DRAFT
ENVIRONMENTAL ASSESSMENT
FOR
LAUNCH COMPLEX 48
JOHN F. KENNEDY SPACE CENTER

Prepared for
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Kennedy Space Center, Florida

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EXECUTIVE SUMMARY

The National Aeronautics and Space Administration (NASA) has prepared this Environmental Assessment (EA) to evaluate the potential environmental impacts resulting from construction and operations associated with the proposed Launch Complex (LC) 48. This EA analyzes effects on resources due to the Proposed Action to develop a Small Class Launch Vehicle (SCLV) complex and the No Action Alternative.

Federal agencies are required to consider environmental consequences resulting from their actions. This is in accordance with regulatory mandates including the National Environmental Policy Act (NEPA) of 1969, as amended (Title 42 of the United States Code [U.S.C.] 4321 - 4347), the Council on Environmental Quality (CEQ) regulations for implementing NEPA (40 Code of Federal Regulations [CFR] parts 1500-1508), NASA regulations for implementing NEPA (14 CFR Subpart 1216.3), and the NASA Procedural Requirement (NPR) for Implementing NEPA and Executive Order (EO) 12114 (NPR 8580.1). Also, because a potential launch operator(s) at LC-48 may apply to the Federal Aviation Administration (FAA) Office of Commercial Space Transportation for a commercial space license once the launch site is built, this EA complies with FAA Order 1050.1F, *Environmental Impacts: Policies and Procedures*, regarding potential launch-related impacts. This will enable the FAA to adopt this EA in the future to support its environmental review of a license application(s) for commercial space launch operations at LC-48. As NASA is considering the development of a launch complex, this EA is necessary to support the federal agencies in compliance with NEPA and related federal and state environmental regulations.

Purpose and Need

The purpose of NASA's Proposed Action is to expand its spaceport capabilities to include the processing, launch, and recovery of small class vertically launched rocket-powered vehicles. This will 1) enable improved access to Kennedy Space Center's (KSC) space launch and test operation capabilities by NASA, as well as commercial and other non-NASA users; 2) advance NASA's mission by fostering a commercial space launch and services industry, and 3) improve the return on taxpayer investment in KSC spaceport facilities through expanded and improved utilization.

This action also furthers the goals of KSC long-term planning initiatives and NASA programmatic objectives, and ultimately increases American competitiveness in commercial space. The proposed LC-48 site would be a direct fulfillment of the KSC Master Plan to "foster and support the fullest commercial use of space". It would also provide greater mission capability to meet small class vehicle customer needs.

Proposed Action

A multi-user launch complex for SCLVs would be constructed approximately 1.6 kilometers (km) (1 mile [mi]) southeast of LC-39A and 1.6 km (1 mi) northwest of LC-41 (Figure 2-1). LC-48 would be designed as a versatile launch pad and integrated stage testing facility, providing a clean pad surface that would allow customers to bring their own launch ground systems. Multiple liquid propellant types would be accommodated, including oxygen, methane, hydrogen, and rocket propellant 1 (RP-1), as well as high-pressure gaseous nitrogen and helium.

LC-48 could support up to two concrete slab pads with room for minimal supporting infrastructure and facilities, or one concrete slab pad that would allow for a greater diversity of supporting facilities. Initial development of the area (Phase 1, Figure 2-2) would include one clean pad design. To account for potential future partners and development, the total build out concept for LC-48 could support fully integrated launch facilities with all necessary supporting infrastructure.

No Action Alternative

The No Action Alternative would mean NASA would not build a small class vehicle launch pad on KSC. There would be fewer commercial customers able to contract for SCLV launches and there would be less diversity in use of KSC property.

Summary of Potential Environmental Effects

This EA considered the following 14 resource areas to provide a context for understanding the potential environmental effects of the Proposed Action and alternatives: land use/visual resources, noise, biological resources, cultural resources, air quality, climate, hazardous materials/hazardous waste (includes solid waste and pollution prevention), water resources, geology and soils, transportation, utilities, health and safety, socioeconomics, environmental justice and children's health and safety, and Department of Transportation Act, Section 4(f).

The environmental consequences associated with the Proposed Action and the No Action Alternative were analyzed for the appropriate Region of Influence (ROI) for each resource area. The following table presents a summary of the resources considered and the potential impacts on those resources. The descriptions include both construction and operations-related tasks associated with this Proposed Action.

Table E-1: Summary of Potential Environmental Impacts from the Proposed Action.

Resource Area	Potential Environmental Impact from Proposed Action
Land Use/Visual Resources	Management of the land would be transferred from Merritt Island National Wildlife Refuge (MINWR) to NASA. Development of the LC-48 site would impact a small impoundment, designated as T-25-B, located east of the railroad track. However, the impoundment is not directly connected to the Indian River Lagoon (IRL), and not actively managed for mosquitos. Site operations at LC-48 would need to be considered by MINWR in future prescribed burn plans to ensure activities would not be negatively impacted. Potential visual impacts to the landscape in the vicinity of the Proposed Action include light emissions during nighttime launch and testing operations. There would be no facilities constructed during Phase 1 that block the view of natural surroundings and temporary, removable lightning arrestor towers would be supplied during launch operations by the launch provider. Though the Proposed Action would require some construction and modifications, these additions would be consistent with existing infrastructure and not cause a significant impact to the area. Impacts from the proposed action on MINWR land management activities and the impact of LC-48 to visual resources would be moderate.

Resource Area	Potential Environmental Impact from Proposed Action
Noise	Under the Proposed Action, short-term and long-term moderate adverse effects would be expected, resulting in the continuation of many of the types of noise presently occurring at KSC. Noise generated during construction activities of the Proposed Action at LC-48 would potentially have discernable, but temporary effects. Long-term effects would include increased traffic to and from the location, and mobilization to the site for pre- and post- launch activities that occur throughout the year. The loudest noise generated at the site would result from launches and test fires; this would be short in duration and intermittent throughout the year. Personnel on site would be required by Occupational Safety and Health Administration (OSHA) and NASA regulations to be equipped with hearing protection. Impacts from the Proposed Action for noise would be short in duration but have moderate impact on the environment and areas beyond the KSC.
Biological Resources	Construction of the Proposed Action would result in moderate impacts to wildlife due to loss of habitat at the proposed LC-48 site. Impacts to the overall wildlife population and biodiversity at KSC would not be significant as the affected area is already partially fragmented by the railroad track and Phillips Parkway, and is only a fraction of the land not used for operations on KSC. Facility lighting and nighttime launch operations would potentially result in moderate impacts due to disorientation of nesting and hatchling marine turtles. Impacts to marine species from rocket debris were determined to be minimal as it is highly unlikely any fish, turtles, or whales would be struck directly by falling materials. Corrosion of rocket parts in the ocean would be slow and the dilution of toxins by the large volume of water would stay below dangerous levels. Impacts to vegetation from launch emissions and potential acid deposition could occur intermittently, resulting in short-term minimal effects. The installation of lightning protection towers with guy wire supports located along the coast near wetlands and in a high bird concentration area, would result in moderate impacts.
Cultural Resources	The development of LC-48 at the proposed project area would have no effect on any archaeological sites or historic resources that are listed, determined eligible, or considered potentially eligible for listing in the National Register of Historic Places (NRHP). No impacts are expected to any cultural resources from the Proposed Action.

Resource Area	Potential Environmental Impact from Proposed Action
Air Quality	Total quantities of criteria pollutants produced during launch or engine test firings are dependent on launch vehicle classes and total number of annual launches and engine tests. Individual launches would be short-term discrete events and rocket emissions released in the lower atmosphere would be rapidly diluted and dispersed by prevailing winds. Effects on ambient air quality at KSC from construction and operation of LC-48 would be minimal. The increase of emissions related to traffic associated with launch complex operations would be negligible. The modest addition of personnel expected for the Proposed Action could increase traffic emissions intermittently and for short periods of time during launch and test firing operations. However, this increase would not exceed emissions that were associated with traffic volume during the Space Shuttle Program.
Climate and Climate Change/Sea Level Rise	In February 2010, the CEQ issued NEPA guidance for evaluating the effects of climate change and greenhouse gas emissions. Based on the anticipated minimal and intermittent addition of employees, and the number of SCLV launches that would occur at the launch complex, annual direct emissions should be well under 25,000 metric tons (55 million pounds). Therefore, according to the CEQ guidance, the impact of this project to global or regional climate change, including sea level rise, is anticipated to be minimal.
Hazardous Materials/ Hazardous Waste	The Proposed Action would increase the amount of hazardous materials being transported and wastes generated and managed at this location. Best Management Practices (BMPs) would be set in place for the handling of hazardous materials and hazardous waste at the site. Construction and operation at the site should not significantly impact the NASA KSC Remediation Program for managing Solid Waste Management Unit (SWMU) or Potential Release Locations (PRL) sites located within the boundary, or interfere with ongoing investigations at these locations. Rocket parts such as fuel tanks would break apart after hitting the water, sinking quickly, but dispersing contents and substances from their surfaces. Therefore, the impact of this project on the environment from hazardous materials and waste would be minimal.
Water Resources	Impacts to surface water and groundwater would occur from runoff associated with newly created impervious surface. Treatment of runoff would be required by permit and involve percolation to groundwater. In each of these cases, the effect would be moderate and easily absorbed by the environment. Additional impacts to surface water might be associated with vehicle exhaust deposition. An example of these effects may be pH change due to acid deposition, similar to Shuttle. In this case, the effect is short term and moderate for surface water and minimal for groundwater. A further potential to impact groundwater is discussed under Industrial Wastewater effects in the Utilities section.

Resource Area	Potential Environmental Impact from Proposed Action
Geology and Soils	Native soil profiles within the top several feet would be disturbed by either leveling, excavation, or filling associated with land clearing and construction activities. Once operational, the launch facility would not be expected to have any measurable impacts to soils within or adjacent to the launch complex. Underlying geological characteristics would not be impacted by construction or operation of LC-48, and are common on KSC and in east-central Florida. Overall impacts would be considered none to geology and moderate to soil.
Transportation	The Proposed Action would result in the continuation of many of the modes of transportation presently occurring at KSC but potentially in greater amounts. LC-48 would accommodate up to 52 launches per year per pad, totaling 104 launches a year overall. Short-term and long-term minimal adverse effects would be expected. Short-term increases in traffic would result from construction worker commutes during construction and modification activities of new or existing facilities. Long-term effects would be primarily due to additional worker commutes and changes in traffic patterns near more centralized activities at KSC and the launch complexes. Increased traffic volumes and changes in traffic patterns would have minimal effects, and there would be some long-term beneficial effects from upgrades to infrastructure leading to the site. The Proposed Action is not expected to cause appreciable changes in the overall traffic volume at KSC; however, some components could affect the level of service at intersections or roadways both at and away from the facilities. Transportation impacts would be classified as minimal due to increased traffic on roadways in support of the
Utilities	The Proposed Action project area would require access to electric, fiber connectivity, water, sewer, and high-pressure gases. Development of the new launch complex would include activities such as construction of roads, upgrading and installing aboveground and underground utilities, excavation, foundation pouring, the building of a clean pad and modification of existing infrastructures. Effects of consumption of resources from the potable water, electric, gas, communication and solid waste systems are all expected to be measurable, but small compared to use at KSC as a whole and, therefore, classified as moderate. Production of industrial wastewater could impact either the domestic wastewater system or groundwater (if disposed of via percolation under permit). In either case, the effect would be moderate.

Resource Area	Potential Environmental Impact from Proposed Action
Health and Safety	Potential adverse effects to human health and safety could occur during construction and launch operations attributed to the Proposed Action. Compliance with OSHA regulations and other recognized standards would be implemented during the construction and operational phases to minimize the impacts to health and safety. With the implementation of safety and health plans, and environmental protection measures, potential health risks to project personnel and the public from construction and launch operations would be minimal. Operations would be required to comply with all applicable safety regulations for storage, use, and transfer of toxic and hazardous materials. Due to the regulatory and safety requirements inherent in the industry and the nature of expected operations, it is considered likely that sufficient engineering and administrative controls would mitigate the risks associated with the presence of these materials to the lowest possible level. An explosive safety plan must be submitted to the KSC Explosive Manager who would determine handling, permitting, transportation, siting, and storage for each commodity to account for public safety. Through this coordination, explosive safety elements would be met and there would be no significant impact. The probability of an accidental release on KSC would increase due to the increased activities and quantity of materials, but best management practices would ensure this increased risk is minimal.
Socioeconomics	There are no negative impacts expected from the Proposed Action. Minimal beneficial effects may result from construction and operation at LC-48 due to the need for a larger
Environmental Justice and Children's Environmental Health and Safety	The population inhabiting the ROI for the Proposed Action is not comprised of greater than 50% minorities and does not exceed the percentage of minorities as compared to the rest of Florida. The poverty level coupled with median household income levels are lower or comparable to the rest of Florida, and the majority of the population is living well above the poverty level as defined by the U.S. Department of Health and Human Services. Therefore, no disproportionate impacts to minorities or low-income residents would occur. The Child Development Center is the only location where children are concentrated in the vicinity of the Proposed Action. Noise levels experienced in that area would be short in duration and greatly diminished due to distance from launch pads. There would be no disproportionately high or adverse impacts to children's environmental health or safety.
Department of Transportation Act, Section 4(f)	Because there would be a maximum of 52 launches per year at LC-48, the noise level would only increase temporarily, and air quality would not be significantly affected. The Proposed Action would not substantially diminish the protected activities, features, or attributes of any of the 4(f) properties identified, and would not result in substantial impairment of the properties. Thus, the Proposed Action would not result in a "use" of a Section 4(f) property.

