spaceforce.mil, or fax to 805-606-6137.

Questions can be directed to Whitsitt-Odell at 805-606-4198.

The report and findings are available for review at www.vandenberg.spaceforce.mil/About-Us/Environmental/EAS/, and hardcopies are available at: the Lompoc, Santa Maria, and Santa Barbara public libraries, and the VSFB Library, Ojai Public Library, Avenue Library (Ventura), E.P. Foster Library (Ventura), and South Oxnard Branch Library.

Lisa André covers lifestyle and local news for the Santa Ynez Valley News and Lompoc Record, editions of the Santa Maria Times. She can be reached at landre@syvnews.com

Lisa Andre

SYV Lifestyles Editor

Falcon 9 Launch Cadence Increase Environmental Assessment

By **Vandenberg Space Force Base**
Tue Sep 17, 2024 | 10:38am

Press releases are posted on Independent.com as a free community service.

VANDENBERG SPACE FORCE BASE, Calif. – The United States (U.S.) Space Force has prepared a Draft Environmental Assessment (DEA) and Finding of No Significant Impact (FONSI) that evaluates the potential environmental impacts of the Proposed Action (PA). The PA is to increase Falcon 9 annual launch cadence from 36 to 50 launches per year at Space Launch Complex 4 (SLC-4) on Vandenberg Space Force Base (VSFB), increase Falcon 9 first stage and fairing recovery activities, and expand the recovery area in the Pacific Ocean. Up to 12 boosters per year would continue to land at SLC-4. The purpose of the Proposed Action is to provide greater mission capability to the Department of Defense DOD, National Aeronautics and Space Administration, and commercial customers by increasing Falcon 9's flight opportunities. This is in furtherance of United States policy to ensure capabilities necessary to launch and insert necessary national security payloads into space.

The DEA/FONSI is available for review are available electronically on the Vandenberg SFB website at https://www.vandenberg.spaceforce.mil/About-Us/Environmental/EAS/ and hardcopies are available at: the Lompoc, Santa Maria, and Santa Barbara Public Libraries, and the VSFB Library, Ojai Public Library, Avenue Library (Ventura), E.P. Foster Library (Ventura), and South Oxnard Branch Library. The public comment period for this DEA/FONSI is 17 September 2024 through 17 October 2024. During this time, comments may be sent to Space Launch Delta 30, Installation Management Flight Environmental Assets, 1028 Iceland Avenue, Building 11146, Vandenberg Space Force Base, California 93437, attention of Ms. Tiffany Whitsitt-Odell, tiffany.whitsitt-odell@spaceforce.mil, or fax to (805) 606-6137. If you have any questions, please call Ms. Tiffany Whitsitt-Odell at (805) 606-4198.

Mon Oct 28, 2024 | 15:44pm
https://www.independent.com/2024/09/17/falcon-9-launch-cadence-increase-environmental-assessment/

Distribution Instructions: Please distribute NEPA documents, including the corresponding notice of availability (NOA), to the following points of contact (POCs) as indicated below. Send NOA only when indicated and ensure a hyperlink to the Draft EA is included in the NOA and in your email correspondence (as applicable). Please cc the SLD 30 NEPA POC on any email correspondence / notifications. Distribute hard copies to the libraries via personal delivery and obtain signed receipt. Please inform SLD 30 NEPA POC of any "return to sender" issues, change of preference for document type/delivery, or any individuals that would like to be removed from this list or need information updated.

Federal

NOAA – Channel Islands National Marine Sanctuary
Attn: Chris Mobley
113 Harbor Way, Suite 150
Santa Barbara, CA 93l09
Email: Chris.mobley@noaa.gov
Email NOA with Website Link to Draft EA

NOAA - National Marine Fisheries Service
West Coast Regional Office
Attn: For Distribution
501 West Ocean Blvd
Long Beach, CA 90802-4213
Email: shelby.l.mendez@noaa.gov
Email NOA with Website Link to Draft EA

National Park Service
Channel Islands National Park
Attn: Superintendent
1901 Spinnaker Drive
Ventura, CA 93001
Mail NOA with Website Link to Draft EA

U.S. Army Corps of Engineers
Attn: David A. Jorgenson, P.E.
1318 New Mexico Avenue, Building 9360
Vandenberg SFB, CA 93437
Email: David.A.Jorgenson@usace.army.mil
Email NOA with Website Link to Draft EA

U.S. Army Corps of Engineers
Regulatory Division, Los Angeles District
Attn: Aaron O. Allen, PhD. and Theresa Stevens
60 South California Street, Suite 201
Ventura, CA 93001-2598
Email: Aaron.O.Allen@usace.army.mil
Theresa.Stevens@usace.army.mil
Email NOA with Website Link to Draft EA

U.S. Coast Guard
LTJG Ruby Sebastian-Echevarria
Waterways Analysis & Management Systems Manger
Eleventh Coast Guard District
Bldg. 50-2, C.G. Island
Alameda, CA 94501-5100
Email: rubymar.sebastianechevarria@uscg.mil
Email NOA with Website Link to Draft EA

Federal Aviation Administration (FAA)
Office of Commercial Space Transportation
Attn: Stacy Zee and Leslie Grey (VSFB POC)
800 Independence Avenue
Washington, DC 20591
Email: Stacey.zee@faa.gov
leslie.grey@faa.gov
Email NOA with Website Link to Draft EA

U.S. Environmental Protection Agency, Region 9
Environmental Review Branch
Attn: Karen Vitulano
Tribal, Intergovernmental and Policy Division
75 Hawthorne St. TIP-2
San Francisco, CA 94105
Email: Vitulano.Karen@epa.gov
Email NOA with Website Link to Draft EA

U.S. Fish and Wildlife Service
Ventura Fish and Wildlife Office
Attn: Stephen P. Henry
2493 Portola Road, Suite B
Ventura, CA 93003-7726
Email: steve_henry@fws.gov
Email NOA with Website Link to Draft EA

State

California Coastal Commission - Energy, Ocean Resources and Federal Consistency Division
Attn: Cassidy Teufel
455 Market Street, Suite 228
San Francisco, CA 94105-2219
Email: cassidy.teufel@coastal.ca.gov
Email NOA with Website Link to Draft EA

Central Coast Regional Water Quality Control Board
Attn: Amber Sellinger, P.G., C.Hg.
Dept of Defense Program Manager
895 Aerovista Place, Suite 101
San Luis Obispo, CA 93401-7906
Email: Amber.Sellinger@Waterboards.ca.gov
Email NOA with Website Link to Draft EA

Central Coast Regional Water Quality Control Board – Central Coast Ambient Monitoring Program (CCAMP)
Attn: Melissa Daugherty
895 Aerovista Place, Suite 101
San Luis Obispo, CA 93401
Email: Melissa.Daugherty@Waterboards.ca.gov
Email NOA with Website Link to Draft EA

California Department of Fish & Wildlife
South Coast Region
Attn: Kelly Schmoker-Stanphill
E-mail: Kelly.Schmoker@wildlife.ca.gov
Email NOA with Website Link to Draft EA

California Environmental Protection Agency
Attn: For Distribution
1001 I Street
P.O. Box 2815
Sacramento, CA 95812-2815
Mail NOA with Website Link to Draft EA

California Office of Historic Preservation
Attn: Julianne Polanco
State Historic Preservation Officer
1725 23rd Street, Suite 100
Sacramento, CA 95816
Email: calshpo.ohp@parks.ca.gov
Email NOA with Website Link to Draft EA

Office of the Governor
Office of Planning and Research
Attn: State Clearinghouse
1400 10th Street
Sacramento CA 95814
Online form submitted

Santa Barbara County Air Pollution Control District
Attn: Alex Economou
260 N. San Antonio Road, Suite A
Santa Barbara, CA 93110-1315
Email: economoua@sbcapcd.org
Email NOA with Website Link to Draft EA

Santa Barbara County Air Pollution Control District
Attn: Carly Barham
260 N. San Antonio Road, Suite A
Santa Barbara, CA 93110-1315
Email: BarhamC@sbcapcd.org
Email NOA with Website Link to Draft EA

Tribes

Santa Ynez Band of Chumash Indians
Elders Council
Attn: Sam Cohen and Nakia Zavalla
P.O. Box 517
Santa Ynez, CA 93460
Emails: SCohen@santaynezchumash.org
nzavalla@chumash.gov
Email NOA with Website Link to Draft EA

Local

Santa Barbara County Board of Supervisors
C/O: Santa Barbara County Planning & Development
Attn: David Villalobos
123 E. Anapamu Street
Santa Barbara, CA 93101
Email: dvillalo@co.santa-barbara.ca.us
Email NOA with Website Link to Draft EA

Santa Barbara County Planning & Development
Attn: David Lackie
123 East Anapamu Street
Santa Barbara CA 93101-2058
Email: dlackie@countyofsb.org
Email NOA with Website Link to Draft EA

City of Lompoc
Economic & Community Development

Attn: Brian Halvorson and Cherridah Weigel
100 Civic Center Plaza
Lompoc CA 93436
Email: b_halvorson@ci.lompoc.ca.us
g_stones@ci.lompoc.ca.us
Email NOA with Website Link to Draft EA

Libraries

Santa Barbara Public Library
40 East Anapamu Street
Santa Barbara, CA 93101-2000
Hardcopy

Lompoc Public Library
501 East North Avenue
Lompoc, CA 93436
Hardcopy

Santa Maria Public Library
421 S. McClelland Street
Santa Maria, CA 93454
Hardcopy

Vandenberg Space Force Base Library
100 Community Loop, Building 10343A
Vandenberg SFB, CA 93437
Hardcopy

Ojai Library
111 E Ojai Avenue
Ojai, CA 93023
Hardcopy

Avenue Library
606 N Ventura Avenue
Ventura, CA 93001
Hardcopy

E.P. Foster Library
651 E Main Street
Ventura, CA 93001
Hardcopy

South Oxnard Branch Library
4300 Saviers Road
Oxnard, CA 93033
Hardcopy

Requesting Entities

California Native Plant Society
Channel Islands Chapter
P.O. Box 6
Ojai, CA 93024-006
Email: cnpschannelislands@gmail.com
Email NOA with Website Link to Draft EA

California Trout
Attn: Russell Marlow
290 Maple Court #140
Ventura, CA 93003
Email: rmarlow@caltrout.org
Email NOA with Website Link to Draft EA
Environmental Defense Center
Attn: Brian Trautwein
906 Garden Street
Santa Barbara, CA 93101
Email:
BTrautwein@EnvironmentalDefenseCenter.org
Email NOA with Website Link to Draft EA

La Purisima Audubon Society
Attn: Tamarah Taaffe
4036 Muirfield Place
Vandenberg Village, CA 93436-1307
Email: bima55@msn.com
Hardcopy

Santa Barbara Museum of Natural History
Attn: Luke J. Swetland
2559 Puesta del Sol
Santa Barbara, CA 93105
Email: lswetland@sbnature2.org
Email NOA with Website Link to Draft EA

Sierra Club
Los Padres Chapter
Attn: Gerry Ching
P O Box 31241
Santa Barbara, CA 93130-1241
Email: gching@cox.net
Email NOA with Website Link to Draft EA

Gaviota Coast Conservancy
Attn: Doug Kern & Ana Citrin
P.O Box 1099
Goleta, CA 93116
Email: doug.kern@gaviotacoastconservancy.org
Ana.citrin@gaviotacoastconservancy.org
Email NOA with Website Link to Draft EA

Surfrider Foundation

Attn: Mandy Sackett
Email: msackett@surfrider.com
Email NOA with Website Link to Draft EA

From: [redacted]
To: WHITSITT-ODELL, TIFFANY A CIV USSF SSC 30 CES/CEIEA
Subject: [Non-DoD Source] Against additional SpaceX launches
Date: Thursday, October 3, 2024 12:21:48 PM

[You don't often get email from [redacted] Learn why this is important at https://aka.ms/LearnAboutSenderIdentification]

Hello,
I am against allowing additional SpaceX launches due to the environmental impacts to people and animals.

Marina Lenney
Architect

From: [redacted]
To: WHITSITT-ODELL, TIFFANY A CIV USSF SSC 30 CES/CEIEA
Subject: [Non-DoD Source] EIS for proposed increase in SpaceX launches
Date: Friday, October 4, 2024 3:35:26 PM

You don't often get email from [redacted] Learn why this is important

Dear Tiffany Whitsitt-Odell,

I am a local California Central Coast resident who is emailing to ask that an Environmental Impact Statement be prepared for the proposed increase in SpaceX launches, because the project has a reasonably foreseeable significant effect on the environment, including on threatened and endangered species.

Thank you for your consideration.

Respectfully,
Gigi Lin

From: [redacted]
To: WHITSITT-ODELL, TIFFANY A CIV USSF SSC 30 CES/CEIEA
Subject: [Non-DoD Source] Environmental Assessment Public Comment
Date: Thursday, October 3, 2024 11:52:43 AM

[You don't often get email from [redacted] Learn why this is important at https://aka.ms/LearnAboutSenderIdentification]

To Tiffany Whitsitt-Odell:

I ask that an Environmental Impact Statement be prepared because the SpaceX projects new request to conduct 14 additional launches in 2024 has a reasonably foreseeable significant effect on the environment, including on threatened and endangered species.

Sincerely,
Lynne Kelly

From: [redacted]
To: WHITSITT-ODELL, TIFFANY A CIV USSF SSC 30 CES/CEIEA
Subject: [Non-DoD Source] Environmental Assessment: Public Comment RE: SpaceX launch frequency
Date: Friday, October 4, 2024 7:25:04 PM

You don't often get email from [redacted] Learn why this is important

Dear Members involved with the Environmental Assessment regarding SpaceX launch frequency,

Thank you for the opportunity to comment in regard to the Environmental Assessment for proposed increase in SpaceX rocket launches from Vandenberg Space Force Base.

As a resident of the Santa Ynez Valley, I have many major concerns to raise with ANY increase in frequency, and I appreciate the very necessary step of an Environmental Assessment. First and foremost, it is clear that an Environmental Impact Statement must be prepared for this issue. Please do this.

One issue which appears to have been overlooked so far is the problem of noise. Rocket launches create a tremendous amount of noise and vibration which disturb humans and wildlife. The extreme levels of noise and vibration often violate all local noise ordinances, and I see no reason why a private company should not be obligated to comply with the noise ordinance. For a full review of Santa Barbara County's noise ordinance, link here: https://cosantabarbara.app.box.com/s/3yex3g6a5vex3cjpkx1bxg1pgvzp9k1y

At the very least, SpaceX should comply with the time limits the County applies to construction:

7:00 a.m. – 5:00 p.m., weekdays
9:00 a.m. – 4:00 p.m., Saturdays
Prohibited on Sundays and legal holidays*

Nighttime launches in particular need severe restrictions due to their noise and vibration impacts. Rocket launches from Vandenberg are extremely disturbing to both humans and animal wildlife in the local area, regardless of time of day, but they cause excess harm if they are launched at night. Nighttime launches disturb the sleep of thousands of citizens, and cause stress, anxiety, and lack of sleep in dogs, coyotes, deer and countless other animals. This needs to be considered seriously when looking at any proposed launch schedule, and nighttime launches should be forbidden for ALL private launches (reserved only for necessary US Government reasons).

I would also like to note that these launches threaten the habitat within both the Gaviota Coast and the proposed Chumash Heritage National Marine Sanctuary. These areas provide critical habitat, provide a sanctuary for humans and must be protected. The safety of both commercial and recreational fishing needs to be addressed more seriously, and launches limited to cause minimal disruption in these areas, and also at Jalama Beach where closures are becoming more and more of an issue with visitors and locals alike.

Finally, further studies of the level of pollutants and their impacts on local residents need to be completed prior to any further launch activity. How does the propellants used impact the health of local residents and wildlife? How will the impacts of the pollution associated with one-time use weather balloons be dealt with.

It is critical to note the history of neglect and disrespect which both SpaceX and Mr. Musk have shown. Given the level of impunity which already been exhibited, much stricter regulations should be imposed, along with meaningly severe punishments. Mr. Musk himself has mocked regulatory agencies publicly both on his social media platform X and on various podcasts, including the recent Lex Fridman Podcast episode #400. Fines and consequences need to be high enough to impact billionaire behavior. No one should be above the law in California, nor the USA.

While I object to increased military launch frequency (particularly if at night), I recognize the potential benefit for both national security and economic benefits to the community and country. The commercial launches simply must be held to a higher level of scrutiny and standards as they are solely for the benefit of private interests, and are often at odds with public health.

There are many open questions to investigate during your Environmental Assessment, and all of these point to a need to halt launch expansions at Vandenberg.

Sincerely,
Brandon Sparks-Gillis
Solvang, CA

From: [redacted]
To: WHITSITT-ODELL, TIFFANY A CIV USSF SSC 30 CES/CEIEA; joshua.smith@coastal.ca.gov
Subject: [Non-DoD Source] FEEDBACK - Sonic Booms
Date: Sunday, September 29, 2024 8:00:19 AM

You don't often get email from [redacted] Learn why this is important

Hello -
I understand that SpaceX has applied to increase the number of rocket launches from Vandenburg to 50 per year. And that the government's draft assessment is that there will be No Significant Impact locally. This is not true!

I'm a resident of the city of Ventura and disagree with this assessment! The last loud sonic boom about a week ago was very startling and my wall shook! The impact of sonic booms on both people and wildlife are harmful. Personally, I find them very nerve racking and that is bad for my health!

I vote that any increase in the amount of sonic booms be DENIED! Thank you,
Christine Ketvirtis

From: [redacted]
To: WHITSITT-ODELL, TIFFANY A CIV USSF SSC 30 CES/CEIEA
Subject: [Non-DoD Source] Increased Launch Assessment Report
Date: Monday, October 14, 2024 12:16:08 PM

You don't often get email from [redacted] Learn why this is important

To Whom it may concern,

I am writing to make sure my voice is heard on this matter.

I feel your assessment is not a thorough enough review, the study needs to take place over many years to get the full impact.
What about 5 to 10 years from now? Will you then find negative environmental impacts? I feel it was rushed .
I wonder about the atmosphere, what really happens when a launch does not go well.?

How about the people who have to evacuate Jalama Beach when they launch.
Increasing the number of launches will be hard for all involved there.

The sonic booms are not necessary since they have the drone ship.

Space X is wanting to increase launches just to make all the money he can as fast as he can. I am afraid that Lompoc being so close is going to suffer in some way. I do not feel Space X cares about long term effects just the here and now. The number of launches is already too much, please do not increase the amount and please stop the sonic booms all together. My worry is if you increase the launches now you cannot reduce in the future. Do not let the amount of money made shield your view of the whole picture.

Thank you,
Peggy Baldwin

From: [redacted]
To: WHITSITT-ODELL, TIFFANY A CIV USSF SSC 30 CES/CEIEA
Subject: [Non-DoD Source] Increased rocket launches at VSFB...
Date: Friday, September 27, 2024 6:55:34 PM

You don't often get email from [redacted] Learn why this is important

Hello Ms. Whitsitt-Odell,

I understand that you are the person to contact regarding the increased launching of SpaceX rockets from Vandenberg Space Force Base.

I am reaching out to you to express my distress these disruptive, nuisance rockets.

As a resident of Lompoc, I am frustrated with the increasing frequency of these rockets. Every rocket launched literally shakes my house. My windows rattle, my wall art tremble, and I stress that one of these days my home will be damaged. For all we know, the very foundation of the homes here and in the surrounding area are being compromised!

The irregularity of the rocket launches is also vexing. Sometimes they are launched early morning, a late evening, or (worst of all) in the middle of the night! All of the noise and the shaking wakes up my family, including my husband that has a medical condition that requires that he have un-interrupted sleep.

I also have great concern about the impact that these rocket launches are having on the local environment and wildlife, not to mention the space pollution.

At some point, surely the number of satellites in our orbit will be sufficient so that further rocket launches will become unnecessary.

Ms. Whitsitt-Odell, I hope you take into consideration my thoughts and concerns about the rockets, and that they will not be so numerous in the near future.

Sincerely,

Sara

From: [redacted]
To: WHITSITT-ODELL, TIFFANY A CIV USSF SSC 30 CES/CEIEA
Subject: [Non-DoD Source] objection to rocket launches
Date: Thursday, October 3, 2024 1:54:03 AM

You don't often get email from [redacted] Learn why this is important

- *An Environmental Impact Statement be prepared because the project has a reasonably foreseeable significant effect on the environment, including on threatened and endangered species.*

From: [redacted]
To: WHITSITT-ODELL, TIFFANY A CIV USSF SSC 30 CES/CEIEA
Subject: [Non-DoD Source] Please stop ??
Date: Saturday, September 28, 2024 11:51:54 AM

You don't often get email from [redacted] Learn why this is important

Space ex is another horrible example of man's arrogance and ignorance. Everyone in my neighborhood hates and resents the sonic boombs. We have no idea what we are doing with any of this. Remember when we thought the ocean was limitless and it was "ok" to launch all of our trash into it?

Do not increase the sonic boombs. Stop the entire project!!

Why were we not able to have input in what happens in our night sky and to our planet?

From: [redacted]
To: WHITSITT-ODELL, TIFFANY A CIV USSF SSC 30 CES/CEIEA
Subject: [Non-DoD Source] Public comment on Environmental assessment of increased SpaceX launches from Vandenberg Space Force Base
Date: Friday, October 4, 2024 11:09:00 PM

You don't often get email from [redacted] Learn why this is important

Tiffany:

I am writing this public comment to request that an Environmental Impact Statement be prepared for the SpaceX application for increased launches from Vandenberg Space Force Base. I live in Ventura on the Hillside (near City Hall) and we hear and feel every launch that heads in our direction. The sonic boom shakes the house significantly and rattles the glass windows. It feels and sounds as though a truck has crashed into our house after each launch. It is hard to believe that these launches aren't causing significant damage to threatened and endangered wildlife and personal property especially closer to the base. I encourage the Commission to further investigate the problems associated with the launches and consider checking with residents further south of the base for their input. I strongly urge the Commission to insist on an Environmental Impact Statement for the application to increase the flights and to determine if additional mitigation is required for the existing approved launches.

Sincerely,

Andy Welcher
[redacted]

From: [redacted]
To: joshua.smith@coastal.ca.gov; WHITSITT-ODELL, TIFFANY A CIV USSF SSC 30 CES/CEIEA
Subject: [Non-DoD Source] Sonic Booms from SpaceX rocket launches
Date: Saturday, September 28, 2024 11:09:21 AM

You don't often get email from [redacted] Learn why this is important

September 28, 2024 Input to Coastal Commission and the Center for Environmental Management of Military Lands at Vandenberg Air Force Base.

Joshua,

I am glad to hear that you, as a Coastal Commission Public Information Officer, are working on collecting feedback about impacts of VAFB launches and associated sonic booms, and folks can reach you at joshua.smith@coastal.ca.gov.

Tiffany,

I understand that the government is inviting public comment through October 17 on the proposal to INCREASE sonic boom producing launches via email to you at tiffany.whitsitt-odell@spaceforce.mil Tiffany, I am glad you have been a Wildlife Biologist at Center for Environmental Management of Military Lands at Vandenberg Air Force Base for the last 8 years.

Joshua and Tiffany,

The impact of sonic booms on people in Ventura County is real. VAFB's position that there is no significant impact on the public is not accurate. **I ask that the launches be adjusted so that sonic booms are reduced significantly within Ventura County and the impact on people and wildlife is reduced.**

SpaceX has applied to increase the number of rocket launches from Vandenburg to 50 per year. At that proposed number, launches will occur on average once a week. Many of these launches will produce the sonic boom that we experience in Ventura County. A further increase to 100 launches per year is also being considered. The government's draft assessment is that there will be No Significant Impact (i.e. approve it).

These proposed increase in rocket launches have a significant impact on Ventura County people and wildlife. They should be reduced, not increased. I would like to see the results of studies done about the impact of these launches on buildings, wildlife and people. I would like to see the science behind the "no significant impact" government draft assessment. Where can I read that? I might feel safer knowing the science, as my 100-year-old home, a designated historic landmark in Ventura, rattles during the launches.

These are my basic understandings, that inform my input. If I have any of this wrong, please to explain where I am off:

- The increased sonic booms over Ventura County are related to SpaceX, a private company, that is part of, but not 100% of, what is on these launches.
- SpaceX business needs drive the recent increase in launches and the proposal for future increased launches.
- The trajectories of these launches and the resulting sonic booms over Ventura County could be changed, to avoid the sonic booms over Ventura County.
- The SpaceX business produces an income stream for the government.
- The increased sonics booms over Ventura County are NOT related to an immediate specific public safety or defense need. From what I understand, we are not asked to endure these startling and home-shaking sonic booms at all hours because of a short term national security issue.
- Increasing sonic booms over Ventura County and declaring them as having no significant impact, is a business decision of VAFB.
- The impact on the residents of Ventura County is not significant to VAFB considering the economic value of the SpaceX contract.

Here is some further info from local media, including details on SpaceX's refusal to address the impact of sonic booms on both people and wildlife:
https://www.independent.com/2024/09/17/falcon-9-launch-cadence-increase-environmental-assessment/
https://amigos805.com/bilingual-report-falcon-9-launch-cadence-increate-environmental-assessment/
https://lompocrecord.com/news/local/military/vandenberg/increased-vsfb-launch-assessment-finds-no-significant-impact-public-comment-period-opens-tuesday/article_ab4ecdcb-2a27-5939-a541-9d7d27a8a290.html
https://santamariatimes.com/news/local/military/vandenberg/increased-vsfb-launch-assessment-finds-no-significant-impact-public-comment-period-opens-tuesday/article_2fc7ebde-7479-11ef-9111-0f2126fded3b.html

Shanna Wasson Taylor
Ventura CA

From: [redacted]
To: WHITSITT-ODELL, TIFFANY A CIV USSF SSC 30 CES/CEIEA
Cc: EORFC@coastal.ca.gov
Subject: [Non-DoD Source] SpaceX Environmental Assessment
Date: Wednesday, October 16, 2024 12:12:04 PM

You don't often get email from [redacted] Learn why this is important

Dear Ms. Whitsitt - Odell -

Please prepare an Environmental Impact Statement for ALL SpaceX launches and any additional plans or projects they are proposing given the reasonably foreseeable significant effect everything SpaceX is doing to our environment that is detrimental. This includes impacts to threatened and endangered species and a host of other harmful impacts including increased climate change issues.

Appendix A of the Environmental Assessment includes pages of species that are of concern, but there seems to be no concern on the part of the Space Force to require SpaceX to follow the proper protocols. One of the first steps should be that SpaceX apply for a Coastal Development Permit, but everyone seems to be looking past the obvious and necessary environmental protections for the richest man in the world.

In case you haven't seen the latest threats from SpaceX, please have a read https://www.pressdemocrat.com/article/news/elon-musk-spacex-caryl-hart-coastal-commission/

I ask again: Please prepare an Environmental Impact Statement.

Thank you -

Penny Elia

From: [redacted]
To: WHITSITT-ODELL, TIFFANY A CIV USSF SSC 30 CES/CEIEA
Subject: [Non-DoD Source] SpaceX launches
Date: Thursday, October 3, 2024 1:42:23 PM

You don't often get email from [redacted] Learn why this is important

Dear Tiffany,

After reading about the effects that the SpaceX launches are having on the snowy plover and other animals, not to mention humans when we hear the sonic boom, we encourage SpaceX to find an alternative location for launching. For example, they could create an offshore launching site.

Best,
Julie Rodgers and Antonio Cortijo

From: [redacted]
To: WHITSITT-ODELL, TIFFANY A CIV USSF SSC 30 CES/CEIEA
Subject: [Non-DoD Source] SpaceX launches
Date: Sunday, October 6, 2024 5:59:51 PM

You don't often get email from [redacted] Learn why this is important

Hello Tiffany,

The proposed increase to 50 satellites launched per year by SpaceX will mean almost 1 launch per week. These launches once fascinating now rattle our windows and are disturbing and disruptive. More launches mean that more toxic fuel and emissions are going into the sensitive Vandenberg and Gaviota coast environments. Our night sky environment is being affected as well. We also should be informed of the full purpose & capabilities built into the instruments being launched. Long term effects need to be studied. Let's do the studies first then consider adding launches.
Please ask the Commission to require a thorough multidisciplinary environmental Impact statement be prepared before any additional launches are added to the Vandenberg launch schedule. Also please require that regular and thorough monitoring be required and well funded for all future requests.
This project has a reasonably foreseeable significant effect on the environment, including on the threatened and endangered species of the surrounding areas.

Sincerely,
Gail Milliken

From: [redacted]
To: WHITSITT-ODELL, TIFFANY A CIV USSF SSC 30 CES/CEIEA
Subject: [Non-DoD Source] SpaceX
Date: Friday, October 4, 2024 8:55:39 PM

You don't often get email from [redacted] Learn why this is important

Public comment for upcoming meeting:

In view of the undeniable environmental effects of rocket launches at Vandenberg, I strongly encourage the Coastal Commission to reject to the proposed increase in the number of launches submitted by SpaceX. These effects should be thoroughly studied and understood before you approve any increase in launches. You have a responsibility to protect both the natural habitat and the residents of our coastal shore.

Susan Shields
Resident of City of Santa Barbara

October 17, 2024

Ms. Tiffany Whitsitt-Odell
Space Launch Delta 30
Installation Management Flight Environmental Assets Building 11146
Vandenberg SFB, CA 93437
tiffany.whitsittodell@spaceforce.mil

Re: Draft Environmental Assessment (EA) and Finding of No Significant Impact (FONSI) for the Falcon 9 Launch Cadence Increase at Vandenberg Space Force Base, California.

Dear Ms.Tiffany Whitsitt-Odell,

On behalf of Audubon California, Gaviota Coast Conservancy, Surfrider Foundation, Santa Barbara Audubon Society, Sierra Club, California Coastal Protection Network, Environmental Center of San Diego, Coastal Environmental Rights Foundation, Center for Biological Diversity, and Ventura Audubon Society we respectfully submit these comments regarding the draft Environmental Assessment (EA) and Finding of No Significant Impact (FONSI) for the Falcon 9 Launch Cadence Increase at Vandenberg Space Force Base (VSFB), California.

The Proposed Action would increase annual SpaceX launches from VSFB on the Gaviota Coast from 36 to 50 annual launches, which represents a nearly 8-fold increase in the historic average of 6.2 annual launches. An Environmental Impact Statement (EIS) is required for this Proposed Action due to its significant effects on the quality of the human environment, including effects on natural resources and on the components, structures, and functioning of affected ecosystems. (NEPA § 102 (2)(C), 40 CFR 1502.3, 40 CFR 1508.1(g)(1))

The Gaviota Coast is Southern California's largest continuous stretch of rural coastal land and contains its healthiest remaining coastal ecosystem.[1] One of only five Mediterranean climate regions which globally encompass only 2% of the world's land area but 20% of its plant species, this region of California is a recognized biodiversity hotspot and refuge for endemic

[1] Gaviota Coast Plan, County of Santa Barbara, p. 2-1, available at: https://cosantabarbara.box.com/s/67cui9hpdphz64ajtmbdndqwq1x8tr5h

species that are threatened by human development.[2] At least 83 special status species are within the Proposed Action's region of influence including 33 special status bird species and 13 special status marine mammal species (EA pp. 3-23-28, 3-34 – 3-35). The Proposed Action is "likely to adversely affect" four threatened and endangered species including Western snowy plover, California least tern, southwestern pond turtle[3] and California red-legged frog. Discussed below, significant adverse effects on these species and their habitats are likely occurring with the existing launch cadence, and efforts to monitor and analyze those effects are currently underway. Any additional increase, including this proposal, requires analysis in an EIS. An EIS is also required to address significant effects related to GHG emissions, beach access, and water resources. Moreover, certain legal deficiencies must be remedied for compliance with NEPA.

1. The Proposed Action Would Have Significant Adverse Effects on Special Status Terrestrial Species.

    a. Federally Threatened Western Snowy Plover

The Western Snowy Plover (*Charadrius nivosus nivosus*) was federally listed as a threatened species in 1993 under the Endangered Species Preservation Act of 1966 and was later listed as a bird species of special concern by the State of California in 1978.[4] Vandenberg Space Force Base sits within the Snowy Plover recovery unit (RU) 5. Based on the 2024 Pacific Coast Distinct Population Segment of Western Snowy Plover 5-year review, RU5 continues to hold the highest number of Snowy Plovers out of the 6 regional units.[5] However, since the 2019 Review, breeding adults counted during the breeding window have declined.[6] The 2024 Review describes threats that Snowy Plovers are faced with which include increased rocket launches from spacecraft. The Review states, "During the terrestrial sonic boom events plovers exhibit stress responses such as hunkering down over the nest or abandoning the nest, which may have resulted in damage to eggs and embryos."[7] Increased nest abandonment was

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[2] See Jack and Laura Dangermond Preserve, Integrated Resources Management Plan, The Nature Conservancy, available at: https://www.scienceforconservation.org/assets/downloads/tncDangermondPreserveIRMP.pdf

[3] Southwestern pond turtle is not yet listed under the Endangered Species Act but is currently proposed threatened and under federal review for listing under the Act (88 FR 68370).

[4] USFWS, Pacific Coast Distinct Population Segment of Western Snowy Plover 5-Year Review, 2024 (https://ecosphere-documents-production-public.s3.amazonaws.com/sams/public_docs/species_nonpublish/19614.pdf)

[5] Ibid

[6] Ibid

[7] Ibid

documented in 2023 and trends showed abandonment was higher for sites closer to rocket launches.[8]

Increased launches at VSFB, carrying one of the largest snowy plover colonies along the U.S. West Coast, could have disproportionately negative impacts to the entire range and must be approached with caution. While these impacts and number of launches will be new to California, populations of Piping Plovers in Texas have shown what the potential impacts are when we increase launches. Based on data from Boca Chica, Texas, Piping Plover population occupancy decreased by 54%.[9] From the 2024 Review, the RU5 Snowy Plover population sits at 676 birds, which is significantly less than the recovery goal of 1200 breeding adults.[10] A drop in population will move us further away from our goal to recover this threatened species.