Cumulative Impacts

Cumulative impacts are defined by the CEQ in 40 CFR §1508.7 as impacts on the environment, which result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (federal or non-federal) or person undertakes such other actions. The CEQ regulations further require that NEPA environmental analyses address connected, cumulative, and similar actions in the same document (40 CFR 1508.25). The cumulative impact analysis for this EA focuses on the incremental interaction the Proposed Action may have with other past, present, and reasonably foreseeable future actions, and evaluates cumulative impacts potentially resulting from these interactions. The past, present, and reasonably foreseeable future actions at KSC, Cape Canaveral Air Force Station (CCAFS), and Port Canaveral focus on constructing facilities and improving transportation modes, spacecraft processing and launch, and the cruise and cargo industry. Implementation of the Proposed Action would not likely cause any significant cumulative impacts to local resources.

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ACRONYMS AND ABBREVIATIONS

ac	acres
AST	FAA Office of Commercial Space Transportation
BDA	Blast Danger Area
BMAPs	Basin Management Action Plans
BMP	Best Management Practice
C	Celsius
CCAFS	Cape Canaveral Air Force Station
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cm	centimeters
CNS	Canaveral National Seashore
CO	carbon monoxide
CO_2	carbon dioxide
CZMA	Coastal Zone Management Act
dB	decibels
dBA	A weighted sound pressure level
DNL	day-night average noise level
DO	dissolved oxygen
DOT	Department of Transportation
EA	Environmental Assessment
EFH	Essential Fish Habitat
EGS	Exploration Ground Systems
EO	Executive Order
EPA	Environmental Protection Agency
ERD	Environmental Resources Document
ERP	Environmental Resource Permit
F	Fahrenheit
FAA	Federal Aviation Administration
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FDOH	Florida Department of Health
FEMA	Federal Emergency Management Agency
FPF	Fairing Processing Facility
FPL	Florida Power and Light
ft	feet
ft^2	square feet
gal	gallon
GHe	gaseous helium
GHG	greenhouse gas
GN_2	gaseous nitrogen
GPS	global positioning system
GSDO	Ground Systems Development and Operations
ha	hectares
HAP	Hazardous Air Pollutants
HIF	Horizontal Integration Facility
ICRMP	Integrated Cultural Resources Management Plan
IRL	Indian River Lagoon
ISS	International Space Station
kg	kilogram
kgf	kilogram-force
km	kilometer

KSC	John F. Kennedy Space Center
kv	kilovolt
lbf	pound-force
lbs	pounds
LC	Launch Complex
LCH_4	liquid methane
LOX	liquid oxygen
LZ-1	Landing Zone 1
m	meters
m^2	square meters
mi	miles
MINWR	Merritt Island National Wildlife Refuge
mph	miles per hour
mt	metric tons
N	nitrogen
NAAQS	National Ambient Air Quality Standards
NASA	National Aeronautics and Space Administration
NCRS	Natural Resources Conservation Service
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NMS	National Marine Sanctuary
NO_2	nitrogen dioxide
NOAA	National Oceanicand Atmospheric
NO_2	nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration
NOx	nitrogen oxide
NPDES	National Pollutant Discharge Elimination System
NPR	NASA Procedural Requirement
NPS	National Park Service
NRHP	National Register of Historic Places
NRO	National Reconnaissance Office
OFW	Outstanding Florida Waters
OSHA	Occupational Safety and Health Administration
OSTDS	On Site Treatment and Disposal System
Pb	lead
PCB	polychlorinated biphenyl
PEIS	Programmatic Environmental Impact Statement
pH	a measure of acidity/alkalinity of a solution
PM10	particulate matter less than or equal to 10 microns in diameter
PM2.5	particulate matter less than or equal to 2.5 microns in diameter
PRL	Potential Release Location
PWQ	Process Waste Questionnaire
QD	quantity distance
RCRA	Resource Conservation Recovery Act
ROI	Region of Influence
RP-1	Rocket Propellant 1 (kerosene)
RWWTF	Regional Waste Water Treatment Facility
SAA	Space Act Agreement
SCLV	Small Class Launch Vehicle

SJRWMD	St. Johns River Water Management District
SLF	Shuttle Landing Facility
SLS	Space Launch System
SO_2	sulfur dioxide
SpaceX	Space Exploration Technologies
SPCC	Spill Prevention, Control, and Countermeasures
SR	State Road
SWMU	Solid Waste Management Unit
tf	ton force metric
TMDL	Total Maximum Daily Load
TRP	Technical Response Package
$\mu g/m^3$	micrograms per liter
UPSS	Universal Propellant Servicing System
U.S.	United States
USAF	United States Air Force
U.S.C.	United States Code
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
VAB	Vehicle Assembly Building
VOC	Volatile Organic Compound

1.0 PURPOSE AND NEED FOR THE PROPOSED ACTION

1.1 Introduction

This Environmental Assessment (EA) was prepared by the National Aeronautics and Space Administration (NASA) to evaluate the proposed development and operation of Launch Complex (LC) 48 at the John F. Kennedy Space Center (KSC) in east central Florida. The complex would provide a clean pad surface to which potential customers could bring their own ground systems for launching Small Class Launch Vehicles (SCLVs) and/or for engine test operational recertification for reflight. At full build-out, LC-48 would include up to two concrete slab launch pads, utility hookups, deluge system, and mobile launch support infrastructure.

Federal agencies are required to consider environmental consequences resulting from their actions. This is in accordance with regulatory mandates including the National Environmental Policy Act (NEPA) of 1969, as amended (Title 42 of the United States Code [U.S.C.] 4321 - 4347), the Council on Environmental Quality (CEQ) regulations for implementing NEPA (40 Code of Federal Regulations [CFR] parts 1500-1508), NASA regulations for implementing NEPA (14 CFR Subpart 1216.3), and the NASA Procedural Requirement (NPR) for Implementing NEPA and Executive Order (EO) 12114 (NPR 8580.1). Also, because a potential launch operator(s) at LC-48 may apply to the Federal Aviation Administration (FAA) Office of Commercial Space Transportation for a commercial space license once the launch site is built, this EA complies with FAA Order 1050.1F, *Environmental Impacts: Policies and Procedures*, regarding potential launch-related impacts. This will enable the FAA to adopt this EA in the future to support its environmental review of a license application(s) for commercial space launch operations at LC-48. As NASA is considering a plan to develop a SCLV launch complex, this EA is necessary for compliance with NEPA, as well as related federal and state environmental regulations. The environmental impacts of the proposed construction and operation of LC-48 must be assessed prior to NASA entering into any agreements such as land use permits and support arrangements authorized under Space Act Agreements (SAAs).

1.2 Location and Background

NASA was created in 1958 to lead the nation's civilian space exploration and aeronautical technology development activities. In 1962, NASA began acquiring property to be used as a base for launch operations in support of the Manned Lunar Landing Program. A Launch Operations Center, later known as KSC, was established in Merritt Island, Florida. KSC is situated along the east coast of central Florida approximately 242 kilometers (km) (150 miles [mi]) south of Jacksonville, 322 km (200 mi) north of Miami, and 64 km (40 mi) east of Orlando (Figure 1-1). KSC is located within Brevard and Volusia counties and is comprised of approximately 57,400 hectares (ha) (142,000 acres [ac]). Today, NASA continues to operate KSC as the nation's primary federal spaceport for government and commercial access to space. NASA at KSC was responsible for ground processing, launch, and landing activities for the Space Shuttle Program, which was retired in 2011. NASA is furthermore engaged in developing new capabilities to implement future space programs and the advancement of the commercial space industry, including the use of KSC property by other governmental agencies, commercial space and related industries, and universities through Enhanced Use Leases and SAAs. Property agreements at KSC include Space Florida's operation of the Shuttle

Landing Facility (SLF) for use by commercial and governmental entities, the Florida Power and Light (FPL) photovoltaic facilities, Boeing's use of the former Orbiter Processing Facility 3 for manufacturing and testing of the CST-100 Starliner, the Blue Origin Manufacturing Facility in Exploration Park, and the Commercial Space Launch Act agreement with Space Exploration Technologies (SpaceX) for processing and launch of Falcon vehicles at LC-39A.

The Proposed Action would support the NASA goal of encouraging activities by the private sector to strengthen and expand U.S. space transportation infrastructure. It would provide greater mission capability to meet small class vehicle customer needs. The Programmatic Environmental Impact Statement (PEIS) for the KSC Master Plan, completed in November 2016, describes the current environmental setting and long range planning (2012-2032) for KSC. Programmatic NEPA documents are broad in scope and may be followed by more site-specific or action-specific documents, as appropriate. This is described as tiering, with focused documents (such as this EA) referring back to broader documents (such as the KSC PEIS) that elaborate in more detail. The more narrowly focused NEPA documents do not need to repeat the impact analysis of common issues from the broad EIS. Instead, they would incorporate by reference a summary of those discussions and analyses, and focus on the project specific issues. The KSC PEIS was prepared to evaluate potential environmental impacts from center-wide KSC operations, activities, and facilities; consider scenarios for repurposing existing facilities; reorganize management of KSC and its land resources; and continue partnerships with government organizations and commercial entities. NASA, as the lead federal agency, has prepared this EA as a tiered document focusing on development of a SCLV launch complex. The KSC PEIS is incorporated by reference with new information and details provided, as appropriate.

This EA was prepared by NASA as the proponent of the Proposed Action and the lead federal agency, in cooperation with the FAA and the U.S. Fish and Wildlife Service (USFWS). As the landowner, NASA is responsible for managing areas on KSC for space-related development and operations, and provides oversight for current non-NASA space and technology development use of KSC property. KSC would be responsible for establishing and coordinating appropriate use agreements and operating procedures for those activities outlined in the Proposed Action.

The FAA Office of Commercial Space Transportation is a cooperating agency in the preparation of this EA due to its role in licensing commercial launch operations. The FAA Office of Commercial Space Transportations' mission is to ensure protection of the public, property, and the national security and foreign policy interests of the United States during commercial launch or reentry activities, and to encourage, facilitate, and promote U.S. commercial space transportation. The FAA may receive a launch license application(s) from a commercial space launch operator(s) for launch operations at LC-48 once the launch complex is built. The FAA intends to adopt this EA in the future to support its environmental review of the launch license application(s). If, after reviewing the launch license application and this EA, the FAA determines that future proposed operations fall within the scope of this EA and that the FAA's action of issuing a license would not individually or cumulatively result in significant impacts on the human or natural environment, the FAA would adopt this EA and issue its own finding of no significant impact (FONSI) to support issuing a license. The FAA will draw its own conclusions from the analysis presented in this EA and assume responsibility for its environmental decision and any related mitigation measures. For the FAA to completely rely on this EA to satisfy its NEPA obligations, the EA must meet the requirements of FAA Order 1050.1F, which contains the FAA's policies and procedures for compliance with NEPA.

The USFWS is a cooperating agency in the preparation of this EA due to management responsibilities for land potentially affected by the activities evaluated in this EA. Through official agreement with NASA (KSC-1649 Rev. A), the USFWS manages KSC lands not specifically used for space-related operations as the Merritt Island National Wildlife Refuge (MINWR).

The various components of the Proposed Action are described in detail in Section 2. The general vicinity and potential location for the activities on KSC are shown in Figure 1-1.