While predators are an issue at military sites and predator management has been proposed, more must be done to protect these vulnerable species. We support the restoration opportunity at the Santa Ynez River Estuary, as Audubon California created a restoration design for the site several years ago funded by the California State Coastal Conservancy. The 5-Year Review states, “It is possible that effects could affect a broader range beyond Vandenberg Space Force Base depending on the trajectory of launches, but more data are needed to understand the extent of these effects.”[11] With the rapid increase in launches, more data must be collected to fully understand the impacts of these launches before 50 launches a year are approved. It is unclear what the effects will have outside of VSFB and with the rapid number of launches requested, mitigation should be considered both onsite and offsite. An In-Lieu Fee (ILF) program should be established to help fund these mitigation projects offsite. Conservation banks along the California coast aren’t easily feasible with the lack of habitat and development. An ILF program can offer an opportunity to conserve existing areas Plovers depend on and ensure their population remains stable.

b. Federally Endangered California Least Tern

The California Least Tern (*Sternula antillarum browni*) was federally listed in 1969 under the Endangered Species Preservation Act of 1966 and was later listed by the State of California in 1971 under the California Endangered Species Act[12]. The California Least Terns are colonial

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[8] Ibid
[9] Lipton, Eric. “Wildlife protections take a back seat to SpaceX’s ambitions” New York Times, 7 July 2024, https://www.nytimes.com/2024/07/07/us/politics/spacex-wildlife-texas.html?unlocked_article_code=1.5U0.lrUE.d6z3KNQB_TLG.
[10] USFWS, 5-Year Review, 2024.
[11] Ibid
[12] U.S. Fish and Wildlife Service. 2020. California least tern (Sternula antillarum browni) 5-year Review: 2020 Summary and Evaluation. Carlsbad Fish and Wildlife Office, Carlsbad, CA. 2.

seabirds and nest between May and August.[13] Historically CA Least Terns have bred at various locations along the north VSFB coastline from San Anotnio Creek to the Santa Ynez River estuary, spanning 10 km. [14] In 2023 from March to September, Point Blue monitored Western Snowy Plover and California Least Tern nesting sites along VSFB using deployed cameras. It was noteworthy that CA Least Terns were observed flushing from their nest during both initial launch noise and sonic booms.[15] Due to their colonial nature, the entire colony will flush in response to a disturbance. Studies have shown that disturbances that cause flushing can have long term impacts such as reduction in breeding success or population size.[16] The Point Blue study states that it will be important to continue monitoring the potential impacts of launches to CA Least Terns nesting success and breeding population size as the cadence of launches at VSFB increases.[17]

More data is needed to fully understand the impacts of launch noise and sonic booms. While the study by Point Blue in 2023 was conducted during the breeding season, the hard drive where most of the data was stored failed and only a portion of the data was recovered. The Biological Opinion the USFWS conducted in 2024, only covered a three-month span from October to December.[18] These months fall outside of the breeding season for CA Least Terns. It is essential that we obtain data on potential impacts during the nesting season, when these species are at their most vulnerable, before increasing the number of launches in this sensitive habitat area.

c. Federally Threatened California Red-Legged Frog

The historical range of the California red-legged frog (*Rana draytonii*) extended from the southern Mendocino County coast, inland from the vicinity of Redding, and southward to northwestern Baja California, Mexico, but has sustained a 70 percent reduction in its geographic range and is now listed as threatened under the ESA. USFWS Biological Opinion, 8/28/24, p. 61. California red-legged frogs have been documented in nearly all permanent streams and ponds on VSFB as well as most seasonally inundated wetland and riparian sites. Id.

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13 Ibid 6.
14 Robinette, E.Rice, S.Gautreaux, and J.Howar. 2024. Monitoring of California Least Terns and Western Snowy Plovers on Vandenberg Space Force Base during 11 SpaceX Falcon 9 Launches in 2023. 4.
15 Ibid 44.
16 Rojek, N.A., M. W. Parker, H. R. Carter, and G. J. McChesney. 2007. Aircraft and Vessel Disturbances to Common Murres Uria aalge at Breeding Colonies in Central California, 1997–1999. Marine Ornithology 35: 61–69. Cited in Robinette, 2024.43
17 Robinette, 2024. 44.
18 U.S. Fish and Wildlife Service. 2024. Biological Opinion on the Launch, Boost-Back, and Landing of the Falcon 9 First Stage at Space Launch Complex 4 (SLC-4) with project modification to include up to 16 additional launches between October 1 and December 31, 2024, Vandenberg Space Force Base, Santa Barbara County, California. Pg.1

Documented populations exist in Bear Creek (located approximately 0.75 mile to the northeast of SLC-4), and Honda Creek (located approximately 2 miles south of SLC-4), and many other locations within the Launch Noise and Overpressure Effect area. Id., pp. 61-62.

The USFWS determined that "the project may result in effects to dispersal behavior, calling, and stress hormone accumulation that could have deleterious physiological effects and overall degrade the quality of existing habitat" and that "using the best available information, the proposed routine noise disturbance over the duration of the proposed project (three months) has the potential to impact the breeding success of California red-legged frog during the 2024 breeding season." 8/24 BO, p. 86. Meanwhile proposed mitigation for the impacts from launch noise and sonic booms is not protective of the important California red-legged frog habitat within the Launch Noise and Overpressure Effect area, resulting in a loss of important habitat in Bear Creek and Honda Creek that presently supports the threatened species. These significant effects on the reproductive success and important habitats of a threatened species must be studied in an EIS, and mitigated with protective measures *in addition* to compensatory mitigation (e.g. restoration of additional habitat areas).

a. Proposed Federally Threatened Southwestern Pond Turtle

The southwestern pond turtle (*Actinemys pallida*) is not currently listed under the ESA, but is currently proposed threatened and under federal review for listing under the Act (88 FR 68370). Southwestern pond turtles are anticipated to occupy wetland and riparian features across VSFB, including in large perennial features (Santa Ynez River, San Antonio Creek), large portions of which are included in the Launch Noise Effects and Overpressure Effect Areas. EA p. 59. Southwestern pond turtles overwinter in a state of little to no activity (e.g., brumation) during the cooler months of the year, nesting in shallow soils, sometimes with hatchlings. BO p. 41-42. "Disturbance needs to be infrequent enough or of sufficiently low intensity that nesting females are not disturbed." Id., p. 41. UFSWS admits to have "no specific data on the response of nesting or overwintering southwestern pond turtle to varying levels or duration of exposure to launch operation vibration." Id., p. 42. However, "the Service anticipates that the proposed project would constitute temporary degradation of southwestern pond turtle habitat across VSFB, particularly in features most adjacent to SLC-4 including Bear Creek, Honda Creek, and portions of the Santa Ynez River due to sensory pollutants (e.g., noise, overpressure, and potential for vibration) associated with the proposed action's increase in launch operations. Until the novel effects of the project activity are studied, the Service is unable to anticipate the specific response at this time using available information." Id., p. 104.

Like with California red-legged frog, mitigation for the impacts from launch noise and sonic booms is not protective of the important southwestern pond turtle habitat within the

Launch Noise and Overpressure Effect area, resulting in a loss of important habitat that presently supports the threatened species. Much more data must be collected about the impacts of launch nose, sonic booms, and associated vibrations on southwestern pond turtle, and protective mitigation measures must be developed in addition to compensatory mitigation (e.g. restoration of additional habitat areas).

2. The Proposed Action's Effects on Marine Reserves Requires Additional Analysis

On October 11th, the Biden-Harris Administration announced that NOAA is designating 4,543 square miles of coastal and offshore waters along 116 miles of California's central coast the Chumash Heritage National Marine Sanctuary (CHNMS)[19] - the first Tribally nominated National Marine Sanctuary in the US. The EA acknowledges that the Northern Chumash Tribal Council is pursuing designation for the CHNMS and that NOAA accepted the nomination for future consideration. However the EA states that "[b]ecause the CHNMS has not been designated at this time, it is not carried forward for analysis." (EA p. 3-36.) How and whether the Proposed Action, including the deposition of marine debris within the CHNMS boundaries, can be allowed within the CHNMS boundaries must be evaluated in this NEPA process.

3. The Proposed Action Would Cause Significant Adverse Effects from GHG Emissions.

"The United States faces a profound climate crisis and there is little time left to avoid a dangerous—potentially catastrophic—climate trajectory. Climate change is a fundamental environmental issue, and its effects on the human environment fall squarely within NEPA's purview." (Council on Environmental Quality (CEQ) 88 FR 1196).

The Proposed Action would result in an additional 18,300 metric tons of CO_2e per year (EA p. 3-7). The social cost of GHG (SC-GHG) associated with this additional carbon pollution is described in the EA as "over $14 million, under a 3% discount rate over $41 million, and at a 2.5% discount rate over $58 million" (EA p. 3-7) "Under USEPA's draft estimates for SC-GHGs, the Proposed Action would have a SC-GHG of over $98 million under the 2.5% discount rate, under the 2% discount rate over $152 million, and at a 1.5% discount rate over $245 million. (EA p. 3-8) Notwithstanding this dramatic cost to the human environment, the EA does not make any effort to determine the significance of this impact, pointing to the lack of an established FAA significance threshold for climate. (Id.)

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19 https://www.noaa.gov/news-release/biden-harris-administration-noaa-designate-3rd-largest-national-marine-sanctuary

However, CEQ's interim guidance on analyzing greenhouse gas (GHG) and climate change effects advises agencies "that the "rule of reason" inherent in NEPA and the CEQ Regulations should guide agencies in determining, based on their expertise and experience, how to consider an environmental effect and prepare an analysis based on the available information". (Id.) The guidance elaborates:

> Where helpful to provide context, such as for proposed actions with relatively large GHG emissions or reductions or that will expand or perpetuate reliance on GHG-emitting energy sources, agencies should explain how the proposed action and alternatives would help meet or detract from achieving relevant climate action goals and commitments, including Federal goals, international agreements, state or regional goals, Tribal goals, agency-specific goals, or others as appropriate.

The interim guidance also reminds agencies "to incorporate environmental justice considerations into their analyses of climate-related effects, consistent with Executive Orders 12898 and 14008." (Id.)

Pursuant to the "rule of reason", 18,300 metric tons of CO2e per year, with a societal cost potentially as high as $245 million, is plainly a significant adverse effect of the proposed action necessitating evaluation in an EIS. Moreover, the SpaceX EA does not explain how the proposed action would detract from achieving relevant climate action goals and commitments, and does not incorporate environmental justice considerations in their analysis of climate impacts.

4. The Environmental Assessment Unlawfully Narrows the Action's Purpose and Need to Eliminate Reasonable Alternatives.

The EA states that the purpose of the Proposed Action–increasing the annual number of Falcon 9 launches from 36 to 50 per year and ultimately to 100 launches per year– "is to provide greater mission capability to the DOD, NASA and commercial customers." EA at 1.2. The EA states that the need for the Proposed Action is to "ensure United States Space Force (USSF) Assured Access to Space without compromising current launch capabilities." EA at 1.2. The EA also states that the "current launch capacity is insufficient to meet critical DOD and key commercial launch missions." EA at 1.1.

The EA lacks information about how many launches are needed to meet critical DOD needs and how many launches would merely provide extra commercial capacity. This information is necessary to determine whether an alternative involving fewer launches per year could meet the DOD's critical national security needs while minimizing impacts on wildlife, people, and the environment. As case law acknowledges, "an agency cannot define its objectives in unreasonably narrow terms." City of Carmel-by-the-Sea v. U.S. Dep't of Transp., 123 F.3d 1142, 1155 (9th Cir. 1997). Indeed, an agency "may not define the objectives of its action in terms so unreasonably narrow that only one alternative from among the environmentally benign ones in the agency's power would accomplish the goals of the action," rendering the environmental review a "foreordained formality." Friends of Southeast's Future v. Morrison, 153 F.3d 1059, 1066 (9th Cir. 1998).

An agency may not "adopt[] private interests to draft a narrow purpose and need statement that excludes alternatives that fail to meet specific private objectives." Nat'l Parks & Conserv. Ass'n v. Bureau of Land Management, 606 F.3d 1058, 1071 (9th Cir. 2010). The Ninth Circuit has rejected a Bureau of Land Management NEPA document where the Bureau adopted a private company's "interests as its own to craft a purpose and need statement so narrowly drawn as to foreordain approval" of the proposed alternative. Id. at 1072. The Court upheld the district court's finding that the agency's "purpose and need" violated NEPA and that the agency failed to consider a reasonable range of alternatives. Id.

Like the Bureau of Land Management in the National Parks & Conservation Association case, the United States Space Force has adopted Space X's private commercial needs as its own purpose and need, unreasonably restricting the range of feasible alternatives, in violation of NEPA. To correct this error, the United States Space Force must clarify how many launches are necessary to meet DOD and NASA mission critical needs and then identify launch cadence alternatives that meet those needs. Clarity is needed to show how many of the proposed launches will carry out federal agency activities versus private activities.

5. The EA Used Inappropriate Measures to Evaluate the Impact of Noise from Sonic Booms and rocket engines.

The EA recognizes that "[r]ocket engine noise and sonic booms are acute, non-sustained, and unpredictable." EA at 3.2.1. It explains that "[a] sonic boom is an impulsive noise similar to thunder caused when an aircraft or rocket vehicle exceeds the speed of sound." Id. To measure the impact of the acute noise from rocket engines and sonic booms, the Agency used Day-Night Average Sound Level, which is "the energy-averaged sound level measured over a 24-hour period." EA at 3.2.1.1.1. The EA acknowledges that it may also use the Community Noise Equivalent Level, which is "an energy-averaged sound level measured over a 24-hour period," to evaluate noise impacts in California. Id.

The EA cannot accurately evaluate the impact of acute noises like sonic booms and rocket engines by using a metric that averages noise over 24 hours. While a 24-hour noise average might make sense to evaluate chronic noise from airport take-offs and landings, those metrics mask the true impact of acute noise in contravention of NEPA's charge to take a "hard look" at a project's environmental impacts.

Indeed, the EA's analysis demonstrates the insufficiency of its chosen metric. The EA reasons that because "[a] sonic boom is typically between 300 and 600 milliseconds in duration,... the contribution to the daily exposure is extremely minimal and would not contribute substantially towards reaching a CNEL of 65 dBA." EA at 3.2.2.1.3. The EAalso concluded that "injury to the ear has been noted above levels [similar to] 170 psf, very far above predicted levels for the Falcon 9, thus injuries would not occur." Id. Yet this analysis does not examine potentially significant cumulative impacts that the noise from sonic booms and rocket engines might have on people's enjoyment of nearby recreational areas or their homes. To properly analyze noise impacts on people, the EA must identify a different metric that examines acute noise impacts and evaluate those impacts in an Environmental Impact Statement.

6. A Mitigated FONSI Cannot Be Issued Where Impacts From the Sonic Boom Have Not Been Quantified and Cannot Be Mitigated.

The Finding of No Significant Impact (FONSI) is based on a plan to implement mitigation measures. Specifically, the FONSI states that "prescribed mitigation and/or minimization measures [would] ensure no significant impacts occur because of the Proposed Action." FONSI at 3. However, the EA acknowledges, "There are no feasible methods to minimize the intensity of the sonic boom or engine noise." EA Appendix A at 2.3.

The EA acknowledges that "[w]ildlife responses to noise can be behavioral or physiological, ranging from mild, such as an increase to heart rate, to more damaging effects on metabolism and hormone balance." EA 3.3.2.1.1. The EA therefore admits that noise can have significant impacts on wildlife. The EA also admits that "exact predictions of the effects on each species are unreliable without data pertaining to the behavioral responsiveness and physiological sensitivity to noise of those species or similar species." Id. Without data and studies the Agency admits is necessary to evaluate noise impacts on wildlife, the Agency's conclusion that noise "would not have a significant effect on wildlife resources" is arbitrary and capricious and not supported by evidence in the record. EA at 3.3.2.1.1.

Similarly, the EA admits that "the increased tempo of launches and landings would increase the frequency at which listed species and migratory birds could respond behaviorally and physiologically to noise." EA at 3.3.2.1.2. The EA recognizes that "[t]here could potentially be a corresponding increase in effects such as long-term habitat avoidance and decreased reproductive success." Id. The EA also concludes that "[i]t is not feasible to predict the number or exposures that would correspond to these types of effects." Id. Therefore, the EA admits that it has not evaluated the potential for the noise to cause significant effects on listed species. Instead, the EA suggests "population monitoring may be used to evaluate long-term noise impacts." Id. In other words, the Proposed Action risks significant negative impacts to listed species because the proposed action is unprecedented in its scope and merely monitoring these potentially significant impacts is proposed. And further, the EA did not conclude, nor could it conclude based on evidence in the record, that the noise impacts to listed species was less than significant.

First, these noise impacts should be evaluated in an EIS because they are potentially significant. Where an EA determines that there may be potentially significant impacts to the environment, the proper next step is an EIS to fully evaluate the impacts, not a FONSI. To the extent that data is unavailable, it should be assumed that the noise impacts from the Proposed Action will significantly affect wildlife. Also, gathering data from the existing launches to inform this current NEPA process is essential. The lack of data from existing launches and launch frequency weighs in favor of assuming that any increase in launch frequency would have significant negative impacts on wildlife.

Finally, a mitigated FONSI is inappropriate unless the record demonstrates that the identified mitigation measures will reduce a proposed action's impacts to less than significant. See O'Reilly v. U.S. Army Corps of Engr's, 477 F.3d 225, 234 (5th Cir. 2007). The EAcannot rely on the current record, which identifies potentially significant impacts from noise to wildlife and admits that impacts from sonic booms and rocket engines cannot be mitigated, to issue a mitigated FONSI. Indeed, "[t]he record before us… is simply not sufficient to determine whether the mitigated FONSI relies on 'mitigation measures which… compensate for any adverse environmental impacts stemming from the original proposal' that, unmitigated, would be significant." Id.

7. The EA Inadequately Evaluates Impacts to Beach Access.

The EA acknowledges that "[i]mpacts to Jalama Beach County Park would result from occasional temporary evacuation of the public during launch/landing events." EA at 3.8.2.1. The EA does not quantify how many times these evacuations would occur or how many people would be impacted by these evacuations and what type of recreation this would disrupt. Nor does it evaluate how many public evacuations would occur if there was an alternative that considered only DOD and NASA mission-critical launches instead of expanding commercial launches to meet the desires of private companies. The EA also admits that "Surf Beach and County of Santa Barbara Ocean Beach Park would… be closed during SLC-4 landing events up to 12 times per year." Id. The EA does not evaluate how many people or what types of recreation would be impacted by these closures or if fewer closures would be possible under an alternative that only provided for DOD and NASA mission critical launches. VSFB previously violated a California Coastal Commission Consistency Determination due to launch activities resulting in more beach closures that were agreed upon with the state agency at Jalama Beach County Park. We are concerned that launch activities and the potential need for temporary park evacuation may also deter visitors and negatively impact coastal access. Furthermore, the California Coastal Commission has found that the increase to 50 launches is not consistent with the California Coastal Zone Management Act at their October 2024 hearing.

Further, while the EA concludes that the closures would "not substantially diminish the protected activities, features, or attributes of any section 4(f) properties and… would not result in substantial impairment of the properties," there is not evidence in the record to support that conclusion. Additionally, the EA does not evaluate whether these impacts on public access and recreation would have a significant impact on beach and public access and recreation. An EIS must be prepared to evaluate these potentially significant impacts.

8. The EA Inadequately Evaluates Impacts to Water Resources.

The EA omits any evaluation of the potential impacts to Spring Canyon, instead referring to a 2023 SEIS. That 2023 SEIS did not evaluate impacts to Spring Canyon from the Proposed Alternative. This evaluation is legally required and must be provided.