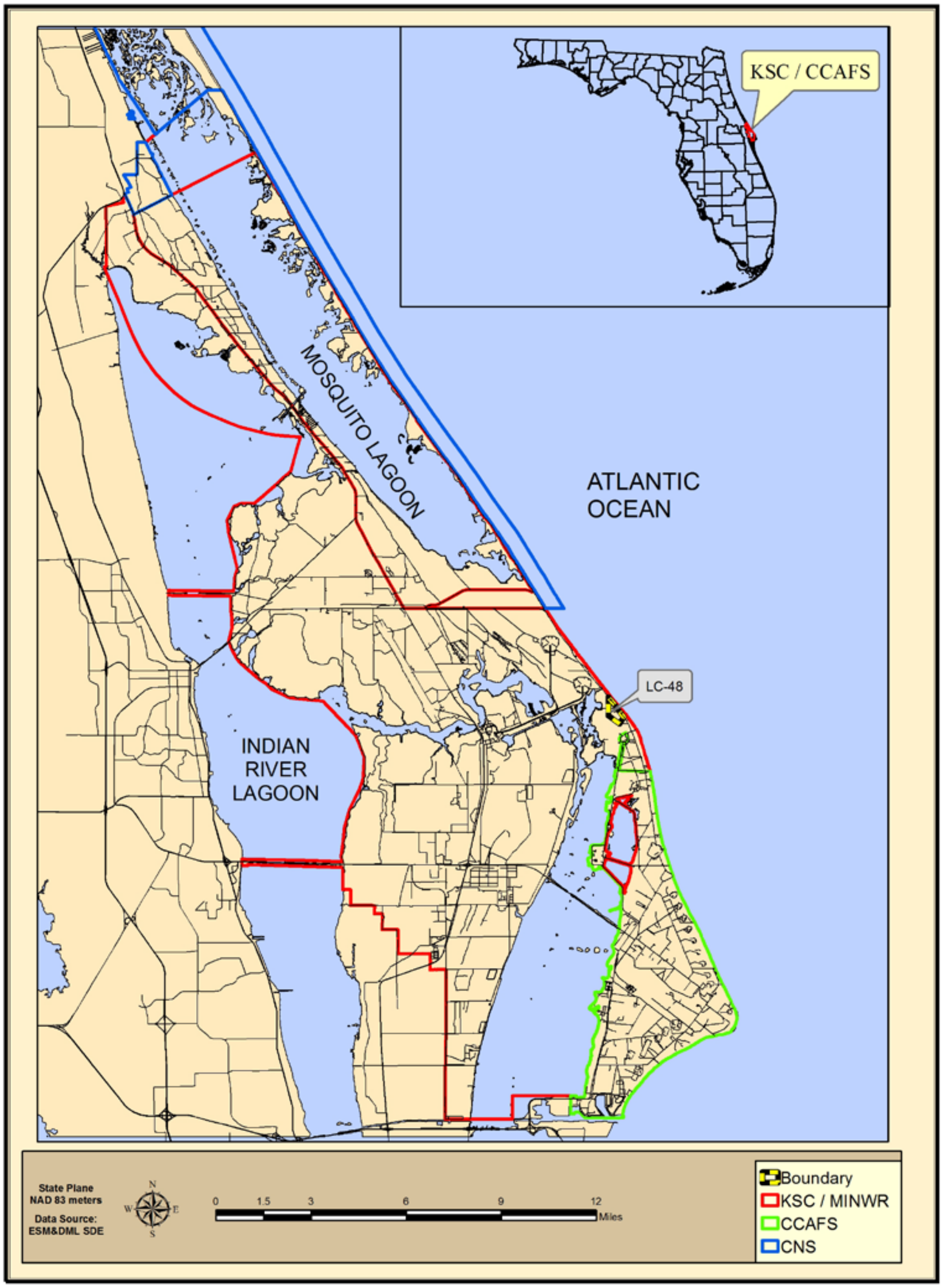

Figure 1-1. Location of the proposed Launch Complex 48 site on KSC.

1.3 Purpose and Need for Action

As established by the Office of the President and directed from Congress, it is NASA's mission to expand commercial uses of space and the space industry. This directive is detailed in the NASA Authorization Act of 2010 and the Space Act of 1958, as amended. The purpose of NASA's Proposed Action is to expand its spaceport capabilities to include the processing and launch of small class vertically launched rocket-powered vehicles. This will: 1) enable improved access to KSC's space launch and test operation capabilities by NASA, as well as commercial and other non-NASA users, 2) advance NASA's mission by fostering a commercial space launch and services industry, and 3) improve the return on taxpayer investment in KSC spaceport facilities through expanded and improved utilization.

This action also furthers the goals of KSC long-term planning initiatives and NASA programmatic objectives, and ultimately increases American competitiveness in the commercial space market. The proposed LC-48 site would be a direct fulfillment of the KSC Master Plan (NASA 2013) to "foster and support the fullest commercial use of space". In 2015, KSC dedicated LC-39C, located within the southeast area of the LC-39B perimeter, to accommodate Small Class Vehicles. LC-39C serves as a multi-purpose site allowing companies to test vehicles and capabilities in the smaller class of rockets, making it more affordable for small class launch vehicle companies to participate in the commercial spaceflight market. A complexity of LC-39C is that it is shared with the Space Launch System (SLS) program utilizing LC-39B, and customers using LC-39C must do so on a non-interference basis. Since the construction of LC-39C, KSC has experienced a much greater interest and demand for the use of a small class launch complex. This resulted in the goal of augmenting capabilities to accommodate increased demand by developing an additional small class vehicle launch complex, to be designated LC-48. More details of site consideration are discussed in Section 2.

The FAA's action of issuing licenses to commercial space launch operators at LC-48 is considered part of the Proposed Action analyzed in this EA. The FAA's purpose of issuing licenses to commercial space operators is to fulfill the FAA's responsibilities as authorized by Chapter 509 of Title 51 of the U.S. Code for oversight of commercial space launch activities, including licensing launch activities. The need for FAA's action results from the statutory direction from Congress under the U.S. Commercial Space Launch Competitiveness Act of 2015 to, in part, "promote commercial space launches and reentries by the private sector; facilitate Government, State, and private sector involvement in enhancing U.S. launch sites and facilities; and protect public health and safety, safety of property, national security interests, and foreign policy interests of the United States." Pub. L. 114-90, § 113(b). Additionally, Congress has determined the Federal Government is to "facilitate the strengthening and expansion of the United States space transportation infrastructure, including the enhancement of United States launch sites and launch-site support facilities, and development of reentry sites, with Government, State, and private sector involvement, to support the full range of United States space-related activities." 51 U.S.C. § 50901(b)(4).

1.4 Structure and Scope of the Environmental Assessment

This EA presents the analysis and description of potential environmental impacts that could result from the Proposed Action and the No Action Alternative. As appropriate, the affected environment and environmental consequences of the Proposed Action and the No Action Alternative are discussed in context with resource area descriptions.

The structure of the EA is as follows: Section 2 describes the Proposed Action, the No Action Alternative, and Alternatives Considered but Eliminated from Analysis, and discusses reasons for alternative site selection or non-selection. Section 3 describes the affected environmental resources and potential direct and indirect effects or consequences of the Proposed Action and the No Action. The resources analyzed in detail are:

- Land Use/Visual Resources
- Noise
- Biological Resources
- Cultural Resources
- Air Quality
- Climate
- Hazardous Materials/Hazardous Waste
- Water Resources
- Geology and Soils
- Transportation
- Utilities
- Health and Safety
- Socioeconomics
- Environmental Justice and Children's Environmental Health and Safety
- Section 4(f) Properties

Section 4 describes cumulative impacts on the resource areas from other similar past, present, and reasonably foreseeable future actions. Section 5 presents a list of those who prepared the EA and key personnel who contributed to its content. Section 6 lists references cited in the EA.

2.0 DESCRIPTION OF THE PROPOSED ACTION AND ALTERNATIVES

2.1 Introduction and Background

This section provides a discussion of the Proposed Action of developing LC-48 on KSC. It also provides descriptions of alternative actions considered but eliminated. Only the Proposed Action and the No Action Alternative were evaluated.

The KSC Master Plan identifies the location for LC-48 as approximately 1.6 km (1 mi) southeast of LC-39A and 1.6 km (1 mi) northwest of LC-41 (Figure 2-1). This location was designated as the most suitable site for a small or medium class pad over twelve other alternatives assessed on KSC as part of a vertical launch site evaluation conducted by Reynolds, Smith, and Hill, Inc. (RSH 2007).

2.2 Description of Proposed Action

The multi-user LC-48 would be designed as a versatile launch pad and integrated stage testing facility for SCLVs. LC-48 would provide a clean pad surface to allow customers to bring their own launch ground systems for launching an SCLV or for engine tests for operational recertification. Multiple liquid propellant types would be accommodated, including oxygen, methane, hydrogen, hypergolic propellants, and rocket propellant 1 (RP-1), as well as a variety of other liquid and hybrid solid propellants. High-pressure gasses (nitrogen [GN_2] and helium [GHe]) would also be allowed for use on LC-48. KSC would be able to provide the Universal Propellant Servicing System (UPSS), which includes propellant loading skids, vacuum jacketed pipes, and propellant manifold connections. There are also two 41,639 liter (l) (11,000 gallon [gal]) liquid methane (LCH_4) storage containers and three 20,441 l (5,400 gal) liquid oxygen (LO_X) storage containers available for use at KSC. Customers could also provide their own mobile propellant service systems. Customers would provide lightning protection, cameras, lighting, access ladders/platforms, umbilical towers, and launch control systems.

LC-48 could support up to two concrete slab pads with room for minimal supporting infrastructure and facilities, or one pad that would allow for a greater diversity of supporting facilities. Initial development of the area (Phase 1, Figure 2-2) would include the one clean pad design. To account for potential future partners and development, the total build out concept for LC-48 could support fully integrated launch facilities with all necessary supporting infrastructure.

Figure 2-1. Location of the proposed Launch Complex 48 and adjacent launch pads.

Under the two-pad design scenario of Phase 2 (Figure 2-3), a company or multiple companies would transport their vehicle from off site before launch. Any infrastructure needed to develop and process vehicles would likely be located elsewhere, leaving this option as flexible as possible to avoid conflict with another company's ability to operate, should there be multiple users.

Once Phase 2 was implemented, LC-48 would accommodate an additional 52 SCLV launches per year, for a total of 104 launches per year once both phases are fully operational. SCLVs weigh up to 136,078 kilograms (kg) (300,000 pounds [lbs]) and have a thrust range up to 226,796 kilogram-force (kgf) (500,000 pound-force [lbf]). Propellants used include solid, RP-1, LO_X, monomethyl hydrazine, dinitrogen tetroxide (N_2O_4), hydrazine (N_2H_4), isopropyl alcohol, and LCH_4. SCLVs can have from one to five stages. Table 2-1 provides vehicular data for the types of SCLVs potentially using LC-48.

Table 2-1. Launch Vehicles Potentially Utilizing LC-48.

Vehicle	Payload	Dimensions	Propellant Type	Propellant Amount klb (tons)	Liftoff Thrust N (lbf)	Gross Liftoff Weight tf[2] (klb[1])
A	680-1361 kg (1500-3000 lbs) to 300+ km (186+ mi) eastward orbit		LOX/methane, LOX/RP-1	250 (113)	1,556,878 (350,000)	0.113 (250)
B	23 kg (50 lbs) to 100 km (62 mi) orbit, low inclination	15 m (50 ft) tall, 1.5 m (5 ft) max diameter	Hybrid: solid, with nitrous oxide or LOX		88,964 (20,000)	0.007 (15)
C	400 kg (882 lbs) to 185km (115 mi) equatorial orbit	21 m (70 ft) tall, 1.8 m (6 ft) diameter	LOX/RP-1, LOX/methane, hypergols on payload	20 (9)	556,028 (125,000)	0.041 (90)
D	100 kg (220 lbs) to LEO[3], 110 kg (243 lbs) to 500 km (311 mi) sun synch	18 m (60 ft) tall	LOX-RP		177,929 (40,000)	0.014 (30)
E	Suborbital		LOX/ethanol or densified propylene		22,241 (5,000)	0.007 (15)
F	40 kg (88 lbs) orbital	12 m (40 ft) tall	LOX/ethanol or densified propylene			
G	Suborbital to >100 km (62 mi), 150 kg (331 lbs) to LEO	6-8 m (20-26 ft) tall, 1.2 m (4 ft) diameter	Hybrid: inert solid (polyethylene plastic or wax	20 (9)	88,964 (20,000)	0.009 (20)

Table 2-1. Launch Vehicles Potentially Utilizing LC-48 (cont.).

Vehicle	Payload	Dimensions	Propellant Type	Propellant Amount klb (tons)	Liftoff Thrust N (lbf)	Gross Liftoff Weight tf[2] (klb[1])
H	300-350 kg (661-772 lbs) to LEO	23 m (75 ft) tall, 1.4 m (4.6 ft) diameter	Hybrid: inert solid (polyethylene plastic or wax	50 (23)	711,715 (160,000)	0.027 (60)
I		8 m (26 ft) tall	LOX/ethanol			
J	1,400-2,300 kg (3,000-5,000 lbs) to LEO	30.5 m (100 ft) tall; 4.1 m (13.7 ft) diameter	LH2/LOX		2,224,111 (>375,000)	0.136 (240)

[1] kilopound (klb) force; [2] ton-force (tf) metric; [3] Newton (N), [4] liquid hydrogen (LH2), [5] low earth orbit (LEO)

In general, the following criteria would apply for each construction phase:

Phase 1:

- A LC-39C equivalent would be sited on the north end of LC-48 and would only include utility hookups, deluge system including catchment basin and sound suppression tanks, fire hydrants, paging and area warning system, perimeter fence, site lighting, connection to high pressure gas lines, and mobile launch support infrastructure (mobile command trailer, UPSS, etc.).
- Payloads and their power supplies, fairings, and cargo modules would be processed in offsite facilities, then brought to the site encapsulated, fueled, and ready for integration to the launch vehicle.
- There would be no launch stand, only the concrete pad. It would have pad dimensions similar to LC-39C. The main launch surface of LC-39C is 17 m (54 ft) wide x 13 m (42 ft) long constructed of 122-cm (48-inch [in]) thick concrete. There would be additional 20-cm (8-in) thick concrete pads, on either side of the main launch surface.
- A 30 ft berm would be constructed to limit quantity distance (QD) impacts and contain hazardous propellant emissions.
- Each launch provider would bring their launch mount and flame deflector.
- Launch rate would be a maximum of 52 launches per year.
- Maximum liftoff weight would be 136,078 kg (300,000 lbs).
- There would be no landings at LC-48.
- The launch pad would be constructed a minimum of 229 m (750 ft) from the road to allow traffic to continue during prelaunch operations and only cease during launches.
- A new access road to the LC-48 site from Phillips Parkway would be required.
- Temporary lightning arrestor towers, if desired, would be supplied by the launch provider.
- A 381 m (1,250 ft) Quantity Distance (QD) would be in effect and is based on standard maximum level of explosives, similar to baseline for LC-39C launch QD.
- Phase 1 would include the potential for engine test operational recertification for reflight.

Figure 2-2. LC-48 Phase 1 conceptual site layout.

Phase 2:

- Additional launch complex would be sited on the south end to the southeast of LC-48 Phase 1, at least 381 m (1,250 ft) away from LC-48 North.
- LC-48 South would accommodate additional supporting infrastructure, including a horizontal integration facility (HIF), multi-use facilities, engine test recertification stand, and deluge system.
- The complex would be located a minimum of 229 m (750 ft) from the road to allow for cessation of traffic only during launches and hazardous operations (test fires, HIF operations, etc.).
- A vehicle rollout pad from the HIF to the pad would be constructed, as well as an access road from Phillips Parkway.
- Launch rate would be an additional 52 launches a year.
- Permanent lightning arrestor towers would be installed.
- A berm would be constructed to protect mobile command trailers from blasts originating at the ground level.

Figure 2-3. LC-48 Phase 2 conceptual dual pad site layout.

2.3 Alternatives Considered and Eliminated from Further Consideration

The proposed location of LC-48 is based on the "KSC Vertical Launch Site Evaluation" (RSH 2007). Eleven sites (A-J, X) on KSC property were assessed for suitability to accommodate small to medium class (up to 227 metric tons [mt] [500,000 lbs of thrust]) vertical launch capabilities. Figure 2-4 shows the locations of the eleven sites considered. Site "A" is the LC-48 site being evaluated as the Proposed Action in this EA.

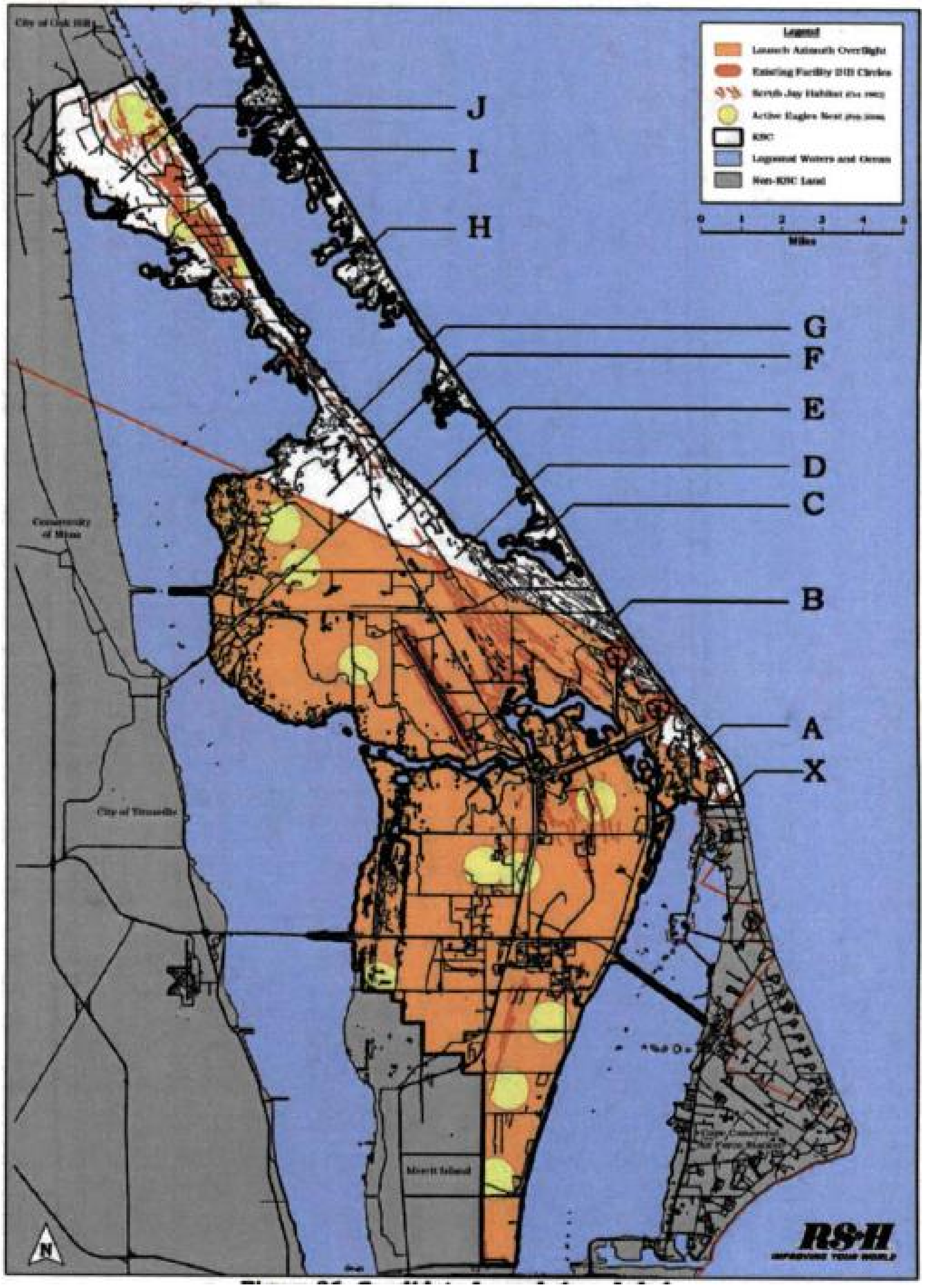

Figure 2-4. Alternate vertical launch sites considered in RSH (2007).

The 2013 KSC Master Plan recommends additional vertical launch pads be located to the north of existing LC-39B, as LC-39C and LC-39D, respectively. Based on public and cooperating agency comments, Spaceport Planning determined that two launch pads in this area were not feasible; one larger notional area also provides a wider range of development options for a non-NASA entity to develop vertical launch capabilities based on its concept of operations, launch trajectory, and rocket type (NASA 2016). These two vertical launch areas northwest were consolidated into one contiguous notional site, LC-49, and designated for heavy lift launch vehicles (Figure 2-5). In addition, the Master Plan endorsed the abovementioned study (RSH 2007) recommending vertical pads be sited to the south of LC-39A and to the north of LC-41. The launch area south of LC-39A was designated LC-48.

Reasons for elimination of other sites included:

- Potential issues with public dissatisfaction over increased Playalinda Beach Road, Canaveral National Seashore (CNS), and Mosquito Lagoon closures.
- Property lost in the development process would result in relocation and possible mitigation of access to CNS.
- Large-scale mitigation for wetlands impact would be required.
- Possible closures or relocation of State Road (SR) 3 in the complex vicinity would occur.
- Close proximity to publicly inhabited lands would result in safety concerns.
- Threatened and endangered species issues, including eagle nests and Florida scrub-jay habitat would occur.
- One site considered was partially outside KSC boundary, overlapping Cape Canaveral Air Force Station (CCAFS).

The proposed LC-48 area was chosen as the preferred site due to the following factors:

- Its location directly on the coast mitigates the effects of potential debris fields on neighboring facilities.
- It is within the KSC secured perimeter, thus reducing security concerns and security operations costs.
- It offers avoidance of over-fly of any existing public recreation areas.

In addition, NASA’s Ground Systems Development Office (GSDO) conducted a Small Vehicle Site and Manufacturing Facility assessment of four sites on KSC and CCAFS. It was determined that the proposed LC-48 site was located outside of the QD and Blast Danger Area (BDA) of any SLS assets at LC-39B, and also outside the QD and BDA for LC-41 and LC-39A. Furthermore, the QD associated with proposed operations that would take place at LC-48 would not impact assets at LC-39B, or LC-41, nor LC-39A.

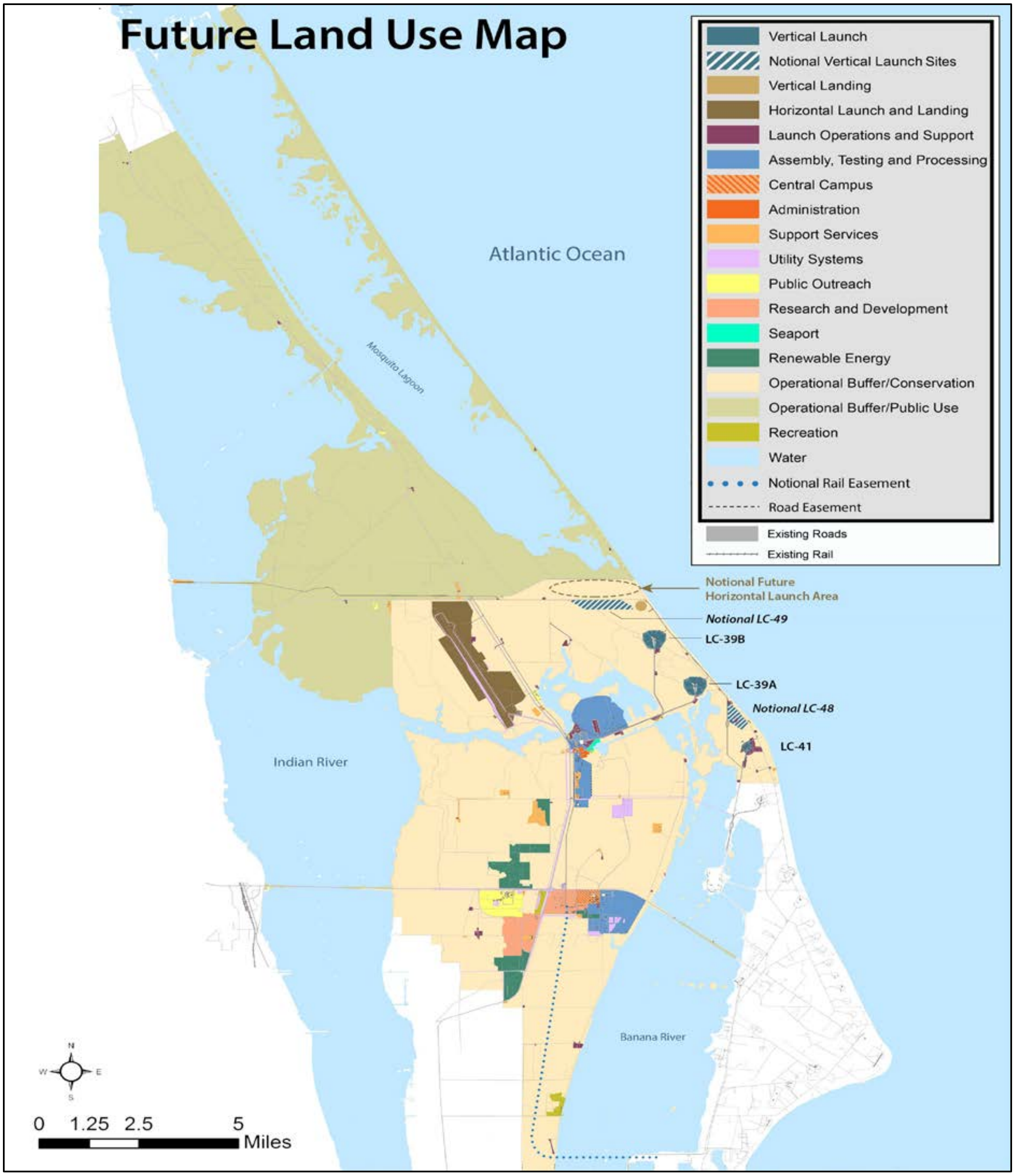

Figure 2-5. Future land use at KSC.

2.4 Description of the No Action Alternative

The No Action Alternative would mean NASA would not build a small class vehicle launch pad on KSC (and thus the FAA would not receive any applications for commercial launch operations at LC-48). There would be fewer commercial customers able to contract SCLV launches, and there would be less diversity in use of KSC property.

3.0 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

This chapter provides a description of the existing environment that could be affected by the proposed action at KSC, followed by an analysis of potential environmental impacts of the proposed action. As directed by NEPA, CEQ regulations on implementing NEPA (40 CFR 1500-1508), NASA's regulations for implementing NEPA (14 CFR 1216), NASA NEPA management requirements (NPR 8580.1A), and FAA Order 1050.1F, the description of the affected environment focuses on those resource areas potentially subject to impacts. Therefore, the level of detail used in describing a resource is in accordance with the anticipated level of environmental impact.

As stated in Chapter 1, this EA complies with FAA Order 1050.1F so the FAA can easily adopt this EA and issue its own FONSI, if applicable. FAA Order 1050.1F, Paragraph 4-1, lists environmental impact categories (i.e., resource areas) for which the FAA considers in its NEPA documents. This EA analyzes all of the FAA's environmental impact categories except farmlands. As stated in Section 3.9.1, none of the soils identified at the site are classified as prime farmland soils. Therefore, this impact category has been dismissed from detailed analysis because the Proposed Action would not affect farmlands.