Similarly, the EA omits any evaluation of potential impacts to the Broad Ocean from the Proposed Action. Referring to the 2023 SEIS, which did not evaluate the impacts the Proposed Action would have on the ocean, is unlawful. Correcting these omissions is required to comply with NEPA.

9. Conclusion

For the foregoing reasons, we respectfully request that an Environmental Impact Statement be prepared to fully evaluate the significant effects, including cumulative effects, of the Proposed Action on the environment.

Sincerely,

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SUBJECT: ENVIRONMENTAL ASSESSMENT (EA) FOR THE FALCON 9 CADENCE INCREASE PROJECT AT VANDENBERG SPACE FORCE BASE, CALIFORNIA, SCH NO. 2024090604, SANTA BARBARA COUNTY, CA

Dear Tiffany Whitsitt-Odell:

The California Department of Fish and Wildlife (CDFW) reviewed the EA from The Department of Air Force (DAF) for the Falcon 9 Cadence Increase Project (Project) pursuant to the National Environmental Policy Act (NEPA) of 1969 with the purpose of informing decision-makers and the public regarding potential environmental effects related to the Project.

Thank you for the opportunity to provide comments and recommendations regarding those activities involved in the Project that may affect California fish and wildlife. Likewise, CDFW appreciates the opportunity to provide comments regarding those aspects of the Project that CDFW, by law, may be required to carry out or approve through the exercise of its own regulatory authority under the Fish and Game Code.

CDFW ROLE

CDFW is California’s Trustee Agency for fish and wildlife resources and holds those resources in trust by statute for all the people of the State (Fish & G. Code, §§ 711.7, subd. (a) & 1802; Pub. Resources Code, § 21070; CEQA Guidelines § 15386, subd. (a)). CDFW, in its trustee capacity, has jurisdiction over the conservation, protection, and management of fish, wildlife, native plants, and habitat necessary for biologically sustainable populations of those species (Fish & G. Code, § 1802). Similarly, for purposes of CEQA, CDFW is charged by law to provide, as available, biological expertise during public agency environmental review efforts, focusing specifically on projects and related activities that have the potential to adversely affect fish and wildlife resources.

PROJECT DESCRIPTION SUMMARY

Proponent: Space Exploration Technologies Corporation (SpaceX)

Objective: Overall, the purpose of the proposed Project is to provide greater mission capability to the Department of Defense (DOD), National Aeronautics and Space Administration (NASA), National Security, and commercial customers by increasing Falcon 9's flight opportunities. The Project proposes to increase the Falcon 9 annual launch cadence from 36 to 50 launches per year at Space Launch Complex (SLC)-4 on Vandenberg Space Force Base (VSFB) and modify SLC-6 to support the Falcon launch vehicles. Following each launch at SLC-4, SpaceX would perform a "boost-back" and landing of the first stage boosters up to 50 times, either downrange on a droneship or at landing zones at VSFB. No more than 12 first stage landings would occur at SLC-4 per year. SpaceX is proposing to expand its downrange recovery area by approximately 900 miles west and approximately 1,000 miles south to account for potential missions with an expended first-stage booster. The Project describes a "region of influence" from these activities, which includes areas potentially impacted by sonic boom, rocket engine noise, and increased water usage, due to expansion of the area of noise impacts.

SLC-6: The current Project Description calls for modification of SLC-6 including demolition of existing structures and construction of necessary infrastructure to support the new launch cadence. Demolition includes the use of heavy machinery to cut or pull down the structures or the use of explosives. Infrastructure that is proposed to be constructed are utilities, a new hanger, a vehicle erector system at the launch pad, and minor modification to the existing flame trench. SpaceX would construct new or improve existing power, water, wastewater, and communications utilities. More specifically, SpaceX would construct two landing zones across 16 acres, south of SLC-6. Each of the landing zones would be a total of 400 feet in diameter consisting of a 280 feet diameter concrete pad surrounded by a 60-foot gravel apron and a 30-ft by 30-ft pedestal would also be constructed at each landing pad. A new nitrogen gas line would be constructed from SLC-6 to an equipment bay at the landing zones. Crane storage is proposed to be created on the western boundary. Lastly, a new firebreak is proposed south of the landing zones and Cypress Ridge Road and N Road would be improved for fire access. It is proposed that construction may occur at any time of the day and night.

Alternative Location 1 – SLC-6 with Horizontal Integration Facility: At this alternative location, in addition to activities proposed in the Project Description, the horizontal integration facility (HIF) located north of SLC-6 would be modified. Proposed Project activities would include interior work, construction of an approximately 5,000 square foot annex on the south side of the building, construction of an approximately 42,000 square-foot paved area north of the building, and rails from the hanger to the launch pad. The existing culverts would be maintained, modified, or improved during construction of the rail system.

Alternative Location 2 – SLC-6 with North Hanger: This alternative location, in addition to activities proposed in the Project Description, proposes the construction of an approximately 61,250 square foot hanger north of the launch pad line. Areas around the hanger would be graded to provide rear access to the hanger. Similar to alternative 1, rails would be constructed, and culverts would be maintained, modified, or improved. The SLC-6 fence would be relocated and vehicular access from Lunar Road to N Road would be removed. Lastly, an apron would be constructed to provide rear access into the hanger.

Location: The proposed Project is located on VSFB which in central Santa Barbara County. VSFB is divided into two distinct parts, North Base and South Base, by the Santa Ynez River and State Highway 246. SLC-4 is located on the South Base approximately four miles south of the Santa Ynez River and 0.9 miles east of the Pacific Ocean. SLC-6 is 3.6 miles south of SLC-4, approximately one mile east of the Pacific Ocean.

Biological Setting: The VSFB is located along the south-central coast of California and covers 99,099 acres. Development surrounding SLC-4 and SLC-6 consists of existing infrastructure, developed land and pavement, access roads and parking lots, and maintained vegetation/landscaping. A Supplemental Environmental Assessment (SEA) Launch was created in 2018 for the Launch, Boost-Back, and Landing of the Falcon 9 at Vandenberg Air Force Base, California and Offshore Landing Contingency Options Final EA and in 2023 for the Falcon 9 Cadence Increase at Vandenberg 29 Space Force Base, California and Offshore landing Locations Final EA. Biological surveys were also conducted for SLC-4 in 2017 but concluded that no additional field surveys were needed due to no occurrence of construction-related ground disturbance at this location. Biological surveys for the proposed construction at SLC-6 were conducted during October and November 2023.

Biological resources within and adjacent to the Project area are referenced from the two SEA documents. There are additional species not included in the 2023 SEA that are within the Project's region of influence. Rare plant species Lompoc yerba santa (*Eriodictyon capitatum*; Endangered Species Act (ESA)-listed endangered; California Rare Plant Ranking (CRPR) 1B.2), crisp monardella *(monardella undulata ssp. crispa*; CRPR 1B.2), and beach layia (*Layia carnosa*; ESA-listed endangered; California Endangered Species Act (CESA)-listed endangered species, CRPR 1B.1) were not found during biological surveys but occur in the greater area. Although suitable habitat for Gaviota tarplant (*Deinandra increscens ssp. Villosa*; ESA-listed endangered; CESA-listed endangered species, CRPR 1B.1) exists where physical impacts would occur, only the common unlisted grassland tarplant (*Deinandra increscens ssp. increscens*) was identified. Wildlife species that have potential to be impacted due to the proposed Project include least Bell's vireo (Vireo bellii pusillus; ESA listed-endangered and CESA listed-endangered), monarch – California overwintering population (*Danaus plexippus plexippus;* ESA candidate species), and nesting birds.

CDFW offers the comments and recommendations below to assist the DAF in adequately identifying and/or mitigating the Project's significant, or potentially significant, direct and indirect impacts on wildlife (biological) resources.

Specific Comments

1) **Biological Resource Assessment**. The EA should be amended to include an updated general field survey for SLC-4 and should be conducted prior to Project activities to provide an accurate assessment of plant and wildlife species utilizing the Project area. Generally, CDFW considers surveys older than two years unable to accurately represent baseline conditions. The new biological resources assessment should include a complete assessment and impact analysis of the flora and fauna within the Project area, and should place emphasis upon identifying endangered, threatened, sensitive, regionally and locally unique species, and sensitive habitats. CDFW also considers impacts to Species of Special Concern (SSC) a significant direct and cumulative adverse effect without implementing appropriate avoidance and/or mitigation measures. Mitigation measures to avoid, minimize, or mitigate for these species should also be included in the revised EA.

2) **Least Bell's Vireo**. While CDFW acknowledges that mitigation measure 2.3.6 is intended to minimize impacts to least Bell's vireo, we recommend that the breeding season window referenced be changed to 15 March – 30 September. These birds typically arrive in southern California breeding areas by mid-March to early-April and generally leave by late-September. The breeding season in the EA leaves the potential for least Bell's vireo to be impacted by construction activities, such as the use of explosives and heavy machinery, if surveys are conducted outside of the appropriate breeding season. CDFW recommends adhering to the Least Bell's Vireo Survey Guidelines for the appropriate protocol (USFWS 2001).

3) **Monarchs**. There are multiple monarch butterfly overwintering habitats documented within the SLC-4 Rocket Engine Noise and SLC-4 Falcon 9 First Stage Landing Sonic footprints. Additionally, there are multiple habitats found within a two-mile range of both sites according to the California Natural Diversity Database (CNDDB) (CDFW BIOS 2023). While there are no direct impacts due to construction on monarch butterflies, indirect impacts due to noise could occur. CDFW is concerned that elevated noise from an increase in launches may result in monarch butterflies abandoning the documented overwintering sites and recommends that the DAF incorporate a measure to avoid Project activities near the overwintering sites during periods of monarch aggregation (typically September 30 through March 1).

4) **Rare Plants**. Rare plant species Lompoc yerba santa, crisp monardella, and beach layia have been observed and recorded through the California Natural Diversity Database to occur within and/or near the SLC-4 and SLC-6 sites (CDFW BIOS 2012). Direct impacts at SLC-4 may occur to rare plant species due to increased

wind speeds and maintenance activities. Also, construction activities and vegetation removal at SLC-6 may result in loss of individuals and seedbank and contribute to the population decline of these rare plants. The EA states that areas occupied by these species would not be affected by ground disturbance and physical impacts but does not discuss avoidance of other rare plants documented within the Project area. Given that survey assessments for SLC-4 are seven years old and may or may not have occurred during the blooming period, we have further concerns that the locations of all sensitive plant species are not known. Additionally, biological surveys for SLC-6 were conducted during October and November, which is outside of the blooming period, exacerbating our concerns that locations of these species are not known.

CDFW recommends the EA incorporate a measure that requires a rare plant survey to be conducted prior to any ground-disturbing activities to ensure that no impacts to undetected rare plants occur. CDFW also recommends a qualified botanist conduct a rare plant survey, adhering to CDFW's Protocols for Surveying and Evaluating Impacts to Special Status Native Plant Populations and Sensitive Natural Communities (CDFW 2018). If rare plants are observed within the Project area, the qualified botanist should implement an adequate buffer around the individual plant or population to prevent any potential adverse impacts. If avoidance is not achievable, the EA should offset the loss of rare plants through compensatory mitigation at a minimum of 2:1 ratio. Translocation of these species are not advisable, as there is insufficient data to support that such translocations would be successful.

5) **Nesting Birds**. The Project area of SLC-4 and SLC-6 have vegetation that may provide nesting habitat for various avian species. The proposed Project would impact nesting birds through construction activities, installation activities, elevated-related noise, and vegetation removal. Furthermore, Project activities occurring during the nesting bird season, especially in areas providing suitable habitat, could result in the incidental loss of fertile eggs or nestlings, or nest abandonment.

   CDFW recommends the DAF revise 2.3.1 General Environmental Protection Measures regarding impacts on nesting migratory birds. CDFW recommends that clearing of vegetation occur outside of the peak avian breeding season, which runs from February 1 through September 15 (as early as January 1 for some raptors). If Project construction is necessary during the bird breeding season, a qualified biologist should conduct a nesting bird survey within three days prior to work in the area. The measure should be revised to include a 100-foot buffer from common avian species, 300 feet for listed or highly sensitive, and 500 feet for raptors if an active nest is identified and an established buffer is necessary between construction activities. Reductions in the nest buffer may occur in consideration of site-specific features such as ambient levels of human activity, screening vegetation, or other factors.

FILING FEES

The Project, as proposed, would have an impact on fish and/or wildlife, and assessment of filing fees is necessary. Fees are payable upon filing of the Notice of Determination by the Lead Agency and serve to help defray the cost of environmental review by CDFW. Payment of the fee is required in order for the underlying project approval to be operative, vested, and final. (Cal. Code Regs, tit. 14, § 753.5; Fish & G. Code, § 711.4; Pub. Resources Code, § 21089.)

CONCLUSION

CDFW appreciates the opportunity to comment on the EA to assist the DAF in identifying and mitigating Project impacts on biological resources. Questions regarding this letter or further coordination should be directed to Joleena De La Fe, Environmental Scientist, at (858) 354-3527 or Joleena.delafe@wildlife.ca.gov.

Sincerely,

DocuSigned by:
5991E19EF8094C3...

Victoria Tang
Environmental Program Manager
South Coast Region

ec: California Department of Fish and Wildlife
Victoria Tang, CDFW EPM
Jennifer Turner, CEQA Supervisor

Office of Planning and Research
State.Clearinghouse@opr.ca.gov

REFERENCES

[CDFW] California Department of Fish and Wildlife. 2012. crisp monardella [ds45]. Calif. Dept. of Fish and Wildlife. Biogeographic Information and Observation System (BIOS). Retrieved October 14, 2024, from https://wildlife.ca.gov/Data/BIOS

[CDFW] California Department of Fish and Wildlife. 2018. Protocols for Surveying and Evaluating Impacts to Special Status Native Plant Populations and Natural. Available from: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=18959&inline

[CDFW] California Department of Fish and Wildlife. 2023. monarch - California overwintering population [ds45]. Calif. Dept. of Fish and Wildlife. Biogeographic Information and Observation System (BIOS). Retrieved October 14, 2024, from https://wildlife.ca.gov/Data/BIOS

[CDFW] California Department of Fish and Wildlife. 2024. California Natural Diversity Database. Available from: https://wildlife.ca.gov/Data/CNDDB

[USFWS] United States Fish and Wildlife Service. 2001. Least Bell's Vireo Survey Guidelines. Available from: https://www.fws.gov/sites/default/files/documents/survey-protocol-for-least-bells-vireo.pdf

one COUNTY one FUTURE

COUNTY EXECUTIVE OFFICE
Mona Miyasato, County Executive Officer
Tanja Heitman, Assistant County Executive Officer
Wade Horton, Assistant County Executive Officer

October 15, 2024

Tiffany Whitsitt-Odell
Space Launch Delta 30,
Installation Management Flight Environmental Assets,
Building 11146, Vandenberg SFB, CA 93437

Email: tiffany.whitsitt-odell@spaceforce.mil

Re: Draft Final Environmental Assessment (EA) Falcon 9 Cadence Increase at Vandenberg Space Force Base, California

Dear Ms. Whitsitt-Odell:

Thank you for the opportunity to review and comment on the Draft EA/FONSI for the Falcon 9 Cadence Increase at Vandenberg Space Force Base, California. At this time, the County submits comments from the Fire Department.

If you should have any questions, please do not hesitate to contact my office directly or Lisa Plowman, Planning and Development Director at (805) 568-2086.

Sincerely,

Brittany Odermann
Deputy County Executive Officer

cc:

Lisa Plowman, Director, Planning and Development Department
Zoë Carlson, Senior Planner, Planning and Development Department

Enclosure: Santa Barbra County Fire Department Letter, dated October 14, 2024

Fire Department

"Serving the community since 1926"

HEADQUARTERS
4410 Cathedral Oaks Road
Santa Barbara, CA 93110-1042
(805) 681-5500 FAX: (805) 681-5563

Mark A. Hartwig
Fire Chief / Fire Warden

Garrett Huff
Deputy Fire Chief
Emergency Services

Anthony Stornetta
Deputy Fire Chief
Operations

Kelly Hubbard
OEM Director

Jennie Brunick
Deputy Director
Administration and Finance

October 14, 2024

Tiffany Whitsitt-Odell
NEPA Plannerd
U.S. Space Force

RE: EA 2024-09-16 Spacex_Falcon 9 50 Launch

Dear Ms. Whitsett-Odell,

The Santa Barbara County Fire Department (SBCFD) has reviewed the "Draft Final Environmental Assessment Falcon 9 Cadence Increase at Vandenberg Space Force Base, California September 2024."

SBCFD has reviewed the provided documentation and has no objections to the proposed increase in cadence. While the increased activity is not inconsequential, it is within an acceptable scope from the current cadence to not warrant additional review.

For awareness; and while recognizing SBCFD has no jurisdiction on the Vandenberg Air/Space Force Base, the document does refer to wildland fires and other potential hazards that might occur as a result of a launch. SBCFD has historically been notified of launches and notification to SBCFD should continue. Additionally, SBCFD will seek cost recovery for any incidents requiring SBCFD response for mitigation, rescue or other emergency response efforts.

Please feel free to contact me with any questions, 805-681-5500.

Sincerely,

Fred Tan
Division Chief/Fire Marshal
Santa Barbara County Fire Department

October 14, 2024

Tiffany Whitsitt-Odell
Space Launch Delta 30
Installation Management Flight Environmental Assets, Building 11146
Vandenberg SFB, California 93437
Sent Via Email: tiffany.whitsittodell@spaceforce.mil

Re: Santa Barbara County Air Pollution Control District Comments on the Draft Environmental Assessment and Finding of No Significant Impact for Falcon 9 Cadence Increase at Vandenberg Space Force Base, California

Dear Ms. Whitsitt-Odell:

The Santa Barbara County Air Pollution Control District (District) is a state-designated special district with regulatory authority over stationary sources of air pollution in the county. The District presently permits several commercial operations at Vandenberg Space Force Base (VSFB). In addition, the District reviews environmental documents prepared by other lead agencies to ensure that air quality impacts from mobile, stationary, and area sources are addressed and that any adverse impacts are adequately mitigated. The District has reviewed the Draft Environmental Assessment (EA) for the referenced project that consists of an increase in Falcon 9 annual launch cadence from 36 to 50 launches per year at Space Launch Complex 4 (SLC-4) on VSFB, increase Falcon 9 first stage and fairing recovery activities, and expand the recovery area in the Pacific Ocean.

The proposed launch operations, including launch support at SLC-4 on VSFB and "roll-on-roll-off (RORO)" barge operations in California Coastal Waters, will trigger New Source Review (NSR) requirements, including the need to obtain District Authority to Construct (ATC)/Permit to Operate (PTO) permits prior to construction and operation. SpaceX has submitted permit applications to the District and staff is in the process of determining application completeness and fulfillment of applicable NSR requirements and other applicable regulatory requirements.

Comments on the EA

1. **2.1 Proposed Action, Section 2.1.2 Launch, page 2-1**: This section states that "*there would be no more than 30 static fire events per year*." The *Air Quality and Greenhouse Gas Emissions Technical Report for the Falcon Program Expansion at Vandenberg Space Force Base, California* included as Appendix E of the Draft EA states on page 1 that "*there would be no more than 50 static fire events per year*." Please resolve the discrepancy in the cited number of static launch events.

2. **3.1 Air Quality and Climate, Section 3.1.2.2 General Conformity Impacts, page 3-7**: The last paragraph in this section states that "*The Proposed Action's NOx emissions would be held steady during the lifetime of the project at 21.26 tpy, or 116.49 lbs per day*." The annual total of 21.26 tpy appears to be a typographical error as Table 3.1-5 indicates NOx emissions will increase by 31.26 tpy as a result of the Proposed Action. We advise the DAF to confirm the accuracy of the daily emissions cited and revise if necessary.

If you or the project applicant have any questions regarding these comments, please feel free to contact me at (805) 979-8337 or via email at BarhamC@sbcapcd.org.

Sincerely,

Carly Barham

Carly Barham
Planning Division

cc: David Harris, Manager, District Engineering Division
Planning Chron File

Public Comments and Responses

1. Introduction

The Department of Air Force (DAF) is evaluating the Space Exploration Technologies Corporation (SpaceX) Falcon Program's proposed increase to 50 launches annually at Vandenberg Space Force Base (VSFB). DAF evaluated the potential environmental effects of the activities associated with SpaceX's Falcon Program in an Environmental Assessment (EA).

The 30-day public comment period was initiated with publication of the Draft EA on September 17, 2024. DAF encouraged the public, agency representatives, tribal entities, and other interested parties to provide comments. The public comment period was initially set for 30 days, ending on October 17, 2024. DAF received 17 public comments during the 30-day public comment period as well as several comments from state and federal government agencies. The Final EA considers all input provided on the Draft EA and addresses comments received, as appropriate.

2. Methodology

During the 30-day public comment period, DAF received written public comment submissions. Each comment submission was reviewed and analyzed. Individual comments (i.e., a portion of the text within a comment submission that addresses a specific subject) were identified, and substantive comments grouped by topic. Substantive comments are regarded as those comments that challenge the analysis, methodologies, or information in the Draft EA as being factually inaccurate or analytically inadequate; that identify effects not analyzed or develop and evaluate reasonable alternatives or feasible mitigations not considered by the agency; or that offer specific information that may have a bearing on the decision, such as differences in interpretations of significance, scientific, or technical conclusions. DAF also received non-substantive comments (i.e., comments that expressed a non-substantive personal preference or opinion not tied to specific topic) and non-germane comments (i.e., comments outside the scope of the Proposed Action).

3. Topical Summaries and Responses

As described in Section 2, substantive comments were organized by topic. The following summaries provide fair representation of the relevant, substantive issues submitted on each topic. DAF's response follows each topical summary.

A. Level of Environmental Review / NEPA Process

Comment Summary

Some commenters requested a more robust analysis of environmental impacts of the Proposed Action. Commenters who were not satisfied with the level of environmental review requested that an EIS be prepared due to reasonably foreseeable significant impacts on the environment. Commenters requested a new environmental analysis be conducted over many years to understand the full impact.

Comment Response

The EA was prepared pursuant to NEPA and Council on Environmental Quality NEPA-implementing regulations (40 Code of Federal Regulations [CFR] Parts 1500 to 1508). Effects or impacts means changes to the human environment from the proposed action or alternatives that are reasonably foreseeable and have a reasonably close causal relationship to the Proposed Action or alternatives, including those effects that occur at the same time and place as the Proposed Action or alternatives and may include effects that are later in time or farther removed in distance from the proposed action or alternatives. The EA also considers “reasonably foreseeable environmental trends and planned actions in the area” to be part of the “affected environment” subject to the effects of the Proposed Action and alternatives. Past, ongoing, and reasonably foreseeable future actions that will occur regardless of whether the Proposed Action is taken are considered in the characterization of the affected environment and analysis of the No Action Alternative.

DAF conducted an independent review of the EA, and DAF considered the comments provided on the EA during the public review period. As explained in the EA, the Proposed Action would not result in significant environmental impacts on any environmental resource category. Additionally, as noted in the EA, DAF plans to prepare an environmental impact statement to evaluate future SpaceX launch increases.

DAF must meet federally mandated deadlines and schedules for the NEPA review process, as established in 40 CFR § 1501.10. To ensure timely decision making, agencies shall complete Environmental assessments within 1 year, unless the lead agency extends the deadline in writing and, as applicable, in consultation with any applicant, and establishes a new deadline that provides only so much additional time as is necessary to complete the environmental assessment. Environmental impact statements shall be completed within 2 years, unless the lead agency extends the deadline in writing and, as applicable, in consultation with any applicant and establishes a new deadline that provides only so much additional time as is necessary to complete the environmental impact statement.

B. Purpose and Need/Alternatives

Comment Summary

Commenters stated that the Proposed Action’s Purpose and Need was too narrow and did not provide a reasonable range of alternatives, such as a lower launch cadence. Commenters stated their position that launches for the Department of Defense (DOD) and other government agencies should be considered separately. Commenters requested launches occur at another site rather than VSFB.

Comment Response

The Purpose and Need is discussed in Section 1.2 of the EA. The Proposed Action’s purpose is to provide greater mission capability to the U.S. government and commercial customers by increasing Falcon 9’s flight capacity. The Proposed Action’s need is to ensure USSF Assured Access to Space and to provide critical launch services on behalf of the U.S. government to allow the government to fulfill defense and national security priorities and statutory obligations

Alternative launch locations were considered in Section 2.4 of the EA and were determined not to meet the purpose and need.

C. Air Quality/Climate

Comment Summary

Concerns expressed by commenters included the impacts of pollutants, such as carbon dioxide emissions and greenhouse gas emissions that could result from the Proposed Action and their effect on the health of humans and wildlife. Commenters stated that greenhouse gas emissions were a significant environmental impact.

Comment Response

An analysis of potential air quality impacts, including greenhouse gases (GHG), is discussed in Section 3.2 of the EA. The detailed Air Quality and Greenhouse Gas technical report is included in Appendix E of the Draft EA. The analysis of potential climate impacts was conducted pursuant to DAF's NEPA-implementing policy, procedures, and guidance. The Draft EA appropriately estimates the GHG emissions from the proposed action and demonstrates that the climate change impacts from the proposed action will not have a significant effect on the human environment. The EA estimates of the Proposed Action are well below the established insignificance threshold identified by the Department of the Air Force. *See DAF Greenhouse Gas (GHG) & Climate Change Assessment Guide for Air Quality (AFCEC/CZTQ) (August 2024) ("DAF Assessment Guide").* As explained in the DAF Assessment Guide:

The DAF adopted the Prevention of Significant Deterioration (PSD) threshold for GHG of 75,000 ton per year (tpy) of CO2e (or 68,039 metric ton per year, mtpy) as an indicator or threshold of significance for NEPA air quality impacts in all areas. This indicator does not define a significant impact; however it provides a threshold to identify actions that are insignificant (de minimis, too trivial or minor to merit consideration). Actions with a net change in GHG (CO2e) emissions below the insignificance indicator (threshold) are considered too insignificant on a global scale to warrant any further analysis beyond producing the *ACAM GHG & Climate Change Reports*. Any action with a net change in emissions below 75,000 tpy of CO2e (insignificance indicator) is insignificant and inconsequential; therefore, no further analysis of GHGs or climate change is required.

D. Noise and Noise-Compatible Land Use

Comment Summary

Commenters expressed concern that noise levels would cause negative impacts to local residents and wildlife. Commenters requested local noise ordinances apply to launch activities and were opposed to nighttime launches. Commenters expressed concern for damage to personal property (house/window breaking/rattling) due to noise, vibrations, and sonic booms. Commenters stated this is a significant impact to humans and wildlife. Commenters stated that inappropriate metrics were used to evaluated noise and sonic boom impacts.

Comment Response

Section 3.2 and Appendix F of the EA analyze the potential impacts of noise events generated by the Proposed Action, including overpressure and vibration effects. Noise and sonic booms were modeled (predicted) utilized DAF and FAA approved methods. Additionally, noise modeling has been field verified over many years of collecting data measured during Falcon 9 launches and landings at VSFB. The EA analyzed noise significance criteria in accordance with FAA Order 1050.1F Desk Reference Chapter 11, and determined there would be no significant impact, discussed in Section 3.2 of the EA. DAF determined there would be no significant impact to wildlife due to noise, discussed in Section 3.3 of the EA.

Launches are scheduled based on mission requirements to reach the required orbit, reducing impacts to the National Airspace System administered by the FAA, avoiding conflicts with operations conducted by the Naval Air Warfare Center Weapons Division at Point Mugu and Fleet Area Control and Surveillance Facility San Diego, and other factors. Thus, launches have specific windows of time they occur during. Additionally, as discussed in Appendix D of the EA, DAF and SpaceX have adjusted launches to times that would not require closure of Jalama Beach County Park which result in more nighttime launches.

Noise associated with launch and landing is not expected to produce vibration that would cause structural damage or high contours of noise in neighboring communities. Cumulative noise in surrounding communities, whether from multiple events of a single operation type or from all individual events combined, is estimated to be below levels associated with adverse noise exposure.

Per FAA regulations and the Commercial Space Launch Act (CSLA), SpaceX is required to carry insurance to cover claims by third parties that result from licensed activities, including any structural damage. The FAA requires that SpaceX carry insurance in the amount of the "Maximum Probable Loss," which is determined on a launch-by-launch basis by the FAA and is up to $500,000,000 per launch. In the event that structural damage results from noise-induced vibrations or sonic booms, any such claims of damage would be subject to the insurance policy terms and process specified by the CSLA and the FAA regulations.

E. Water Resources

Comment Summary

Commenters stated the Draft EA omits an evaluation of impacts to Spring Canyon. Commenters stated the EA omits analysis of impacts to the Broad Ocean.

Comment Response

As stated in the Section 3.5.2 of the EA, an analysis of potential impacts to Spring Canyon and the Broad Ocean are included in Section 4.5.1 of the 2023 Supplemental Environmental Assessment and incorporated by reference into the EA. The Proposed Action does not change the results of this prior analysis, as disclosed in Section 3.5.2 of the EA.

F. Biological Resources

Comment Summary

Commenters expressed concerns regarding the potential of the Proposed Action to impact wildlife (including threatened and endangered species) and critical habitat via noise, sonic booms, and vibration. Species of concern that commenters stated were being significantly impacted included, but were not limited to, western snowy plover, California least-tern, California red-legged frog, southwestern pond turtle, and marine mammals. Commenters cited news articles about SpaceX's Starship/Super Heavy's alleged impact on bird populations in Texas as sources for potential impacts on populations due to launch.

Commenters stated that existing launches are having a significant adverse effect on the wildlife populations and requested no additional launches occur. Additionally, commenters requested thorough monitoring be conducted.

Comment Response

The Proposed Action would not result in significant environmental impacts to biological resources, including wildlife and protected species, as discussed in Section 3.3.2 of the EA. Monitoring of launch activities for several decades at VSFB has not found population level impacts to protected species or wildlife in general. The DAF engaged in formal consultation with the United States Fish and Wildlife Service pursuant to Section 7 of the Endangered Species Act. The EA and Biological Assessment acknowledge that the Proposed Action has the potential to adversely affect Endangered Species Act-listed species. The Proposed Action would significantly impact any listed species. The United States Fish and Wildlife Service (USFWS) has concurred with these determinations. Launches from Vandenberg operate under a Letter of Authorization from National Marine Fisheries Service, which permits Level B harassment of marine mammals. Short-term and noise, vibration, and sonic boom effects from launch operations are not expected to significantly impact wildlife. Impacts to wildlife are

A discussion of studies showing the potential effect of launch noise and sonic booms on Endangered Species Act-listed species is included in the Biological Assessment for USFWS, Appendix A of the EA, and for the National marine Fisheries Service, Appendix B of the EA. This analysis includes monitoring data collected during Falcon 9 launches and landings. DAF continues to monitor for potential effects to protected species through monitoring programs reviewed and approved by the USFWS and National Marine Fisheries Service.

Falcon 9 is a different launch vehicle than Starship/Super Heavy, thus alleged impacts in Texas are non-germane to the Proposed Action. This topic was responded to by the FAA in the *Final Programmatic Environmental Assessment for the SpaceX Starship/Super Heavy Launch Vehicle Program at the SpaceX Boca Chica Launch Site in Cameron County, Texas.* The response was as follows:

The FAA appreciates CBBEP's [Coastal Bend Bays & Estuaries] piping plover survey report from October 2021 and the additional information on piping plover populations throughout the Boca Chica/South Bay area over the past three years. The FAA also acknowledges that the USFWS considered this report as part of the FAA's ESA [Endangered Species Act] Section 7 consultation with the USFWS. Since 2015, SpaceX has been conducting annual piping plover surveys around the launch site (across a 3-mile radius) as a requirement of the USFWS's 2013 BO to track the potential effects of SpaceX activities on federally listed birds. SpaceX contracted UTRGV to conduct these surveys and SWCA Environmental Consultants (SWCA) to analyze the results. These ongoing annual surveys (and methodologies developed for the surveys) are specific to the area of the SpaceX activities that have been occurring since 2015. As stated in PEA Section 3.10.4.1, and the FAA's BA, a trend analysis found little to no evidence of meaningful trends, either increasing or decreasing, in the number of birds observed through time for all four target species (Wilson's plover, snowy plover, piping plover, and red knot). To date, avian monitoring conducted by UTRGV has not shown any piping plovers or other species harmed by launch operations. In addition, the FAA has worked with the USFWS, including their avian experts, throughout the formal consultation process to address potential impacts on the piping plover and piping plover critical habitat and to ensure measures are implemented to avoid or minimize effects on the species and its habitat

According to SWCA's review of CBBEP's piping plover report, although the mark-resight models applied appear to be generally suitable for the data type, potential violations of some of the model assumptions and inconsistencies in survey methods may compromise the reported confidence in the results of the report. Specifically, potential violations of the geographic closure/access restriction assumption would *cause the population to be undefined and would produce biased estimates of population and survival. Due to these potential issues, a linear regression through four years of estimates may not constitute a robust or reliable evaluation of a population trend. Additionally, the inconsistent survey methods in the CBBEP study may not adequately address variable detection probability and could have resulted in overly precise confidence intervals. It is not clear whether the resulting analysis is sensitive enough to detect a difference in abundance of 50% in a short 4-year period. In April 2022, CBBEP (Newstead and Hill) also released an extended analysis incorporating additional data for the 2021 field season. The extended analysis states that the original October 2021 report missed a period in which plovers were continuing to enter the Boca Chica population, and the 2021 population mean estimate increased over the previous year. This suggests that the closure assumption was violated in the original report for the 2021 year and may have also been violated in the 2020 year. Also of note, counts of plovers may be confounded by survey frequency, which varied over the four years, with more plovers found in years with more surveys in both analyses. In both of CBBEP's reports, limited details of field methodology were provided to provide context and support for the conclusions. In the extended report, estimates of abundance and survival increased, as well as the reported precision in those estimates, across all four survey years. It is unclear why these estimates changed when the only changes described include the addition of 11 surveys to the 2021 survey year and the addition of a launch covariate*

G. Coastal Resources

Comment Summary

Commenters expressed concern over impacts to the Chumash Heritage National Marine Sanctuary, Jalama Beach County Park, and recreational fishing. Commenters also expressed their concern with impacts from pre-launch weather balloons. Commenters stated SpaceX should apply for a Coastal Development Permit from the California Coastal Commission.

Comment Response

The Chumash Heritage National Marine Sanctuary was officially recognized during the public comment period. An analysis of potential impacts to it has been added to Section 3.7 of the EA.

As discussed in Section 3.8 and Appendix D of the EA, the Proposed Action would not result in additional closures of Jalama Beach County Park than those previously analyzed in past NEPA documents, Consistency Determinations, and Negative Determinations.

As described in in Section 2.1.2.1.1 of the EA, a Notice to Mariners (NOTMAR) would be issued for launch and reentry operations. A NOTMAR provides a notification regarding a temporary hazard within a defined area (a Ship Hazard Area [SHA]) to ensure public safety during proposed operations. A NOTMAR itself does not alter or close shipping lanes; rather, the NOTMAR provides a notification regarding a temporary hazard within a defined area to ensure public safety during the proposed operations. Advanced notice via NOTMAR and identification of SHAs would assist mariners in scheduling around any temporary disruption of shipping activities in the area of operation. The Proposed Action would not require shipping lanes to be altered or closed. Launches and reentries would be of short duration, and scheduled in advance to minimize interruption to ship traffic.

As described in Section 2.1.2, pre-launch weather balloons are required for launch operations. There would be no significant impact on coastal resources due to weather balloons.

VSFB is statutorily excluded from the coastal zone, thus a Coastal Development Permit is not required. Furthermore, the launch program at SLC-4 is a federal agency activity for which a Coastal Development Permit is not required.