Additionally, the FAA uses thresholds that serve as specific indicators of significant impact for some impact categories. FAA actions that would result in impacts at or above these thresholds require the preparation of an EIS, unless impacts can be reduced below threshold levels. Quantitative significance thresholds do not exist for all of FAA's impact categories. However, consistent with the CEQ Regulations, the FAA has identified factors that should be considered in evaluating the context and intensity of potential environmental impacts (FAA Order 1050.1F, Paragraph 4-3.3). Because the FAA plans to adopt this EA to support its environmental review of a future license application(s), the FAA's significance thresholds are considered in the assessment of potential environmental consequences in this EA.

The analysis in this EA considers the current conditions of the affected environment and compares those to conditions that might occur should NASA implement the action. The affected environment for this EA includes the geographic extent of the land encompassed by the proposed LC-48. The following parameters are used to evaluate the duration and extent of potential impacts associated with the Proposed Action and alternatives:

- ***Short term or long term.*** These characteristics are determined on a case-by-case basis and do not refer to any stringent time period. Generally, short-term effects occur only with respect to a particular activity or for a finite period, such as the time required for construction. Long-term effects are more likely to be persistent and chronic.
- ***Direct or indirect.*** A direct effect is caused by and occurs contemporaneously at or near the location of the action. An indirect effect is caused by a proposed action and might occur later in time or be farther removed in distance, but still be a reasonably foreseeable outcome of the action.
- ***None, minimal, moderate, or major.*** These relative terms are used to characterize the magnitude or intensity of an impact. The term "none" would be used when there are no impacts expected. Minimal effects are not expected to be measurable, or are too small to cause any discernable degradation to the environment. A moderate impact would be measurable, but not substantial, because the impacted system is capable of absorbing the change, or the impacts could be managed through conservation measures and mitigation. Major effects could be substantial either individually or cumulatively.

- ***Adverse or beneficial.*** An adverse effect is one having unfavorable or undesirable outcomes on the man-made or natural environment. A beneficial effect is one having positive outcomes on the man-made or natural environment. A single act might result in adverse effects on one environmental resource and beneficial effects on another resource, or could result in both adverse and beneficial impacts on a single resource.

This EA examines the environmental impacts of the Proposed Action and alternatives on the following resource areas: land use, visual resources, coastal zone management, noise, biological resources, cultural resources, air quality, climate, hazardous materials and wastes (includes solid waste and pollution prevention), water resources, geological resources, transportation, utilities, health and safety, socioeconomics, environmental justice and children's environmental health and safety, and Department of Transportation Act, Section 4(f).

NASA's NEPA policy requires NASA Centers to maintain an Environmental Resources Document (ERD) that provides a detailed description of environmental resources and related permits. There is a complete description of all resource areas in the 2015 ERD for KSC (NASA 2015a). The 2015 ERD can be accessed at https://environmental.ksc.nasa.gov/projects/documents/ERDrevF.pdf.

3.1 Land Use/Visual Resources

Land use can be defined as the human use of land resources for various purposes including economic production, natural resources protection, or institutional uses. Land uses are frequently regulated by mission objectives, program and project plans, policies, ordinances, and regulations that determine the types of uses that are allowable, or protect designated or environmentally sensitive land. The proposed action sites are bound by NASA land use regulations. Visual resources are defined as the natural and man-made features that give an area its aesthetic qualities. These features define the landscape character of an area and form the overall impression received by an observer of the property.

3.1.1 Affected Environment

Detailed discussions of land use at KSC are available in the KSC PEIS and ERD (NASA 2016, and NASA 2015a). A summary is provided in the following paragraphs.

Land Use

Land and open water resources of KSC comprise 57,400 ha (142,000 ac) in Brevard County and Volusia County, and are located along the east coast of central Florida at approximately 28° 38'N, -80°42'W. The majority of the KSC land is located on the northern part of Merritt Island, which forms a barrier island complex adjacent to Cape Canaveral. Undeveloped areas (uplands, wetlands, mosquito control impoundments, and open water) comprise approximately 95% of KSC. Nearly 40% are open water areas of the Indian River Lagoon system (IRL), including portions of the Indian River, Banana River, Mosquito Lagoon, and all of Banana Creek (NASA 2015a).

KSC was established under NASA jurisdiction for the purpose of implementing the Nation's space program (National Space Act 1959). NASA maintains operational control over approximately 1,787 ha (4,415 ac) of KSC (NASA 2015a). These are the operational areas, which are dedicated to NASA ground processing, launch, and landing activities, and include facilities and associated infrastructure such as roads, parking areas, and maintained right-of-ways. Undeveloped lands within the operational areas are dedicated safety zones, or are reserved for planned and future expansion.

The overall land use and management objectives at KSC are to maintain the Nation's space mission operations while supporting alternative land uses that are in the Nation's best interest. KSC land use is carefully planned and managed to provide required support for missions while maximizing protection of the environment. Land planning and management responsibilities for areas not directly utilized for NASA operations have been delegated to the USFWS at Merritt Island National Wildlife Refuge (MINWR) and the National Park Service (NPS) at CNS. The 54,723 ha (135,225 ac) outside of NASA operational control are managed by the NPS and the USFWS. The NPS administers a 2,693 ha (6,655 ac) area of the CNS, while the USFWS administers the remaining 52,030 ha (128,570 ac) of the CNS and the MINWR (NASA 2015a). This unique relationship between space flight and protection of natural resources is carefully orchestrated to ensure that both objectives are achieved with minimal conflict.

MINWR was created in 1963, by agreement between the Bureau of Sport Fisheries and Wildlife (later USFWS) and NASA to manage the undeveloped lands needed as a safety buffer around KSC. KSC has an agreement with the U.S. Department of the Interior for management of a part of the CNS by the NPS and a part by the FWS.

According to an Interagency Agreement between NASA and USFWS for Use and Management of Property at KSC known as MINWR (KCA-1649 Rev. B), the USFWS shall conduct habitat management activities, including prescribed burning. The USFWS shall coordinate prescribed burns on MINWR in accordance with the "Joint Operating Procedure between the 45th Space Wing, USFWS, and KSC for Prescribed Burning on the MINWR, KSC, and Cape Canaveral Air Force Station, Florida," KCA-4205, Rev. B.

Fire managers at MINWR have been conducting prescribed fire and wildfire control operations in smoke sensitive areas of KSC and CCAFS for over 35 years. KSC facilities are intermixed with fire-dependent wildland habitats including oak-palmetto scrub, pine flatwoods, and marshlands. Due to the high occurrence of lightning strikes, wildfires will continue to occur on MINWR. These wildfires can be managed but not eliminated. Unplanned wildfires pose a risk to public health and safety and interfere with spaceflight operations.

Prescribed burning is the intentional ignition of grass, shrub, or forest fuels for specific purposes. Burn programs on CCAFS and KSC are used as an important natural resource and land management tool and provide biological, ecological, environmental, and safety benefits. Prescribed burns are conducted to: enhance and restore wildlife habitats to conditions that occurred prior to fire exclusion, to promote and benefit wildlife species that are dependent on fire adapted ecosystems, to aid the control of exotic plants and vegetation, and to reduce wildfire threat or "hazardous fuel loads" to protect critical spaceflight infrastructure on CCAFS and KSC.

The LC-48 location is within Fire Management Unit (FMU) 7.4. This unit encompasses 754 ha (1,864 ac), of which 321 ha (792 ac) burned in August 2011. Smoke sensitive areas are located northwest and southwest of this burn unit. This unit does not receive fire according to the prescribed fire schedule. As described above, the USFWS attempts to manage wildfire threats through planned prescribed burn ignitions.

The future land use plan for KSC promotes the best and most efficient use of land area resources balanced with an understanding of development suitability and capacity. The Master Plan outlines a development framework that would support the growth of the multi-user spaceport model. KSC devised eighteen land use categories to describe regions within which various types of operational or support activities are conducted (NASA 2016). Future land use at KSC is depicted in Figure 2-5.

Visual Resources

The area of consideration for visual resources includes the viewshed around the Proposed Action site, such as adjacent lands at KSC and the adjacent CCAFS within view of facilities. Visual resources are any naturally occurring or man-made feature that contributes to the aesthetic value of an area. Areas such as coastlines, national parks, and recreation or wilderness areas are usually considered to have high visual sensitivity.

NASA considers the extent to which any lighting or other visual impacts associated with an action would create an annoyance among people in the vicinity or interfere with their normal activities. Visual and aesthetic resources refer to natural or developed landscapes that provide information for an individual to develop their perceptions of the area. The existing conditions at KSC are characterized as having low visual sensitivity because the site is currently an industrialized area that supports rocket launches. Notable visual structures include the lightning protection towers at LC-39B. Due to the flat topography and the height of the lightning towers (approximately 181 m [594 ft]), the lightning protection towers can be seen several miles away. Other highly visible structures include the Vehicle Assembly Building (VAB) and the KSC Visitor Complex Space Shuttle Atlantis External Tank and Solid Rocket Booster Display.

The visual resources at KSC are typical of an administrative and industrial campus. The LC-39 area is characterized by facilities for launch vehicle assembly, testing, and processing, while the Industrial Area includes various facilities dedicated to administration, payload and launch vehicle processing, and research. Specialized development at KSC includes the SLF (with associated hangars and fueling facility), LC-39A, and LC-39B.

CCAFS, located just to the south of the proposed LC-48 site, is primarily flat with scrub oak and palmetto as dominant land cover types. Visual resources at CCAFS are typical of a military installation with hangars and administrative facilities, but also encompass launch complexes, lightning protection towers, and a lighthouse.

Existing light sources at KSC and CCAFS include nighttime security lighting at the launch complexes and buildings. NASA has guidelines to address the light impacts to wildlife species under the KSC exterior lighting requirements in Chapter 24 of the Kennedy NASA Procedural Requirements (KNPR) 8500.1 Rev. E (NASA 2018). The installation and use of any lighting that is visible from the exterior of a facility must be in compliance with these guidelines. Development of a Lighting Operations Manual that meets the exterior lighting requirements is mandatory for all new structures.

Coastal Zone

Federal activity in a coastal zone requires preparation of a Coastal Zone Consistency Determination in accordance with the Coastal Zone Management Act (CZMA) of 1972 as implemented by the National Oceanic and Atmospheric Administration (NOAA) through State coastal zone management offices. Any activities that directly affect the State's coastal zone are subject to a determination of consistency with the State's Coastal Management Program (15 CFR 930.30-44). NASA and other federal agencies are required to review their activities with regard to direct effects on the coastal zone and are responsible for making the final coastal zone consistency determinations. Florida’s statewide coastal management program, executed by the Florida Department of Environmental Protection (FDEP), oversees activities occurring in or affecting the coastal zone and is based on a network of agencies implementing 24 statutes protecting coastal resources. The State of Florida’s coastal zone is the area encompassed by the entire state and its territorial seas.

The CZMA provides for management of our Nation's coastal uses and resources. CZMA encourages coastal states to develop and implement comprehensive management programs that balance the need for coastal resource protection with the need for economic growth and development in the coastal zone. Once a management program is developed and approved by the NOAA, the state is authorized to review certain federal activities affecting the land or water uses or natural resources of its coastal zone for consistency with the program. This authority is referred to as "federal consistency". The Florida Coastal Management Program was approved by NOAA in 1981, and is codified in Chapter 380, Part II, Florida Statute (F.S.).

Federal activities at KSC which are likely to require consistency determinations include:

- Any project subject to state or federal dredge and fill permitting review
- Point or new non-point source discharge to surface waters
- Major industrial expansion or development projects

The review of consistency with the Coastal Zone Management Program is coordinated through the Florida State Clearinghouse. Because any federal action that directly affects the coastal zone would also be subject to NEPA, consistency review is typically addressed in the NEPA documentation, which is submitted to the Clearinghouse for review.

3.1.2 Environmental Consequences

The following describes potential impacts of the Proposed Action and No Action Alternative on land use, visual resources and coastal zone management. Impacts on land use are determined by comparing established land uses with the changes that would result from the Proposed Action. Because land use is not expected to be impacted differently between the construction and operational (ground) phases of the project, the discussion of the effects of these two stages has been combined in this section. The FAA has not established significance thresholds for land use, visual resources, or coastal resources.

Land Use/Visual Resource

The future land use designation for the proposed LC-48 site is Vertical Launch. This area was previously designated as Operational Buffer/Conservation and managed by MINWR. These conservation lands are currently designated as non-operational areas by NASA and are managed by MINWR. Management of the land would be transferred from MINWR to NASA. Once this area was removed from MINWR oversight, it would no longer be subject to controlled burning operations, one of the Refuge's primary management tools. In addition, MINWR would have to include LC-48 site operators in their prescribed fire planning and coordination activities to ensure that controlled burning of adjacent land and related issues would not impact operations at the launch complex.

The fire management program, which is administered by MINWR, controls vegetative fuel loads at KSC to reduce the potential of wildfires. When NASA KSC receives USFWS notification of a planned prescribed burn adjacent to LC-48, NASA KSC shall notify the launch provider within a reasonable amount of time to allow coordination of prescribed burn between all responsible parties. NASA KSC management will assist the USFWS in resolving any operational or other barriers in order to accomplish prescribed burns. In addition, NASA shall maintain a minimum 30.5 m (100 ft) wide buffer around launch facilities or the outside of the site boundary fence if one is installed, as defensible fire space. This buffer would serve to protect NASA and commercial assets and to better enable USFWS management of adjacent land via prescribed burns.