H. Environmental Justice

Comment Summary

Commenters stated that the EA did not sufficiently analyze climate change impacts to Environmental Justice communities.

Comment Response

The Proposed Action would not have the potential to lead to a disproportionately high and adverse impact on an environmental justice population due to significant impacts in other environmental impact categories or impacts on the physical or natural environment that affect an environmental justice population. Impacts from the proposed project would not be unique or significant to an environmental justice population.

I. General Opposition

Comment Summary

Commenters who expressed general opposition to the Proposed Action stated that they are not in support of SpaceX launches due to environmental impacts, including the human and natural environment. Other commenters stated their general disdain of SpaceX and/or Elon Musk, do not support launching more material into space, and do not support the Proposed Action. Other commenters generally stated that the project would negatively impact the local community, biological and ecological resources, and homes. Commenters stated the public should be provided a detailed review of all payloads and their purpose prior to launch.

Comment Response

DAF appreciates the public's input on the proposed project.

4. Agency Comments

A. Environmental Protection Agency

Comment – Number of Launches

According to Vandenberg SFB's website, a launch occurred on October 15, 2024, marking the 37th launch from the Vandenberg Space Force Base in 2024. The deadline for commenting on this Draft EA to increase launches above 36 was October 17, 2024; therefore, it is unclear whether the Finding of No Significant Impact (FONSI) had been signed prior to completion of the NEPA process or whether the project was implemented before a FONSI was signed. We recommend clarifying the project analysis and decision-making timeline, and disclosing how the public's input has been included in the NEPA process for this project.

Comment Response

SpaceX has not exceeded 36 Falcon launches at VSFB in 2024. Other launch operators have conducted operations from VSFB, which are included in the total count tracked and publicized by SLD 30.

Comment – General Conformity for Oxide of Nitrogen (NOx) Emissions

The project includes activities in the South Central Coast and the South Coast Air Basins, and the DEA documents the National Ambient Air Quality Standard (NAAQS) nonattainment status for several criteria pollutants in Los Angeles County (p. 3-3). For purposes of demonstrating general conformity, the DEA discloses that emissions fall below the de minimis thresholds with the exception of NOx levels, which are three times greater than the de minimis thresholds for South Coast Air Quality Management District (Table 3.1-5). To achieve conformity, the DEA references the general conformity budgets for NOx and Volatile Organic Compounds (VOC) in the 2016 Air Quality Management Plan and indicates its intention to utilize the set aside accounts established in the 2016 Air Quality Management Plan (p. 3-7). Since the set aside budget is 730 tons per year (tpy) of NOx, the Proposed Action's NOx emissions of approximately 34 tpy would not exceed the remaining set aside budget, and the DEA indicates that conformity will be achieved once the SCAQMD approves use of the set aside account.

EPA is in receipt of the SCAQMD's September 26, 2024 letter indicating the NOx emissions exceeding the de minimis thresholds can be accommodated within the general conformity budgets established in the 2016 AQMP. SCAQMD notes, however, that this is valid through 2030 only, and they identify their interest in eliminating the general conformity set-aside account after 2031 and propose to require that new federal project emissions be accommodated with appropriate mitigation or offset.

Disclose in the Final EA that conformity has been demonstrated through 2030 only. While the DEA indicates that NOX emission will be held steady during the lifetime of the project through 2030, we recommend exploring ways to further reduce NOx emissions in anticipation of the possible elimination of the set aside budget for Los Angeles County. Additionally, since NEPA requires the discussion of reasonable mitigation, we recommend identifying possible emission reductions from the "roll-on-roll-off" barge and associated tugs, in the Final EA. Appendix E states that one tug would use a tier 3 engine or better. If emissions were modeled on this assumption, this should be clearly identified as mitigation in the Finding of No Significant Impact (FONSI).

We note that fully electric and hybrid electric tugboats exist, with hybrid tugboats combining engines with battery-electric propulsion and thus not limited by battery range. EPA is funding a hybrid electric tugboat to be operated out of the Port of Los Angeles and Port of Long Beach which will operate primarily using electricity, with the diesel generators to be used only for safety and emergency reasons. We recommend exploring the use of hybrid-electric tugboats for the activities that would impact Los Angeles County residents in the future.

The SCAQMD also is requiring Space Force to track project activities and emissions within the Basin by quantifying associated emissions and reporting annually to the District by March 30th of each year. This requirement should also be specifically identified in the FONSI.

Comment Response

Section 3.1.2.3 of the Final EA has been revised to state "Operations beyond 2030 would require additional coordination with SCAQMD and an additional GCR Determination." The engine tiers are not considered a mitigation measure for the purpose of NEPA as they are not being utilized to mitigate an impact below significance. The engines are already in use and vessel operations are permitted through the Santa Barbara Air Pollution Control District. SpaceX will continue to explore opportunities to reduce emissions where practicable, but it is imperative the EPA understand that an electric ocean-going tugboat that could support booster transport operations does not exist at this time. The reporting requirements have been added to the FONSI.

Nonconcurrence with recommendation, conformity for the original Proposed Action will be demonstrated upon a formal GCR Determination. A federal agency is obliged to prepare a demonstration of conformity only for those years in which the net annual increase in emissions would equal or exceed the *de minimis* rates. Given the applicable SIP for the South Coast Air Basin and Coachella Valley (2016 AQMP) indicates the South Coast Air Basin (SCAB) will be in attainment with the 8-hour Ozone NAAQS by 2031 (and therefore designated as maintenance with a de minimis value of 100 tpy), the only years the original Proposed Action will equal or exceed the *de minimis* rates are 2025 through 2030 which are accounted for in the set-aside GCR budgets of the applicable SIP. Note that an action only needs to conform to the applicable (current) SIP as written, not to SIPs that do not exist at this time.

The "applicable implementation plan or applicable SIP," which is the 2016 AQMP, states the area will be in attainment by 2031; therefore, the projected emissions will be *de minimis* (consistent with the current SIP) from 2031 and beyond. Note this will be implemented through a future amended FONSI and final resolution of this comment will occur with the finalizing of the future amended FONSI.

Section 176(c)(1) of the CAA and 40 CFR 51.853 asserts that a Federal agency cannot approve or support any activity that does not conform to the applicable SIP. Per 40 CFR 51.852 "Applicable implementation plan or applicable SIP means the portion (or portions) of the SIP or most recent revision thereof, which has been approved under section 110 of the Act, or promulgated under section 110(c) of the Act (Federal implementation plan), or promulgated or approved pursuant to regulations promulgated under section 301(d) of the Act and which implements the relevant requirements of the Act."

The Proposed Action is partially located within the SCAB which is within the geographic jurisdiction of the SCAQMD. On March 3, 2017, the SCAQMD adopted the 2016 Air Quality Management Plan for the South Coast Air Basin and Coachella Valley (2016 AQMP). Therefore, 2016 AQMP is the current "applicable implementation plan or applicable SIP" as defined in 40 CFR 51.852.

The 2016 AQMP, established set-aside budgets to accommodate emissions subject to GCR requirements. The set-aside accounts include 730 tons per year (tpy) of NOx each year starting in 2017 through 2030 and 182.5 tpy of NOx each year in 2031 and thereafter. Additionally, the CAA requires attainment of the standard to be achieved as "expeditiously as practicable," but no later than the attainment years listed in the applicable SIP; Table ES-1 of the 2016 AQMP lists the latest attainment year as 2031 for the 8-hour Ozone NAAQS. As such, in accordance with the 2016 AQMP (the applicable implementation plan or applicable SIP) the SCAB area will be in attainment with the 8-hour Ozone NAAQS by 2031. If the area is within attainment in 2031, the South Coast Air Basin will be designated maintenance from 2031 and beyond. As a maintenance area, the 100 tpy *de minimis* level would apply (40 CFR 51.853); which is above the 31.26 tpy Proposed Action's projections beyond 2030.

Comment – Santa Barbara County Air Pollution Control District

The DEA identifies that Santa Barbara County is in attainment for all NAAQS (p. 3-3). While the federal general conformity program no longer applies to Santa Barbara County because it has been more than twenty years after the redesignation to attainment, we note that the SBCAQMD has a general conformity rule approved into the SIP. Rule 702 sets a de minimis level of 100 tons of NOx per year for maintenance areas.

Consider identifying this requirement in the Final EA in the discussion of the regulatory environment and in future NEPA documents.

Comment Response

Nonconcurrence with recommendation; as EPA Region 9 acknowledged, Santa Barbara County is not considered a maintenance area because the area was redesignated attainment (i.e., maintenance) over twenty years ago (redesignation effective on 8 August 2003). There is no SIP revision that extended the maintenance period. SBAPCD Rule 702 is simply the codification of Santa Barbara's adoption of the Federal General Conformity Regulations (58 FR 63214, 30 November 1993). Although SBAPCD Rule 702 sets a *de minimis* level of 100 tons of NOx per year for maintenance areas, since Santa Barbara County is in attainment (not maintenance or nonattainment) for all criteria pollutants, the recommendation to apply the 100 tpy threshold for NOx to Santa Barbara County is not appropriate.

During October 2014, EPA released guidance, *Transportation Conformity Guidance for Areas Reaching the End of the Maintenance Period*, that clearly stated conformity obligation ends twenty-years after the effective date of the area being redesignated maintenance for a NAAQS (CAA § 175(a) and 42 USC 7505a(c)), unless the approved maintenance plan extends the maintenance period beyond 20 years from designation. Although the October 2014 guidance was written for Transportation Conformity, the regulatory logic extends to General Conformity. Additionally, SBAPCD's Final 2007 Clean Air Plan did not establish emission budgets for conformity purposes and per Section 7.7 of the Plan, "Conformity for the federal 1-hour ozone standard and 8-hour ozone standard no longer applies to Santa Barbara County."

Furthermore, the EPA revoked the 1-Hour Ozone NAAQS effective 15 June 2005, and Santa Barbara County was maintenance for the 1-Hour Ozone NAAQS at the time of the revocation and has been designated as attainment and/or unclassifiable for all other Ozone NAAQS. A conformity analysis is not required in attainment areas in accordance with 42 USC 7506(c)(1)(B) since the area is already in attainment for ozone.

Comment – Climate Change Effects & Stratospheric Ozone Depletion

The DEA does not disclose all of the climate impacts of the Proposed Action. We appreciate that the Space Force estimated the greenhouse gas (GHG) emissions from the action, and applied the social cost of GHGs to the emissions to provide context by quantifying the monetary value of the long-term societal damage caused by GHG emissions (p. 3-7 through 3-8). However, the DEA does not discuss the radiative forcing (RF) effects to climate.

Rocket launches emit black carbon (BC) particles directly into the stratosphere where they accumulate, absorb solar radiation, warm the surrounding air, and are thought to have a much greater contribution to global radiative forcing than surface and aviation sources. According to Ryan et al (2022), rocket emissions of BC produce substantial global mean radiative forcing (RF)after just 3 years of routine space tourism launches, which is a much greater contribution to global radiative forcing (6%) than emissions (0.02%) of all other BC sources, as radiative forcing per unit mass emitted is ∼500 times more than surface and aviation sources.2 According to Ross and Sheaffer (2014), BC and alumina emissions, under some scenarios, have the potential to produce significant RF. They suggest that absorption of solar flux by BC is likely the main RF source from rocket launches, although note that alumina particles, previously thought to cool the Earth by scattering solar flux back to space, are found to absorb outgoing terrestrial longwave radiation, resulting in net positive RF.

Space Force's response to our previous comment to disclose this impact for the Phantom Space Corporation Daytona-E and Laguna-E Launch Operations DEA (letter dated April 24, 2024) stated that "DAF does not think it is appropriate to address potential impacts of space launch on the upper atmosphere as there is not enough research to draw conclusions." While this is an emerging science, there is more than sufficient information available in the literature to disclose this impact while acknowledging the current limitations of the data. Space Force also stated that "there is no DAF or Department of Defense (DoD) guidance that requires this issue to be addressed." NEPA has specific disclosure requirements, and emerging issues are not exempt. The Council on Environmental Quality provides guidance for incomplete or unavailable information in its regulations.

In the final EA, discuss the radiative forcing effects on climate from the proposed action's emissions in the stratosphere in both the project and cumulative (base-wide and national) scenario. This is consistent with the guidance provided in 40 CFR 1502.21 c. We have attached some recent references that include discussion of these impacts.

Global rocket emissions cause ozone depletion and deposit particulates into the stratosphere.

The latest scientific assessment of ozone depletion considers future scenarios of space industry emissions, including the potential for a significant increase in launch rates. Some studies suggest that with a weekly launch frequency, which is the frequency under the proposed action, rockets could be responsible for stratospheric ozone loss to an extent that researchers have identified as being of concern.

Space Force's response to our previous comment to disclose this impact (letter dated April 24, 2024) stated that "DAF does not think it is appropriate to address potential impacts of space launch on the upper atmosphere as there is not enough research to draw conclusions." While this is an emerging science, there is more than sufficient information available in the literature to disclose this impact. Space Force also stated that "there is no DAF or Department of Defense (DoD) guidance that requires this issue to be addressed." NEPA has specific disclosure requirements, and emerging issues are not exempt. Council on Environmental Quality provides guidance for incomplete or unavailable information in its regulations.

Discuss stratospheric ozone depletion effects of the proposed action from both the project and cumulative scenario. To address incomplete or unavailable information, utilize the guidance provided in 40 CFR 1502.21 c (4).

Comment Response

DAF believes the EA discloses climate change impacts that are reasonably certain to occur. DAF appreciates the EPA providing literature on this topic; however EPA did not include a concrete suggestion for how this theoretical information might be applied to analyze the Proposed Action. To the extent there is research in this area, multiple studies indicate that any potential impacts are expected to be small. DAF emphasizes that a "rule of reason" should apply to any such analysis. *See* The Council of Environmental Quality (CEQ)'s "Interim National Environmental Policy Act Guidance on Consideration of Greenhouse Gas Emissions and Climate Change" (88 Fed. Reg. 1196, 1202 (January 9, 2023) ("2023 CEQ Interim Guidance") ("Agencies should be guided by the rule of reason, as well as their expertise and experience, in conducting analysis commensurate with the quantity of projected GHG emissions and using GHG quantification tools suitable for the proposed action. The rule of reason and the concept of proportionality caution against providing an in-depth analysis of emissions regardless of the insignificance of the quantity of GHG emissions that the proposed action would cause.") (footnotes omitted).

DAF underscores that the articles cited by EPA on this issue consistently reference the lack of studies and data related to black carbon-related upper atmosphere impacts, in particular the lack of concrete observational data and in-situ measurements as they relate to rockets such as the Falcon 9, which use a kerosene and liquid oxygen as rocket propellants. For instance, one of the studies cited by EPA in its comments explains that "[t]he literature on BC and alumina emissions is sparse and experimental procedures are not well described; comprehensive in situ stratospheric sampling of rocket particles is almost entirely lacking." Ross, M.N. and Sheaffer, P.M., *Radiative forcing caused by rocket engine emissions*, Earth's Future, 2: 177-196 (2014).

Another recent study emphasizes the lack of concrete scientific consensus around, and understanding of, potential effects, stating: "Many of the impacts of rocket activity involve chemistry and radiative interactions that are poorly understood and, in some cases, not yet studied … The uncertainties in these processes and in any potential new emission sources limit the confidence level of predictions of present and future impacts of space industry emissions on stratospheric ozone." World Meteorological Organization, *Scientific Assessment of Ozone Depletion*, GAW Report No.278, at 49 (2022).

Much of the body of literature concerning potential environmental impacts of rockets relates to solid rocket motors ("SRMs"), like those formerly used for the space shuttle, as opposed to liquid propellant rockets like those used by SpaceX. Solid rocket motors [SRM] are the subject of most of the environmental studies on rocket launches, while the now more commonly used liquid rocket propellants are underrepresented in the literature. The limited studies of emissions from rocket engines using liquid propellent reveal that while they do result in stratospheric ozone loss, solid rocket motors are responsible for orders of magnitude greater loss. Dallas, et al., *The environmental impact of emissions from space launches: A comprehensive review*, Journal of Cleaner Production (May 10, 2020).

Moreover, although the cited studies recognize that emissions might increase in the future with increasing launch activity worldwide, multiple studies indicate that current levels of emissions are insignificant. For instance, the World Meteorological Organization's 2022 Scientific Assessment of Ozone Depletion notes that "[r]ocket launches presently have a small effect on total stratospheric ozone (much less than 0.1%)." Similarly, one of the articles cited by EPA, a recent 2020 "comprehensive review" of the environmental impact of space launches, explained that "[w]hile the total alumina emitted from SRMs is well quantified, uncertainty remains as to the amount of black carbon emitted from hydrocarbon-fueled rocket engines, which makes the climate impact difficult to estimate. At present, the number of rocket launches using kerosene as the propellant will likely have a negligible impact on global climate."). Dallas, et al. The effect of the proposed project itself—which is only an incremental increase of launches—is necessarily only a small fraction of an already small effect.

Notably, in September 2022, the United States Government Accountability Office ("GAO") released a Technology Assessment that includes discussion of the black carbon issue. *See* U.S. GAO, GAO-22-105166, Technology Assessment, Large Constellations of Satellites, Mitigating Environmental and Other Effects (Sept. 2022) ("GAO Technical Assessment"). The GAO relied upon extensive scientific outreach to compile its report. GAO Technical Assessment at 2 ("To conduct this technology assessment, GAO reviewed technical studies, agency documents, and other key reports; interviewed government officials, industry representatives, and researchers; and convened a 2-day meeting of 15 experts from government, industry, academia, and a federally funded research and development center."). While the GAO Technical Assessment acknowledges the issues raised in EPA's comments, it states that "scientific understanding of atmospheric effects is nascent." *Id.* at 10. The report provides multiple examples of where the science is poorly understood, all of which illustrate that mitigation cannot be identified for these issues:

- "Rocket launches and satellite reentries produce particles and gases that can affect atmospheric temperatures and deplete the ozone layer ... However, the size and significance of these effects are poorly understood due to a lack of observational data, and it is not yet clear if mitigation is warranted." *Id.* at 6;

- "[T]he size of the potential effect from particle emissions [e.g. black carbon] is unknown because the observational data needed to validate modeling studies for rocket emissions are few, with most of the data collected in only the lower stratosphere." *Id.* at 13;

- "[T]here are currently no observational data for black carbon emissions from rockets, and as a result, both studies had to make assumptions about the amount and physical processes of black carbon emissions released from rockets." *Id.* at 14; and

- "Current knowledge is not sufficient to determine the extent to which some effects need to be mitigated. For example, researchers do not yet know the types and magnitude of rocket emissions that are likely to result from planned satellite launches. These data are necessary to accurately predict the potential environmental effects from rocket emissions through computer modeling." *Id.* at 53

Put simply, there is not a generally accepted method for analyzing any impacts because the necessary data and tools do not exist to accurately estimate climate or ozone-related effects from black carbon, either as a whole or resulting from this particular Proposed Action.

A detailed analysis and/or effort to quantify the atmospheric effects of this particular project are simply not feasible. Any quantification efforts could not be based on actual observations and/or the use of generally accepted tools; instead, as evidenced by the state of the science, any quantification would instead be based on assumptions and hypotheses. Neither CEQ regulations nor guidance require such a result. *See* 2023 CEQ Interim Guidance ("Agencies should make decisions using current scientific information and methodologies. CEQ does not necessarily expect agencies to fund and conduct original climate change research to support their NEPA analyses or for agencies to require project proponents to do so. Agencies should exercise their discretion to select and use the tools, methodologies, and scientific and research information that are of high quality and available to assess relevant effects, alternatives, and mitigation."). As previously noted, this is an emerging area of study. A discussion of the state of the science and potential effects has been added to Section 3.1.2.4 of the EA.

Comment – Biological Resources/Adaptive Management Program

We very much appreciate that the Space Force has agreed to the conditions requested by the California Coastal Commission in their federal consistency determination pursuant to the Coastal Zone Management Act. The California Coastal Commission indicated at the 10/10/24 public hearing that Space Force agreed to the conditions and they are now a part of the project and are not considered additional mitigations. Additionally, the DEA states that the terms and conditions and reasonable and prudent measures identified in the 2024 Biological Opinion from the U.S. Fish and Wildlife Service would be implemented (p. 3-32).

We again emphasize that all mitigation and monitoring commitments should be specifically identified in the FONSI, since it is effectively a "mitigated FONSI". We note that the conclusions of less than significant impacts to wildlife in the DEA are not currently supported since there is not sufficient data on sonic booms and wildlife, but we understand that an interagency working group is being formed with U.S. Fish and Wildlife Service and National Marine Fisheries Service to assess future monitoring results with an agreed to adaptive management strategy. Adaptive management is an important tool, but needs to be expounded to support a Finding of No Significant Impact (FONSI).

The effectiveness of any adaptive management program monitoring depends on (a) the ability to establish clear monitoring objectives; (b) agreement on the impact thresholds being monitored; (c) the existence of a baseline or the ability to develop a baseline for the resources being monitored; (d) the ability to see the effects within an appropriate time frame after the action is taken; (e) the technical capabilities of the procedures and equipment used to identify and measure changes in the affected resources and the ability to analyze the changes; and (f) the resources needed to perform the monitoring and respond to the results. For adaptive management to be considered a valid strategy for mitigating impacts of the project, the above points need to be addressed.

Update the project description in the FEA to include the conditions the Space Force agreed to during Federal Coastal Consistency process;

2. Identify the interagency working group for biological resources in the FEA and discuss the commitment to an adaptive management strategy to help support conclusions of less-than-significant impacts to wildlife and species in the Final EA;

3. Develop an adaptive management plan, or provide a commitment to do so, that addresses the above points. We recommend appending an outline of this plan to the FEA;

4. Append the Sonic Boom Assessment Plan to the FEA. We recommend making monitoring information publicly available

Comment Response

Requirements of the Consistency Determination are included in the FONSI. However, DAF does not agree that these measures are being implemented to reduce impacts below significance. As discussed in Section 3.3 and 3.4 of the Environmental Assessment, the Proposed Action would not result in significant impacts to biological resources or wildlife. Please refer to the Biological Assessment, Appendix E of the EA, as well as an additional literature summary of noise studies provided to the California Coastal Commission regarding biological resources from launch noise and/or sonic booms. DAF has monitored impacts to wildlife due to launch noise, including sonic booms, for decades at VSFB and monitoring data does not support EPA's position of a significant impact to wildlife. If EPA has additional literature that would constitute the best available science, DAF requests EPA provide it.

Monitoring will continue to be done in a manner consistent with the most recent Letter of Authorization from the National Marine Fisheries Service, Biological Opinion from the United States Fish and Wildlife Service, and agreed upon measures with the California Coastal Commission.

B. Santa Barbara County

Comment

The Santa Barbara County Fire Department stated they have no objection to the proposed increase in cadence. They requested launch notifications continue and that they would seek cost recovery for any incidents requiring response for mitigation, rescue, or other emergency response efforts.

Comment Response

DAF appreciates the County's comments.

C. Santa Barbara County Air Pollution Control District

Comment – Proposed Action, Section 2.1.2 Launch, page 2-1

This section states that "*there would be no more than 30 static fire events per year*." The *Air Quality and Greenhouse Gas Emissions Technical Report for the Falcon Program Expansion at Vandenberg Space Force Base, California* included as Appendix E of the Draft EA states on page 1 that "*there would be no more than 50 static fire events per year*." Please resolve the discrepancy in the cited number of static launch events.

Comment Response

Appendix E has been revised to correctly stated that 30 static fire events per year would occur rather than 50. Emissions tables in the EA have been updated to reflect this.

Comment – Air Quality and Climate, Section 3.1.2.2 General Conformity Impacts, page 3-7

The last paragraph in this section states that "*The Proposed Action's NOx emissions would be held steady during the lifetime of the project at 21.26 tpy, or 116.49 lbs per day*." The annual total of 21.26 tpy appears to be a typographical error as Table 3.1-5 indicates NOx emissions will increase by 31.26 tpy as a result of the Proposed Action. We advise the DAF to confirm the accuracy of the daily emissions cited and revise if necessary.

Comment Response

Table 3.1-5 has been revised to accurately reflect a total of 31.26 tons per year.

D. California Department of Fish and Wildlife

Comment – Biological Resources Assessment

The EA should be amended to include an updated general field survey for SLC-4 and should be conducted prior to Project activities to provide an accurate assessment of plant and wildlife species utilizing the Project area. Generally, CDFW considers surveys older than two years unable to accurately represent baseline conditions. The new biological resources assessment should include a complete assessment and impact analysis of the flora and fauna within the Project area, and should place emphasis upon identifying endangered, threatened, sensitive, regionally and locally unique species, and sensitive habitats. CDFW also considers impacts to Species of Special Concern (SSC) a significant direct and cumulative adverse effect without implementing appropriate avoidance and/or mitigation measures. Mitigation measures to avoid, minimize, or mitigate for these species should also be included in the revised EA.

Comment Response

The Proposed Action does not involve ground disturbance. Given the lack of development around SLC-4 and in the project area, DAF considers the surveys to still be valid. Monitoring will continue to be done in a manner consistent with the most recent Letter of Authorization from the National Marine Fisheries Service, Biological Opinion from the United States Fish and Wildlife Service, and agreed upon measures with the California Coastal Commission. A discussion of impacts to wildlife, including listed species, is included in Section 3.3 and Appendix A of the EA. There would be no significant impacts to wildlife or listed species.

Comment – Least Bell's Viero

While CDFW acknowledges that mitigation measure 2.3.6 is intended to minimize impacts to least Bell's vireo, we recommend that the breeding season window referenced be changed to 15 March – 30 September. These birds typically arrive in southern California breeding areas by mid-March to early-April and generally leave by late-September. The breeding season in the EA leaves the potential for least Bell's vireo to be impacted by construction activities, such as the use of explosives and heavy machinery, if surveys are conducted outside of the appropriate breeding season. CDFW recommends adhering to the Least Bell's Vireo Survey Guidelines for the appropriate protocol (USFWS 2001).

Comment Response

The Proposed Action does not involve construction or ground disturbance. The EA does not reference a breeding season and is a sufficient analysis, along with the Biological Assessment included in Appendix A, for potential impacts to this species.

Comment – Monarchs

There are multiple monarch butterfly overwintering habitats documented within the SLC-4 Rocket Engine Noise and SLC-4 Falcon 9 First Stage Landing Sonic footprints. Additionally, there are multiple habitats found within a two-mile range of both sites according to the California Natural Diversity Database (CNDDB) (CDFW BIOS 2023). While there are no direct impacts due to construction on monarch butterflies, indirect impacts due to noise could occur. CDFW is concerned that elevated noise from an increase in launches may result in monarch butterflies abandoning the documented overwintering sites and recommends that the DAF incorporate a measure to avoid Project activities near the overwintering sites during periods of monarch aggregation (typically September 30 through March 1).

Comment Response

DAF has surveyed overwintering stands on VSFB since 1997, including one immediately adjacent to Space Launch Complex-4, and has not observed impacts to this species due to noise. Thus, DAF does not believe avoidance measure for monarch butterflies is warranted.

Comment – Rare Plants

Rare plant species Lompoc yerba santa, crisp monardella, and beach layia have been observed and recorded through the California Natural Diversity Database to occur within and/or near the SLC-4 and SLC-6 sites (CDFW BIOS 2012). Direct impacts at SLC-4 may occur to rare plant species due to increased wind speeds and maintenance activities. Also, construction activities and vegetation removal at SLC-6 may result in loss of individuals and seedbank and contribute to the population decline of these rare plants. The EA states that areas occupied by these species would not be affected by ground disturbance and physical impacts but does not discuss avoidance of other rare plants documented within the Project area. Given that survey assessments for SLC-4 are seven years old and may or may not have occurred during the blooming period, we have further concerns that the locations of all sensitive plant species are not known. Additionally, biological surveys for SLC-6 were conducted during October and November, which is outside of the blooming period, exacerbating our concerns that locations of these species are not known.

CDFW recommends the EA incorporate a measure that requires a rare plant survey to be conducted prior to any ground-disturbing activities to ensure that no impacts to undetected rare plants occur. CDFW also recommends a qualified botanist conduct a rare plant survey, adhering to CDFW's Protocols for Surveying and Evaluating Impacts to Special Status Native Plant Populations and Sensitive Natural Communities (CDFW 2018). If rare plants are observed within the Project area, the qualified botanist should implement an adequate buffer around the individual plant or population to prevent any potential adverse impacts. If avoidance is not achievable, the EA should offset the loss of rare plants through compensatory mitigation at a minimum of 2:1 ratio. Translocation of these species are not advisable, as there is insufficient data to support that such translocations would be successful.

Comment Response

The Proposed Action does not involve ground disturbance or construction. DAF considers the surveys at SLC-4 to remain valid. DAF is unaware of any literature supporting the claim that launch activity can result in additional wind speed that would adversely impact plants.

Comment – Nesting Birds

The Project area of SLC-4 and SLC-6 have vegetation that may provide nesting habitat for various avian species. The proposed Project would impact nesting birds through construction activities, installation activities, elevated-related noise, and vegetation removal. Furthermore, Project activities occurring during the nesting bird season, especially in areas providing suitable habitat, could result in the incidental loss of fertile eggs or nestlings, or nest abandonment.

CDFW recommends the DAF revise 2.3.1 General Environmental Protection Measures regarding impacts on nesting migratory birds. CDFW recommends that clearing of vegetation occur outside of the peak avian breeding season, which runs from February 1 through September 15 (as early as January 1 for some raptors). If Project construction is necessary during the bird breeding season, a qualified biologist should conduct a nesting bird survey within three days prior to work in the area. The measure should be revised to include a 100-foot buffer from common avian species, 300 feet for listed or highly sensitive, and 500 feet for raptors if an active nest is identified and an established buffer is necessary between construction activities. Reductions in the nest buffer may occur in consideration of site-specific features such as ambient levels of human activity, screening vegetation, or other factors.

Comment Response

The Proposed Action does not involve ground disturbance or construction. Vegetation clearing conducted as part of routine maintenance would be conducted in accordance with the Biological Opinion from the United States Fish and Wildlife Service. Surveys are conducted prior to clearing activities. Avian monitoring would continue to occur in accordance with the Terms and Conditions of the Biological Opinion, included in Appendix A.

E. Central Coast Regional Water Quality Control Board

Comment – Section 3.4.1.1, page 3-35, Table 3.4-3

In the table's notes, please spell out the meaning for the acronym MMPA (i.e., Marine Mammal Protection Act).

Comment Response

The table notes have been revised to spell out the acronym MMPA.

Comment – Section 3.5.1.1, page 3-43, lines 23 to 24, and Section 3.5.1.4, page 3-44, lines 11 to 13

It is assumed that the references in these sections to the RWQCB (Regional Water Quality Control Board)-required monitoring and mitigation is referring to the Spring Canyon Riparian Mitigation and Monitoring Plan referenced above in the Background Section of this letter. To improve clarity, please cite the MMP in the text and provide the full document citation in the references section.

Comment Response

The MMP has been cited in the EA and added to the references section.

Comment – Section 3.5.2.1.1, page 3-44, lines 29-30

This section states that "Any water that remains after launches or stormwater that accumulates within the trench would be tested for contamination." Please cite, possibly in a footnote, a document (or documents) that specifically describes the contamination types for which the water would be tested. Assuming Alternative 1 is chosen, please define the specific chemicals and characteristics that will be tested for, the sampling locations/types, the sampling frequency, and the reporting process and frequency. Since receiving Launch Monitoring Report No. 3, dated Feb 7, 2019 (pursuant to the IMMRP, with November 2018 water sampling results), Central Coast Water Board staff has not been provided with more recent testing results associated with SpaceX's launch-related water, static test-related water, landing-related water, nor stormwater that presumably has episodically accumulated within the water management infrastructure at SLC-4E and SLC-4W and may have been applied on land at one or more spray fields. If more recent testing results exist (e.g., post-November 2018 analytical results and/or observational results), please provide these results to Central Coast Water Board staff.

As indicated in SpaceX's November 7, 2018, Report of Waste Discharge Supplement, there is a SLC-4E spray field for discharging water to land; associated with launch system testing, wet dress rehearsal, static fire testing and launch deluge waters. In addition, a proposed second spray field, intended to discharge to land water from the fire suppression system and accumulated storm water from the SLC-4W retention basin, may have been installed and used as a contingency to support SLC-4W landing pad operations.

Please provide Central Coast Water Board staff with a summary that describes the spray fields that have been discharged to, and the approximate gallons discharged to them through time.

Going forward, SpaceX and/or the Department of Air Force (DAF) must re-enroll, continue to meet the requirements/conditions in the General Waiver, and assist the Central Coast Water Board by providing any additional information needed to determine the potential impacts to water quality and the need for additional conditions in the General Waiver related to the launch cadence increase at SLC-4. It should be noted that the General Waiver does not relieve the discharger of action; the General Waiver defines the requirements and conditions that the discharger must meet to continue operation under the General Waiver.

Comment Response

The retention system at SLC-4W has been constructed and was intended to capture water used at the landing zone. It was included in the existing General Waiver Order. The system now is a retention basin that captures residual stormwater only. The Fire-X system at the landing zone was formally deactivated in 2023. The system is isolated and not utilized. After rain events, the area is inspected during nominal Spill Prevention, Control, and Countermeasure Plan walkdowns. A pedestal system is above the basin with a recessed trench gate raound it to capture any potential residual fuel from post-landing processing. This area is fully isolated and contained with isolation valves prior to processing, and opened again after processing to allow for stormwater flow. If a spill were to occur in the trench, it would be cleaned with nominal BMPs and spill kits. There is no risk of entry to the retention basin.

DAF will provide the Water Board sampling results when available. SpaceX will coordinate with the Water Board on reenrollment with the General Waiver.

Comment – Section 3.5.2.1.1, page 3-44, lines 34-35

It is stated that "The DAF will continue to monitor water quality in Spring Canyon, as described in "Table 2.1-3." Central Coast Water Board staff cannot locate Table 2.1-3, and therefore are unable to fully review and understand the water quality monitoring referenced in the Draft EA. In addition to adding this table to the Draft EA or providing a reference to this table, a document describing specifically what will be tested to monitor water quality in Spring Canyon should be cited.

Comment Response

This text has been revised to remove reference to table 2.1-3 and includes reference to soil sampling if water levels are too low to adequately sample.

Comment – Section 3.5.2.1.2, page 3-45, line 17, section title

To provide clarity, Water Board staff requests that the title for Section 3.5.2.1.2 be changed from "Ground Water" to "Groundwater Withdrawal" or to "Groundwater Extraction". The use of groundwater as one word is the current industry standard and adding "withdrawal" or "extraction" will clarify the section's topic.

Comment Response

The section heading has been revised to state "Groundwater."

Comment – Section 3.5.2.1.2, page 3-45, lines 23 and 25

The groundwater discussed in this section is extracted from the San Antonio *groundwater basin*, not the San Antonio Creek, therefore the sentences in lines 23 and 25 should be revised to: "…any extraction from the San Antonio *groundwater basin* for the proposed action…" and "…no measurable impacts to groundwater levels in San Antonio *groundwater basin*…", respectively.

Comment Response

This section has been revised to state groundwater basin.

Comment – Section 3.5.1.4, page 3-44, lines 34 and 37

Please cite the specific document (e.g., MMP or other relevant document) that the DAF is referring to with the statement, "To comply with the RWQCB."

Comment Response

This section has been revised and the MMP has been referenced.

Comment – Section 3.5.2.1.6, page 3-46, line 6 and Section 3.13.2.1, page 3-66, lines 30 to 33

The best management practices (BMPs) and environmental protection measures (EMPs) as described in Appendix L are not specific nor detailed enough (e.g., reference documents, plans or policies that define the analytical testing methods to be used, and reporting results to regulatory agencies) to ensure protection of surface water and groundwater from exceeding any federal, State or local regulatory agencies' water quality standards. Please revise Appendix L to provide specific details and/or cite related documents where specific details can be found, to clearly communicate how surface water and groundwater will be protected from exceeding any federal, State, or local regulatory agencies' water quality standards. In addition, the BMP acronym needs to be added to the list on page v.