MINWR also manages a series of impoundments on KSC. In the early 1960s as KSC was being constructed, many of the marshes were impounded to help control mosquitoes. The impoundments are also currently managed to increase their value to wildlife. Development of the LC-48 site would impact a small impoundment, designated as T-25-B, located east of the railroad track. However, the impoundment is not directly connected to the IRL, so no changes to management for mosquitos would be expected. Impacts from the proposed action on MINWR prescribed burning activities at the proposed LC-48 site and adjacent properties would result in a moderate impact to land use.

Potential visual impacts to the landscape in the vicinity of the Proposed Action include light emissions during launch and testing operations if these were to occur at night. There would be no facilities constructed during Phase 1 that block the view of natural surroundings. The launch provider would supply temporary lightning arrestor towers during launch operations. Lightning protection towers, low profile buildings and launch pads would potentially be constructed during Phase 2. LC-48 is outside of the public access area with exception of KSC Visitor Complex tour buses. Though the Proposed Action would require some construction and modifications, these additions would be consistent with existing infrastructure and not cause a significant visual impact to the area. A site plan with details on structure dimensions and site layout would be submitted for review. The KSC site plan review process identifies potential constraints including land use, operational conflicts, natural resources, line-of-sight (LOS), safety, and security. The impact of LC-48 to visual resources would be moderate.

No Action Alternative

Under the No Action Alternative there would be no new construction of facilities on the proposed LC-48 property. Therefore, there would be no project-related impacts to land use or visual resources.

Coastal Zone Management

Florida's coastal zone includes the entire state and its territorial seas. NASA has determined that the Proposed Action is consistent with the Florida Coastal Management Program. As part of the CZMA determination process, this EA will be sent to the FDEP and the Florida State Clearinghouse during the public review period.

No Action Alternative

Under the No Action Alternative there would be no new construction of facilities and no additional launch operations from the proposed LC-48 area. Therefore, there would be no additional impacts to coastal zone resources. The future land use designation for the proposed LC-48 site is Vertical Launch.

3.2 Noise

Noise is defined as any sound that is undesirable because it may interfere with communication, be of sufficient intensity and time to result in decreased hearing acuity, or is otherwise intrusive. Given certain intensities, frequencies, and duration, noise can change the behavior of humans and wildlife. Noise is often generated by activities essential to a community's quality of life, such as construction or vehicular traffic. Noise sources can be continuous (constant) or transient (short-duration) and contain a wide range of frequency (pitch) content. Determining the character and level of sound aids in predicting the way it is perceived. Additional noise sources found on KSC outside of normal community sources include launches from the different launch complexes. Both propulsion noise and sonic booms are classified as transient noise events (BRRC 2017).

Noise is measured in decibels (dB), which is a ratio that compares the sound pressure of a sound source of interest (e.g., the rocket launch) to a reference pressure (the quietest sound humans can hear, 20 μPa [micropascal]). Standard weighting filters help to shape the levels in reference to how they are perceived. An "A-weighting" filter approximates the frequency response of human hearing, adjusting low and high frequencies to match the sensitivity of human hearing. For this reason, the A-weighted decibel level (dBA) is commonly applied to assess community noise. However, if the structural response of a building is of concern in the analysis, a "flat-weighted" (unweighted) level is more appropriate. Sonic boom noise levels are described in units of peak overpressure in pounds per square foot (psf) (BRRC 2017).

Noise criteria have been developed to protect the public health and welfare of the surrounding communities. The Noise Control Act of 1972 (PL 92-574) directs federal agencies to comply with applicable federal, state, and local noise control regulations. In 1974, the Environmental Protection Agency (EPA) provided information suggesting continuous and long-term noise levels in excess of a day/night average sound level of 65 dBA are normally unacceptable for noise-sensitive land uses such as residences, schools, churches, and hospitals. The Brevard County Code §46-131 includes a nuisance noise ordinance which does not set specific not-to-exceed noise levels. The county noise ordinance exempts construction noise between the hours of 7:00 a.m. and 8:00 p.m. (NASA 2016).

3.2.1 Affected Environment

Background information on noise in the vicinity of the Proposed Action is well described in the KSC PEIS (NASA 2016) and the KSC ERD (NASA 2015a). Noise generated at KSC originates from: aircraft noise, industrial operations, construction, launches, and vehicle traffic. Noise levels around facilities at KSC approximate those of any urban industrial area, reaching levels of 60 to 80 dBA. KSC is a large controlled-access area; the noise environment is isolated to activities within the areas where launch vehicle and spacecraft processing and launches represent the primary mission. Aircraft, rocket launches, and landings present sound levels that extend beyond the boundaries of KSC, but only for a short duration. KSC is strategically located away from large population areas. The sound produced by current rocket launches is noticed in all local population areas and the perimeters of KSC are commonly visited by the public for launch viewing.

Traffic noise is generated by employees traveling to and from their workplaces, and the local traffic movement. Typical noise levels from passenger vehicles, tourist buses, and heavy trucks range between 72 and 86 dBA at speeds up to 89 km per hour (55 mph) at a distance of 15 m (50 ft). Overall noise from these sources is dependent on many factors including traffic volume, speed, vehicle type, roadway geometry, and local structures. Most of the vehicular activity is during the daylight hours, commonly between 6:00 a.m. and 4:30 p.m. There are both second and third work shifts at KSC and CCAFS, however, the population and traffic are greatly reduced during those times.

A noise study of activities proposed for LC-48 was performed as part of the efforts for this EA (see Appendix C). Although a number of SCLV could operate from the proposed LC-48, this study examined a single nominal launch vehicle representing the largest SCLV (in terms of thrust) projected to be launched from LC-48. The thrust of the SCLV's engine was modeled using the time varying thrust profile on a nominal trajectory, with a maximum thrust of 414,090 lbf. The largest proposed SLCV in terms of thrust is model vehicle J as shown in Table 2-1 with a thrust >375,000 lbf. Noise contours were presented for the modeled SCLV annual operations which include launches, pre-launch hot fire tests, and engine tests. While SCLV engine testing does not currently occur at KSC, pre-launch hot fire tests and engine tests are included in this analysis to assess noise levels associated with the maximum potential level of future development and operations at LC-48. The potential for propulsion noise and sonic boom impacts was evaluated on a single-event and cumulative basis in relation to human annoyance, hearing conservation, and structural damage criteria. Although FAA Order 1050.1F does not have guidance on hearing conservation or structural damage criteria, it recognizes the use of supplemental noise analysis to describe the noise impact and assist the public's understanding of the potential noise impact (BRRC 2017).

3.2.2 Environmental Consequences

Under the Proposed Action, short-term and long-term adverse effects would be expected. They would result in the continuation of many of the types of noise presently occurring at KSC. Short-term increases in noise would result from the use of heavy equipment during construction and modification of the site, test fires, and rocket launches. Construction noise is largely limited to the site being developed, yet noise can carry to surrounding areas. Typical values for noise levels from construction and associated vehicles are described in the PEIS (NASA 2016). Construction sound levels typically range from 78 to 89 dBA at a 15 m (50 ft) distance from the source. Noise generated during construction activities of the Proposed Action at LC-48 would potentially have discernable, but temporary effects on wildlife occurring nearby. Most wildlife occurring closer to noise sources would be free to move away or find shelter (e.g., burrows), or relocate to another area; therefore, the impacts would be expected to be moderate. Long-term effects would include increased traffic to and from the location and mobilization to the site for pre- and post- launch activities that occur throughout the year.

The loudest noise generated at the site would result from launches and test fires. Personnel on site would be required by Occupational Safety and Health Administration (OSHA) and NASA regulations to be equipped with ear protection devices. Other intermittent raised levels of noise would occur during operation of lifting equipment, diesel-powered generators, and heavy-duty service vehicles. The highest levels of noise from test fires, launches, launch support, and industrial type activities taking place at the site would have moderate impact on the environment and areas beyond the KSC boundaries. See Table 3-1 for typical noise sources and levels (NASA 2015a).

Table 3-1. Typical noise sources and levels.

Outdoor	Sound Level (dBA)	Indoor
Jet Plane (at 100 ft)	130	Rock band (at 15 ft)
SCLV Launch	103	Personal music listening device
Construction site	100	Factory machinery
Tractor/boiler room	90	Garbage disposal
Heavy traffic	85	Hand saw
Freight train	80	Manual machine tools
Freeway traffic	70	Classroom chatter
Normal conversation	60	Sewing machine

Outdoor	Sound Level (dBA)	Indoor
Rainfall	50	Refrigerator

Sources: NASA (2016), OSHA (2017), CHC (2017), ADOT (2008), BRRC (2017), and DD (2017).

For the supporting noise study, the Launch Vehicle Acoustic Simulation Model (RUMBLE), developed by Blue Ridge Research and Consulting, LLC (BRRC), was the noise model used to predict the SCLV noise associated with the proposed operations at LC-48. The core components of the model are visualized in Figure 3-1 and are described below.

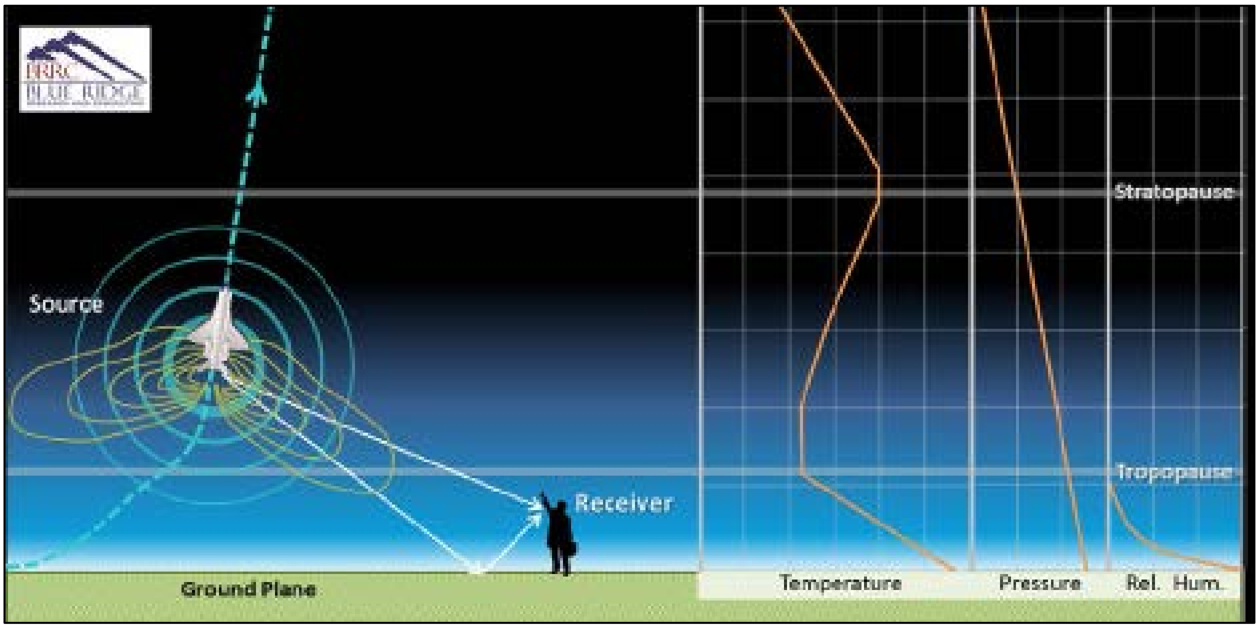

Figure 3-1. Conceptual overview of rocket noise prediction model methodology.

KSC's Hearing Loss Prevention Program has set an upper limit of 103 dBA for unprotected exposures as a guideline to protect human hearing from long-term continuous daily exposures to high noise levels, and to aid in the prevention of noise-induced hearing loss. To assess the potential risk in relation to hearing conservation, the 103 dBA LA, max (maximum A-weighted overall sound pressure level in dB) contours generated by each SCLV event were examined. During an engine test, a receptor located along the peak directivity angle may experience an LA, max of 103 dBA at approximately 1.6 km (1.0 mi) from the launch pad or engine test stand. Levels produced by engine tests would remain constant over the duration of the event, whereas the levels produced by launch events would change as the vehicle sound source moved away from the receiver. The 103 dBA contours are contained within KSC boundaries; the contours encompass LC-39A for launch events and part of LC-41 for launches and engine tests. Predicted noise levels in the community are less than OSHA's 115 dBA upper noise limit guideline (BRRC 2017).

A sonic boom is the sound associated with the shock waves created by a vehicle traveling through the air faster than the speed of sound. For the nominal SCLV launch event, sonic booms intercept the ground during the supersonic portion of the ascent because the flight path angle deviates from vertical with increasing altitude. The boom footprint falls in the Atlantic Ocean, approximately 48.3 km (30 mi) from the launch pad along the launch azimuth (Figure 3-2). The nominal sonic boom from a SCLV launch operation is not predicted to intercept the mainland of Florida and, as such, would not exceed the hearing conservation and structural damage criteria (BRRC 2017).

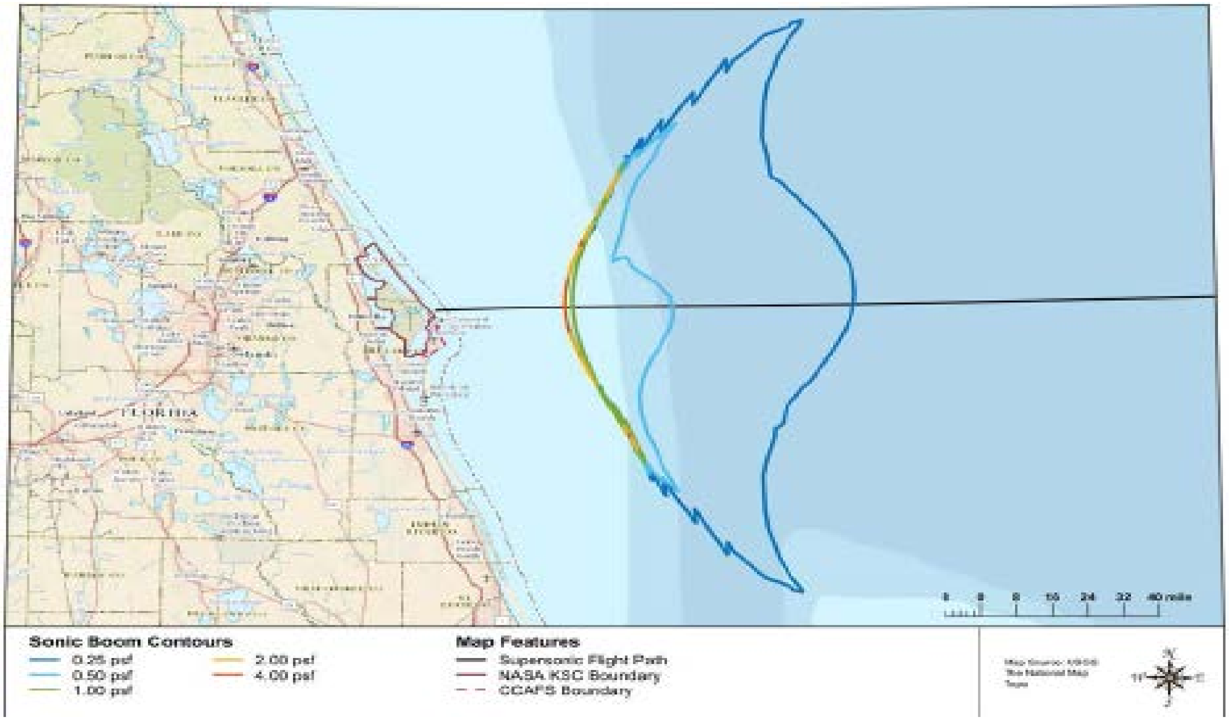

Figure 3-2. Sonic boom peak overpressure contours for a SCLV launch.

The day-night average sound level (DNL) is based on long-term cumulative noise exposure and correlates well with long-term community annoyance. Per FAA Order 1050.1F, impacts are considered significant if the DNL of 1.5 dB or more for a noise sensitive area that is exposed to noise at or above the DNL 65 dB noise exposure level, or that will be exposed at or above the DNL 65 dB level due to a DNL 1.5 dB or greater increase, when compared to the no action alternative for the same timeframe. DNL represents the total accumulation of all sound energy but spread out uniformly over a 24-hour period. Since DNL contours representing the no action alternative at KSC were unavailable, it was determined that for any potential impacts to occur as a result of the SLCV operations, the launch and engine test noise would have to combine with existing noise to increase the 65 dBA DNL by 1.5 dBA or more. Existing noise at the proposed LC-48 site includes noise from LC-39A (operated by SpaceX), and LC-41 (operated by United Launch Alliance). Existing noise exposure at or above DNL 63.5 dBA would require SCLV launches and engine tests to generate levels above the threshold considered significant by FAA. A DNL of 60 dBA was used to conservatively identify potential area where noise impacts may occur as a result of the Proposed Action. The DNL 65 and 60 contours were all contained within KSC boundaries and would not have an impact on residences. Since the sonic boom footprint for nominal launch azimuths does not intercept land, sonic booms would not contribute to the CNL contours. A figure depicting DNL contours for SLCV operations at LC-48 is provided in the report in Appendix C (BRRC 2017).

Under the Proposed Action, moderate adverse noise effects on the immediate environment and areas beyond the KSC would be expected. They would consist of the continuation of many of the types of noise presently occurring at KSC, such as traffic noise, as well as temporary effects, such as those from construction.

Operational noise (launches, test firings, etc.) would be short in duration and intermittent throughout the year.

No Action Alternative

No construction, increase of local traffic, test fires, launches or ground disturbing activities would occur under the No Action Alternative. Therefore, there would be no impacts to cause an increase in noise levels to the area or its inhabitants.

3.3 Biological Resources

Detailed information and descriptions of the flora and fauna of KSC are addressed in the KSC PEIS and ERD (NASA 2016, and NASA 2015a). A summary of this information and additional site specific descriptions of the Proposed Action area are provided in the following paragraphs.

3.3.1 Affected Environment

Biological resources include vegetation, wildlife, and the habitats in which they live. The variety of habitats found on KSC and the adjacent federal properties provides for the greatest wildlife diversity among federal facilities in the continental U.S. (Breininger et al. 1994). KSC is bordered on three sides by parts of the IRL system, considered to be one of the most diverse estuarine ecosystems in the U.S. (Swain et al. 1995). Further to the west lies the St. Johns River Basin ecosystem, one of the largest freshwater marsh systems in the state. In addition, KSC's proximity to the coast fosters an abundance of migratory birds. All of these factors contribute to the exceptional species diversity found on KSC (Breininger et al. 1994). The KSC region has several terrestrial and aquatic conservation and special designation wildlife management areas and aquatic preserves (NASA 2015a). Much of the land of KSC is undeveloped and in a semi-natural state. Topography is generally flat, with elevations ranging from sea level to approximately 6 m (20 ft) above sea level. More than 50% of KSC is classified as wetlands. These areas host a variety of plant communities that are habitat for many resident and transient animal species.

Any federal action that may affect federally protected species or designated critical habitats requires consultation with the USFWS under Section 7 of the Endangered Species Act (ESA) of 1973, and/or with the National Marine Fisheries Service (NMFS) under the Marine Mammal Protection Act (MMPA) of 1972, as amended. The MMPA applies because the Proposed Action, with potential falling debris, launch noise, lighting, etc., is adjacent to the Atlantic Ocean. In addition, potential effects on Essential Fish Habitat (EFH) in offshore waters require consultation and analysis by NMFS under the Magnuson-Stevens Fisheries Conservation and Management Act of 1996.

The aquatic environment surrounding KSC provides diverse fish habitat which supports sport, commercial, and recreational fishes, as well as many shorebird and wading bird species. The Atlantic beaches are important to nesting sea turtles. In addition, the Mosquito Lagoon is primary habitat for juvenile green turtles (*Chelonia mydas*) and loggerheads (*Caretta caretta*), and the IRL is considered among the best oyster and clam harvesting areas on the east coast (NASA 2015a).

The Biological Resources section addresses the plants and animals within the project area that are potentially affected by the Proposed Action. Oceanographic and estuarine habitats and wildlife, terrestrial habitats and wildlife, and threatened and endangered species are discussed in the following paragraphs.

Oceanographic and Estuarine Resources

The NASA (2015) *Environmental Assessment for the Kennedy Space Center Shoreline Protection Project* describes in detail the nearshore environment of KSC and requirements of the Magnuson-Stevens Fishery Conservation and Management Act, Public Law 104-208, which provides for the protection of Essential Fish Habitat (EFH). Ocean waters off KSC have several areas designated as EFH that are of particular importance to sharks and other game fish, as well as numerous species of lobsters, shrimp, and crabs. These habitats include soft bottom substrates, consolidated substrates, and the surf zone (Reyier and Garreau 2012). In addition, the northern boundary of Oculina Bank, a unique strip of coral reefs not duplicated elsewhere on Earth, is located approximately 37 km (20 nautical mi) off of Cape Canaveral. The entire reef is 145 km (90 mi) long.

The benthic habitat of the nearshore off KSC consists primarily of topographically elevated sand ridges which provide an important food resource for fish and larger organisms. Studies in 2000-2001 over nine sand shoal sites off of Brevard County and several counties to the south produced 63 fish taxa, with dusky anchovy (*Anchoa lyolepis*) and silver seatrout (*Cynoscion nothus*) comprising 69% of all fish caught (Hammer et al., 2005). Macroinvertebrate catches included 32 taxa of stomatopods, decapod crustaceans, echinoderms, and squid. Density of several economically valuable fish species including red drum (*Sciaenops ocellatus*), black drum (*Pogonius cromis*), pompano (*Trachinotus carolinus*), sheepshead (*Archosargus probatocephalus)*, and whiting (*Menticirrhus* sp.) appears quite high. The open surf zone and longshore troughs serve as a high value nursery for juvenile lemon sharks (*Negaprion brevirostris*), (Reyier et al. 2008).

Fisheries data from the Florida Fish and Wildlife Research Institute (FWRI) document commercial landings and the Marine Recreational Fishery Statistics Survey documents recreational fisheries landings. The regionally dominant commercial finfish species are sharks, kingfish (*Menticirrhus americanus*), Spanish mackerel (*Scomberomorus maculatus*), striped mullet (*Mugil cephalus*), and king mackerel (*Scomberomorus cavalla*). Recreational catches are numerically dominated by spotted seatrout (*Cynoscion nebulosus*), crevalle jack (*Caranx hippos*), kingfish, gray snapper (*Lutjanus griseus*), and red drum. Pinfish (*Lagodon rhomboides*) are also recorded as a large component of the recreational fishery. Decapod crustaceans sustain the largest commercial and recreational fisheries by weight in east Florida, with landings dominated by white shrimp (*Litopenaeus sp*.) and blue crabs (*Callinectes sapidus*).

The IRL was designated as an "estuary of national significance" in 1990 by the EPA. The IRL supports over 400 species of fishes, 260 species of mollusks, and 479 species of shrimps and crabs (NASA 2015a). Commercially important species include game fish [e.g., red drum, snook (*Centropomus undecimalis*), spotted seatrout, and tarpon (*Megalops atlanticus*)] and crabs. Lagoon habitats also serve as important nursery areas for fish resident within the lagoon, as well as many offshore species. In the impounded wetlands, the fish fauna is numerically dominated by resident fish spending their entire life cycle within the wetland or impounded wetland area. They are usually well adapted physiologically to handle the wide variation in environmental conditions such as extremes in temperature, salinity, and dissolved oxygen (DO), and commonly occur in a variety of habitats. These species include sailfin molly (*Poecilia latipinna*), eastern mosquitofish (*Gambusia holbrooki*), and sheepshead minnow (*Cyprinodon variegatus).*

Terrestrial Habitats and Vegetation

Florida's geological history has largely been determined by sea level changes that directly influenced soil formation and topography, and resulted in the plant communities present today. Fluctuating sea levels that corresponded to glacial and inter-glacial periods have created a series of alternating relict dune ridges and depressions. This "ridge and swale" topography is now a series of adjacent bands of uplands and wetlands running in a generally north/south direction across the island. The dominant upland communities on KSC are scrub and pine flatwoods (Provancha et al. 1986). Long, narrow freshwater marshes are interspersed among the bands of uplands. Forests occur on higher areas among marshes and lower areas among scrub and pine flatwoods (Breininger et al. 1994a). Adjacent to the IRL estuary that surrounds much of the AOI are salt marshes, various wetland shrub communities, and mangrove swamps.

The proposed action site lies on a narrow strip of land between the Atlantic Ocean and an impounded marsh on the northern Banana River (Figure 2-1). The dominant land cover is oak scrub (19.2 ha [47 ac] - 37%), followed by palmetto scrub (14.4 ha [35 ac] - 27%), and coastal strand (7.7 ha [19 ac] - 15%), with the six other land cover types making up the remaining 21% of the site (Table 3-2 and Figure 3-3). The oak scrub, palmetto scrub, and coastal strand areas are relatively undisturbed, and the site contains relatively few exotic plants, although Brazilian pepper (*Schinus terebinthifolius*) has invaded much of the disturbed hydric areas and wetland edges along the northwestern portion of the proposed action site.

Several permanent vegetation monitoring transects have been located in coastal strand and oak scrub habitats within the proposed action area since 1999 to assess coastal scrub restoration efforts by MINWR land managers (Schmalzer and Foster 2016). The most abundant tree and shrub species in order by cover are live oak (*Quercus virginiana*), saw palmetto (*Serenoa repens*), nakedwood (*Myrcianthes fragrans*) and tough buckthorn (*Sideroxylon tenax*), all common species found in these coastal habitats on KSC. The site has been monitored since 1999; it was partially burned once in 2011. Although the fire did temporarily reduce live oak cover and created more openings, it did not reduce vegetation height. The oak scrub within the site is dense, with few openings due to infrequent burning, and in its current condition is not optimal habitat for either the Florida scrub-jay (*Aphelocoma coerulescens*) or gopher tortoise (*Gopherus polyphemus*). However, this site would likely respond favorably to a combination of mechanical restoration and prescribed burning (Schmalzer and Foster 2016).

Table 3-2. Acreages of the nine major land cover types found within the boundary of the proposed action area.