Comment Response

DAF believes the measures included in Appendix L are sufficient.

Comment – Section 3.5.2.1.6, page 3-46, line 7

Replace "ground water" with "groundwater." Please apply this comment globally in the Draft EA, for consistency.

Comment Response

Ground water was replaced with groundwater globally.

Comment – Section 3.13.1.4, page 3-65

The Draft EA should consider the increased launch cadence's impact on the Air Force Civil Engineering Center's (AFCEC) Installation Restoration Program (IRP) contractors that conduct ground-intrusive site assessment and contamination cleanup actions at VSFB as funded by the federal Defense Environmental Restoration Account (DERA), contracted by Army Corps of Engineers/AFCEC, overseen by VSFB-based IRP staff, and with State oversight from the California Department of Toxic Substances Control (DTSC) and Central Coast Water Board. It is our understanding that ground-intrusive work (e.g., drilling soil borings, drilling/installing monitoring wells, excavating soil, etc.) is sometimes prohibited, especially near utilities, at VSFB in the hours leading up to launch windows, and in other instances equipment and personnel evacuation is required if within protective envelopes associated with certain launches. These prohibitions and requirements can limit the workhours and workdays available to conduct necessary/contracted IRP-related ground-intrusive work, especially if the cumulative launch cadence is on the order of 100 launches per year as suggested in Section 1.1, page 1-2, lines 7 to 9, and in Section 4, page 4-1, lines 18 to 20. In addition, SpaceX must continue to coordinate with IRP contractors, allowing access and asset/well protection for required groundwater monitoring and remediation activities to continue at IRP site WP008, where legacy trichloroethene (TCE) and released perchlorate overlap with SLC-4's footprint.

Comment Response

DAF and SpaceX will continue to coordinate with IRP contractors to ensure access and remediation activities can occur.

Comment – Central Coast Water Board Comments and Recommendations Related to Other Rocket Propellants and Space Launch Complexes

SLC-1 & 2, SLC-3 and SLC-4 have legacy pollution in soil and groundwater and are actively undergoing remediation activities as IRP sites SD02513, WP00514, and WP00815, respectively. The chlorinated solvent TCE, and its breakdown products are the primary contaminants at these sites. Because these SLCs have legacy pollution, soil sampling was conducted in the past and groundwater monitoring well networks exist in these areas. This provides baseline chemical data, and groundwater information that can be compared with more recent data/information collected to evaluate the potential impacts of current and future launch activities on soil and groundwater, providing a basis for permitting launch-related activities at these SLCs under the General Waiver or similar permitting mechanisms.

In contrast, baseline chemical data and groundwater information are not available for SLC-6, SLC-7, SLC-8, and SLC-10. Central Coast Water Board staff recommend that baseline chemical testing be performed at these SLCs and recommend that monitoring well networks be installed, to provide a basis for understanding potential impacts through time from launch activities. We underscore the importance for all stakeholders to understand potential impacts before they are significant, and to encourage innovation of ways to minimize impacts before they become significant, while launches are performed at an increasing cumulative cadence over time.

The Falcon 9 rocket operates with rocket propellant-1 (RP-1), a further-refined kerosene, and liquid oxygen (LOX), which combine to propel the rocket and form water and carbon dioxide (CO2), a mild acid. If this rocket propellant fully oxidizes, the potential impact to soil, surface water, and groundwater may be minimal. This has been demonstrated by empirical data gained from testing conducted at SLC-3E and SLC-4E. If this rocket propellant does not fully oxidize, petroleum hydrocarbons are released, which may or may not be detrimental, depending on the concentrations released and depending on site specific scenarios (e.g., depth to groundwater, soil-types, other contaminants present, groundwater remediation systems already in place, etc.).

In contrast, ammonium perchlorate used in solid rocket fuel oxidizes primarily to water and hydrochloric acid (HCl), a strong acid. If this ammonium perchlorate propellant fully oxidizes, impact to soil, surface water and groundwater is likely, due to metals mobilization from HCl coming in contact with infrastructure surfaces and soil (i.e., pH changes often mobilize certain metals). This has been demonstrated by empirical data gained from testing at SLC-3E. If ammonium perchlorate propellant does not fully oxidize, perchlorate is released, impacting soil, groundwater, and surface water. This has been demonstrated by empirical data obtained from testing soil, groundwater, and surface water seeps along the coastline at SLC-4, documenting perchlorate impacts, years after a Titan 34D rocket with solid rocket motors was detonated in April 1986.

For rockets using propellent systems other than RP-1 and LOX, Central Coast Water Board staff requests that the DAF and its SLC users/lessees prepare and perform monitoring and reporting plans to collect data to evaluate potential impacts, similar to the IMMRP prepared and performed for SLC-4.

Comment Response

DAF appreciates the Water Board's comments and looks forward to collaborating on other launch complexes.

APPENDIX L
Environmental Protection Measures

Implementing the environmental protection measures (EPMs) outlined below would avoid or minimize potential adverse effects to various environmental resources during the Proposed Action. Qualified SpaceX personnel or contractor staff would oversee fulfilling EPMs.

L.1 Air Quality

The Santa Barbara County Air Pollution Control District (SBCAPCD) and California Air Resources Board (CARB) require the measures described in Table L-1 to decrease emissions, as applicable to the Proposed Action.

Table L-1. Control measures to decrease emissions

✓ Any portable equipment powered by an internal combustion engine with a rated horsepower of 50 brake horsepower or greater used for this project shall be registered in the California State-wide Portable Equipment Registration Program or have a valid SBCAPCD Permit to Operate.
✓ Ultra-low sulfur diesel fuel (15 parts per million by volume) will be used for all diesel equipment.
✓ CARB-developed idling regulations will be followed for trucks during loading and unloading.
✓ When feasible, equipment will be powered with Federally mandated "clean" diesel engines.
✓ The size of the engine in equipment and number of pieces of equipment operating simultaneously for the project should be minimized.
✓ Engines should be maintained in tune per manufacturer or operator's specification.
✓ U.S. Environmental Protection Agency (USEPA) or CARB-certified diesel catalytic converters, diesel oxidation catalysts, and diesel particulate filters may be installed on all diesel equipment.
✓ SpaceX shall adhere to the CARB In-Use Off-Road Diesel-Fueled Fleets Regulation (CARB 2024) for fleet management and fuel selection.
✓ CARB diesel will be the only fuel combusted in the engines while in California Coastal Waters.

L.2 Noise

In order to minimize any potential disturbance to human populations as a result of sonic boom, the DAF and SpaceX will notify the public prior to missions with potential sonic boom impacts in the Lompoc area, eastern Santa Barbara County, and Ventura County so that the public can anticipate and prepare for the potential disturbance.

L.3 Terrestrial Biological Resources

The EPMs listed below would be implemented to avoid, minimize, or characterize the effects of the Proposed Action on terrestrial biological resources.

Table L-2. Biological monitoring qualifications

Biologist Level	Necessary Qualifications
Permitted Biologist	Biologist with a valid and current USFWS section 10(a)(1)(A) Recovery Permit or specifically named as an approved biologist in a project-specific Biological Opinion (BO). The DAF will coordinate with the USFWS prior to assigning permitted biologists to this project

Biologist Level	Necessary Qualifications
USFWS Approved Biologist	Biologist with the expertise to identify species listed under the ESA and species with similar appearance. A USFWS-approved biologist could train other biologists and personnel during surveys and project work; in some cases, a USFWS-approved biologist could also provide on-site supervision of other biologists. The DAF will review and approve qualifications of each individual, and then submit them to the USFWS for review and approval no less than 15 days prior to the start of the Proposed Action. Each form submitted to the USFWS will list the biologist's experience and qualifications to support efforts prevent and mitigate potential effects of agency actions to listed species.
Qualified Biologist	Biologist trained to accurately identify specific federally listed species and their habitats by either a Permitted or USFWS-approved biologist. This person could perform basic project monitoring but would need to have oversight from a permitted or USFWS-approved biologist. Oversight will require a permitted or USFWS-approved biologist to be available for phone/email consultation during the surveys and to have the ability to visit during monitoring/survey activities if needed.

L.3 Special Status Species

SLD 30 and the USFWS completed Section 7 consultation for the addition of 16 additional launches between 1 October and 31 December 2024 (thus reaching a cadence of 50 launches in calendar year 2024) on endangered and threatened species due to the Proposed Action. The USFWS prescribed reasonable and prudent measures/terms and conditions set forth in the Incidental Take Statement section of the BO (Appendix A) will be implemented as part of the Proposed Action.

L.4 Marine Biological Resources

The following EPMs would be implemented to avoid, minimize, or characterize the effects of the Proposed Action on marine biological resources. The DAF and qualified SpaceX personnel or contractor staff would ensure that all non-discretionary measures included in the NMFS LOA issued for launch activities at VSFB (Appendix B) would be implemented during operation of SpaceX's launch program at SLC-4. The Final EA will include the USFWS prepared BO, which addresses effects on the federally threatened southern sea otter due to the Proposed Action. USFWS prescribed reasonable and prudent measures/terms and conditions regarding the southern sea otter set forth in the Incidental Take Statement section of the BO will be implemented as part of the Proposed Action.

Table L-3. Monitoring and reporting measures

✓ Sonic boom modeling (commercially available modeling software [PCBoom] or an acceptable substitute) would continue to be completed prior to each launch to verify and estimate the overpressure levels and footprint.
✓ Semi-monthly surveys (two surveys per month) would continue to be conducted to monitor the abundance, distribution, and status of pinnipeds at VSFB. Whenever possible, these surveys will be

timed to coincide with the lowest afternoon tides of each month when the greatest numbers of animals are usually hauled out. ✓ Marine mammal monitoring and acoustic measurements will be conducted at the Northern Channel Islands (NCI) if the sonic boom model indicates that pressures from a boom will reach or exceed 7 psf from 1 January through 28 February, 5 psf from 1 March through 31. July, or 7 psf from 1 August through 30 September. No monitoring is required on NCI from 1 October through 31 December. The monitoring methods are described in the LOA included in Appendix B.
✓ The DAF will continue to submit report detailing results of the monitoring program, to the Office of Protected Resources, NMFS, and the West Coast Regional Administrator, NMFS, in compliance with the requirements of the current LOA. ✓ Discoveries of injured or dead marine mammals, irrespective of cause, would be reported to the Office of Protected Resources, NMFS, and the West Coast Regional Stranding Coordinator, NMFS. Specific protocol would be followed depending on the cause of the event, if cause is unknown, and whether injury or death was relatively recent.
To reduce the risk of injury or mortality of ESA-listed species in the marine environment, the following EPMs will continue to be implemented during first stage and fairing recovery operations: ✓ The DAF will ensure that all personnel associated with vessel support operations are instructed about marine species and any critical habitat protected under the ESA that could be present in the proposed landing area. Personnel will be advised of the civil and criminal penalties for harming, harassing, or killing ESA-listed species. ✓ Support vessels will maintain a minimum distance of 150 ft from sea turtles and a minimum distance of 300 ft from all other ESA-listed species. If the distance ever becomes less, the vessel will reduce speed and shift the engine to neutral. Engines would not be re-engaged until the animal(s) are clear of the area. ✓ Support vessels will maintain an average speed of 10 knots or less. ✓ Support vessels will attempt to remain parallel to an ESA-listed species' course when sighted while the watercraft is underway (e.g., bow-riding) and avoid excessive speed or abrupt changes in direction until the animal(s) has left the area. ✓ The DAF will immediately report any collision(s), injuries, or mortalities to ESA-listed species to the appropriate NMFS contact.
✓ To offset the impacts from unrecoverable debris in state waters, SpaceX will continue to make an annual contribution to the California Lost Fishing Gear Recovery Project. For every pound of unrecovered debris in state waters, SpaceX would make a compensatory donation of $20.00.
✓ Vessels will enter the harbor, to the extent possible, only when the tide is too high for pinnipeds to haul-out on the rocks. The vessel will reduce speed to 1.5 to 2 knots once the vessel is within 3 mi of the harbor. The vessel will enter the harbor stern first, approaching the wharf and mooring dolphins at less than 0.75 knots.
✓ Vessels using the harbor will follow a predetermined route that limits crossing kelp beds.
✓ No vessels will anchor within kelp beds or hard-bottom habitat outside of the dredge footprint, and no vessel anchors within the dredge footprint will be placed in kelp or hard bottom habitat.
✓ Activities that could result in the startling of wildlife in the vicinity of the harbor will be allowed so long as they are initiated before dusk and not interrupted by long periods of quiet (in excess of 30

	minutes). If such activities cease temporarily during the night, they will not be reinitiated until dawn.
✓	Starting-up of activities (either initially or if activities have ceased for more than 30 minutes) will include a gradual increase in noise levels if pinnipeds are in the area.
✓	The restrictions on access to the intertidal area will be included in the personnel orientations provided at project startup and for new employees.
✓	The tug vessels and barge will be periodically cleaned as necessary to avoid impacts related to the transfer of non-native invasive pests and vegetation to VSFB Harbor.

L.5 Water Resources

The following EPMs would be implemented to avoid, minimize, or characterize the effects of the Proposed Action on water resources.

Table L-4. Water resources and stormwater measures

✓	The Proposed Action shall implement Best Management Practices (BMPs) to minimize sediment, chemicals, debris or other pollutants from entering the storm water system, natural surface water drainages or groundwater per the latest California Stormwater Quality Association's Stormwater Best Management Practices Handbooks.
✓	Storm drain inlet protection will be used as needed to minimize pollutant discharge into storm drains.
✓	Fueling equipment or systems will only occur in pre-designated areas designed to capture runoff or spilled fuel or with portable spill containment devices or absorbents.
✓	Hazardous and industrial materials that can be mobilized by contact with stormwater will be stored under cover at all times.
✓	Trash disposal containers will be covered at all times. Trash that escapes from containers will be collected.
✓	Concrete materials, curing compounds, waste and washout water will be properly managed to prevent pollution. Washout water will be contained for evaporation.
✓	SpaceX will continue to ensure that water ejected from the flame trench during launches does not result in any overland surface flow reaching Spring Canyon by maintaining current v-ditches within the SLC-4 fence-line and routinely assessing whether any additional diversion structures are necessary.
✓	SpaceX will employ personnel trained to follow current California storm water pollution prevention industrial activity BMPs.
✓	Wastewater discharges would continue to follow the conditions of the Regional Water Quality Control Board (RWQCB) letter for Enrollment in the General Waiver of Waste Discharge Requirements for SLC-4E Process Water Discharges to eliminate potential adverse effects to water quality. Any stormwater that accumulates within the trench would be tested for contamination. If contamination is encountered, the contents would be pumped out and disposed of per the waiver/permit and state and Federal regulations.

L.6 Cultural Resources

The following EPMs would be implemented to avoid, minimize, or characterize the effects of the Proposed Action on cultural and sensitive archaeological resources.

Table L-5. Cultural resources measures

✓	If previously undocumented cultural resources are discovered during maintenance activities, work would stop, and the procedures established in 36 CFR Part 800.13 and the VSFB Integrated Cultural Resources Management Plan shall be followed.

L.7 Human Health and Safety

SpaceX personnel or contractor staff would ensure the following measures would be implemented to minimize the potential for adverse impacts on human health and safety.

Table L-6. Human health and safety measures

✓	Comply with Occupational Safety and Health Administration (OSHA), Air Force Occupational Safety and Health (AFOSH), California Division of Occupational Safety and Health regulations, and other recognized standards and applicable DAF regulations or instructions.
✓	Provide for the health and safety of workers and all subcontractors who may be exposed to operations or services. Submit a health and safety plan to VSFB and appoint a formally trained individual to act as safety officer who would be the point of contact (POC) on all problems involving job site safety.
✓	Site-wide anomaly avoidance would be implemented since it is possible UXOs may be encountered outside of Military Munitions Response Program (MMRP) boundaries.
✓	Comply with all provisions and procedures prescribed for the control and safety of personnel and visitors to the job site.

L.8 Hazardous Materials and Waste Management

SpaceX personnel or contractor staff would ensure the following measures would be implemented to minimize impacts on hazardous materials and waste management.

Table L-7. Hazardous materials and waste management measures

✓	Proper disposal of hazardous waste would be accomplished through identification, characterization, sampling (if necessary), and analysis of wastes generated.
✓	All hazardous materials would be properly identified and used IAW manufacturer's specifications to avoid accidental exposure to or release of hazardous materials required to operate and maintain equipment.
✓	All equipment would be properly maintained and free of leaks during operation and maintenance activities. All necessary equipment maintenance and repairs would be performed in pre-designated controlled, paved areas to minimize risks from accidental spillage or release.
✓	SpaceX would ensure employees and contractor staff are trained in proper prevention and cleanup procedures.
✓	SpaceX would store liquids, petroleum products, and hazardous materials in approved containers and drums and would ensure that any open containers are covered prior to rain events.
✓	Per 40 CFR Part 112, Spill Prevention, Control, and Countermeasure Plan, SpaceX would place chemicals, drums, or bagged materials on a pallet and, when necessary, secondary containment.
✓	All aboveground oil or fuel tanks and containers 55 gallons or greater shall be reported to the tank manager at (805) 605-0342. All tanks and containers must be doubled-walled or constructed with secondary containment at minimum of 110 percent of the total capacity. Please contact 30 CES/CEIEC Tank Manager at 605-0342 for questions.

L.8 Solid Waste

Solid waste would be minimized by strict compliance with SLD 30's Integrated Solid Waste Management Plan (ISWMP; DAF 2015). SpaceX personnel or contractor staff would ensure the following measures would be implemented to further minimize the potential for adverse impacts associated with solid waste.

Table L-8. Solid waste measures

✓	All materials that are disposed of off Base would be reported to the 30th Civil Engineer Squadron, Installation Management Flight (30 CES/CEI) Solid Waste Manager.