Habitat Type	Hectares (ac)
Brazilian Pepper	5.3 (13.0)
Coastal Strand	7.7 (19.1)
Infrastructure-Primary	0.15 (.37)
Mangrove	1.7 (4.1)
Oak Scrub	19.2 (47.4)
Palmetto Scrub	14.4 (35.5)
Ruderal-Herbaceous	0.88 (2.2)
Water – Interior – Salt	3.1 (7.7)
Wetland Scrub-Shrub-Saltwater	0.24 (0.6)

Habitat Type	Hectares (ac)
TOTAL	**52.5 (129.8)**

Figure 3-3. Existing land cover within the proposed action site for LC-48.

Terrestrial Wildlife

Studies of terrestrial invertebrates have been limited to research aimed at controlling salt marsh mosquitoes, *Ochlerotatus taeniorrhynchus* and *Ochlerotatus sollicitans* (Platts et al. 1943, Clements and Rogers 1964). A detailed biological survey of terrestrial invertebrates has not been performed on KSC.

Four hundred thirty-three species of amphibians, reptiles, birds, and mammals have been documented on KSC. Eleven species are protected by the State of Florida as Threatened (Table 3-3). Nine other terrestrial species are federally protected and two additional species are Candidates for federal protection; these are listed in Table 3-4 and discussed in the Threatened and Endangered Species section below.

Table 3-3. Wildlife species documented on KSC which are not federally listed, but are protected by the State of Florida.

SCIENTIFIC NAME	COMMON NAME	PROTECTION LEVEL
Pituophis melanoleucus mugitus	Florida pine snake	Threatened
Gopherus polyphemus	Gopher tortoise	Threatened
Egretta caerulea	Little blue heron	Threatened
Egretta tricolor	Tricolored heron	Threatened
Egretta rufescens	Reddish egret	Threatened
Ajaia ajaja	Roseate spoonbill	Threatened
Falco sparverius paulus	Southeastern American kestrel	Threatened
Grus canadensis pratensis	Florida sandhill crane	Threatened
Sterna antillarum	Least tern	Threatened
Rynchops niger	Black skimmer	Threatened
Haematopus palliates	American oystercatcher	Threatened

Herpetofauna

Seventy-two species of amphibians and reptiles have been documented as occurring on KSC (Seigel et al. 2002, R. Bolt pers. comm. 2019): four aquatic/semi-aquatic salamanders, 16 frogs and toads (including two introduced exotic species), one crocodilian, 11 turtles, 13 lizards (including four introduced exotic species), and 27 snakes. Six of these are federally protected as either Threatened or Endangered.

Two of the 72 species are not federally listed, but are protected by the State of Florida. These include the gopher tortoise and the Florida pine snake (*Pituophis melanoleucus mugitis*). The Florida pine snake is rarely observed on KSC and little is known about its numbers or distribution. It inhabits the uplands and will use gopher tortoise burrows as den sites, but seems to prefer pocket gopher (*Geomys pinetis*) burrows (Franz 1992); pocket gophers do not occur on KSC.

The gopher tortoise has been classified as a Candidate species for federal listing. The gopher tortoise is discussed further in Threatened and Endangered Species in this section.

Birds

KSC provides habitats for 331 bird species (U.S. Geological Service 2007; updated R. Bolt pers. comm. 2017); nearly 90 species nest on KSC, many of which are year-round residents (Breininger et al. 1994). There are over 100 species that reside in the area only during the winter, including many species of waterfowl. The remaining birds regularly use KSC lands and waters for brief periods of time, usually during migration. The wood stork (*Mycteria americana*) and Florida scrub-jay are federally protected, and the black rail (*Laterallus jamaicensis*) is a Candidate species for federal listing. In addition, there are nine species that are protected by the State of Florida (Table 3-3). Four of these belong to a group of birds commonly called waders (*Order Ciconiiformes*). They are typically associated with wetlands and aquatic habitats and include the storks, egrets, herons, ibises, and spoonbills. The wading bird population on KSC is very large, and it is estimated that between 5,000 and 15,000 birds are present at any given time, depending on the season (Smith and Breininger 1995). The largest numbers occur during the spring and the fewest birds are present in the winter.

Mammals

Thirty species of mammals inhabit KSC lands and waters (Ehrhart 1976). Typical terrestrial species include the opossum (*Didelphis virginiana*), hispid cotton rat (*Sigmodon hispidus*), cotton mouse (*Peromyscus gossypinus*), raccoon (*Procyon lotor*), river otter (*Lutra canadensis*), and bobcat (*Lynx rufus*). Due to the regional loss of large carnivores such as the Florida panther (*Puma concolor coryi*) and red wolf (*Canis rufus*), the bobcat and otter now hold the position of top mammalian predators on KSC. Feral pigs (*Sus scrofa*) are widespread in every habitat, causing much environmental damage, and coyotes (*Canis latrans*) are becoming more common.

A proliferation of mid-level predators, such as the raccoon, has resulted from an imbalance of predator/prey ratios and human-induced habitat changes. Opportunistic species such as the cotton rat, opossum, and eastern cottontail rabbit (*Sylvilagus floridanus*) account for a large portion of the small mammal biomass, rather than habitat-specific species such as Florida mouse (*Podomys floridanus*) and the federally protected southeastern beach mouse (*Peromyscus polionotus niveiventris*). Other small mammals include the least shrew (*Cryptotis parva*), eastern mole (*Scalopus aquaticus*), round-tailed muskrat (*Neofiber alleni*), and the eastern spotted skunk (*Spilogale putorius*). Four species of bats have been documented, the most common being the Brazilian free-tailed bat (*Tadarida brasiliensis*).

Two species of mammals occurring on KSC are federally protected: the southeastern beach mouse and the Florida manatee (*Trichechus manatus*). These are discussed further in the Threatened and Endangered Species section below.

Threatened and Endangered Species

No federally listed plant species have been found on KSC. KSC supports 39 plant species that are protected by the State of Florida as endangered, threatened, or species of special concern (NASA 2015a).

Twenty-one federally protected wildlife species have been documented on or in the near vicinity of KSC, more than on any other national wildlife refuge in the continental U.S. The Atlantic saltmarsh snake (*Nerodia clarkii taeniata*) historically occurred along the coastline from Volusia County through Brevard County south into Indian River County. It is now believed to be restricted to a limited coastal strip in Volusia County (USFWS 2005) and is no longer expected to be found on KSC. Seven species are rare or incidentally present and do not make important contributions to the area's biota. These include the smalltooth sawfish (*Pristis microdon)*, which has been documented in the ocean waters near KSC, the hawksbill sea turtle (*Eretmochelys imbricata*), Kemp's ridley sea turtle (*Lepidochelys kempi*), snail kite (*Rostrhramus sociabilis*), Audubon's crested caracara (*Polyborus plancus audubonii*), piping plover (*Charadrius melodus*), and roseate tern (*Sterna dougallii*).

Twelve federally protected species regularly occur on KSC (Table 3-4). The American alligator (*Alligator mississippiensis*) was once on the brink of extinction, but recovery efforts enabled populations throughout its range to rebound strongly. However, because the alligator is similar in appearance to another listed species, the American crocodile (*Crocodylus acutus*), it remains on the federally protected list. Alligators are abundant on KSC and sometimes cause problems related to traffic safety and encounters with people around and within facilities. Other species that are common are loggerhead sea turtle (*Caretta caretta*), green sea turtle (*Chelonia mydas*), leatherback sea turtle (*Dermochelys coriacea*), eastern indigo snake (*Drymarchon couperi*), wood stork (*Mycteria americana*), Florida scrub-jay, southeastern beach mouse, and the West Indian manatee. The bald eagle (*Haliaeetus leucocephalus*) was removed from the ESA list in 2007, but continues to receive federal protection via the Bald and Golden Eagle Protection Act, Migratory Bird Treaty Act, and Lacey Act. The gopher tortoise is listed as threatened by the State of Florida, but its status was elevated in 2011 to Candidate species for federal listing, and it is included in this section. The black rail (*Laterallus jamaicensis*) became a Candidate species for federal listing in 2018 and is also included in this section. It is considered to be rare on KSC, but it is a very cryptic species. Surveys have not been conducted and its true status is unknown.

Designated critical habitat for the northern right whale (*Eubalaena glacialis*) is located along the KSC coast and extends east for 9.3 km (5 nautical mi). Right whales are often observed between December and March.

Nine of the federally listed species in Table 3-4 could potentially be impacted by construction or operations at LC-48. These species are described in the following paragraphs and will be further discussed in Section 3.3.2 Environmental Consequences.

Table 3-4. Federally protected wildlife species documented to occur on KSC.

SCIENTIFIC NAME	COMMON NAME	PROTECTION LEVEL
Alligator mississippiensis	American alligator	Threatened (S/A)*
Caretta caretta	Loggerhead	Threatened
Chelonia mydas	Atlantic green turtle	Threatened
Dermochelys coriacea	Leatherback sea turtle	Endangered
Gopherus polyphemus	Gopher tortoise	Candidate for listing
Drymarchon couperi	Eastern indigo snake	Threatened
Mycteria americana	Wood stork	Threatened
Haliaeetus leucocephalus	Bald eagle	P*
Laterallus jamaicensis	Black rail	Candidate for listing
Aphelocoma coerulescens	Florida scrub-jay	Threatened
Calidris canutus rufa	Rufa red knot	Threatened
Peromyscus polionotus niveiventris	Southeastern beach mouse	Threatened

SCIENTIFIC NAME	COMMON NAME	PROTECTION LEVEL
Eubalaena glacialis	Northern right whale	Endangered
Trichechus manatus	West Indian manatee	Endangered

*Key: S/A = similarity of appearance; P = protected under the Bald and Golden Eagle Protection Act, Migratory Bird Treaty Act, and Lacey Act.

Marine Turtles

Three species of marine turtles are documented using KSC beaches for nesting. The loggerhead and green sea turtle, both listed as threatened, are abundant during their nesting season (May through October). Leatherbacks, listed as endangered, have increased their nesting on KSC over the past 20+ years; they are no longer considered rare. Juvenile loggerheads and green sea turtles are also found in many portions of the nearby IRL and the estuary is considered to serve as developmental habitat before the turtles return to the Atlantic Ocean for their adult phase.

The KSC nesting beach is 10 km (6.2 mi) long (Figure 3-4). Table 3-5 shows the number of nests, by species, deposited on the KSC beach from 2013 through 2015. Nesting "hot spots" over the last 30 years are typically in kilometers 26-27 and 32-33 (Figure 3-4; Gann 2012). Recently, the area between kilometers 30-31 had the highest percentage of false crawls (emergences that do not result in a nest). During the past few years this same area has experienced high erosion and multiple wash overs (Coastal Planning & Engineering, Inc. 2011).

Some disorientation of marine turtles related to lighting from nighttime space operations has occurred along the KSC beach over the last decade. Disorientation surveys on KSC for adults and hatchlings show that hatchling disorientation rates vary from year to year (Figure 3-5) depending on photo pollution from facilities and the relative condition of the dunes that are between light sources and the nesting beach. Over the last 14 years, the disorientation rate for KSC sources has ranged from 2% to near 12%, with the average between 2000 and 2015 at approximately 5%. Continual erosion events have re-exposed parts of the nesting beach to the exterior lights located landward. In 2016, the USFWS Endangered Species Office issued a Biological Opinion (BO) (FWS Log No. 04EF-1000-2016-F-0083) for exterior light use anticipated under the KSC Master Plan. This BO was based upon the review of lighting impacts and management activities on nesting marine turtles and emerging hatchlings. The resulting rate of incidental take (i.e., hatchling disorientation) allowed by the BO is 3% of nests producing emergent hatchlings and 3% of adult nesting attempts. The Service concluded that this level of incidental take is not likely to result in jeopardy to sea turtle species or result in destruction or adverse modification to critical habitat (FWS 2017). Reasonable and Prudent Measures and non-discretionary Terms and Conditions identified in the BO help reduce lighting impacts and incidental take of sea turtles. This issue continues to be monitored and addressed by KSC environmental managers (NASA 2015).

Kemp's ridley sea turtles have never been observed nesting on KSC, but two incidences of nesting (likely by the same turtle) occurred on CCAFS in 2015. Because they are so rare, they are not included in Table 3-4. However, the number of Kemp's ridley nests in Florida is slowly increasing, possibly as a result of intensive conservation efforts (FNAI 2001). Currently, the potential for disorientation of adults and hatchlings is not a concern, but the possibility of a nesting female or hatchlings being disoriented by LC-48 lighting in the future exists.

Figure 3-4. Marine turtle nesting beach on KSC/MINWR with monitoring marker locations at each kilometer.

Table 3-5. Annual number of nests, by species, deposited on the KSC security beach from 2008 through 2015.

SPECIES	YEAR							
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
Loggerheads								
Nests	1072	789	1163	1089	1584	1080	1092	1404
False crawls	826	734	869	776	1250	760	960	1184
Total	1898	1523	2032	1865	2834	1840	2052	2588
Green Turtles								
Nests	104	53	142	176	156	509	81	779
False crawls	136	71	219	302	130	617	117	618
Total	240	124	361	478	286	1126	198	1397
Leatherbacks								
Nests	1	2	6	3	9	3	8	5
False crawls	0	0	0	1	2	3	2	0
Total	1	2	6	4	11	6	10	5
Total Emergences	**2139**	**1649**	**2399**	**2347**	**3131**	**2972**	**2260**	**3990**

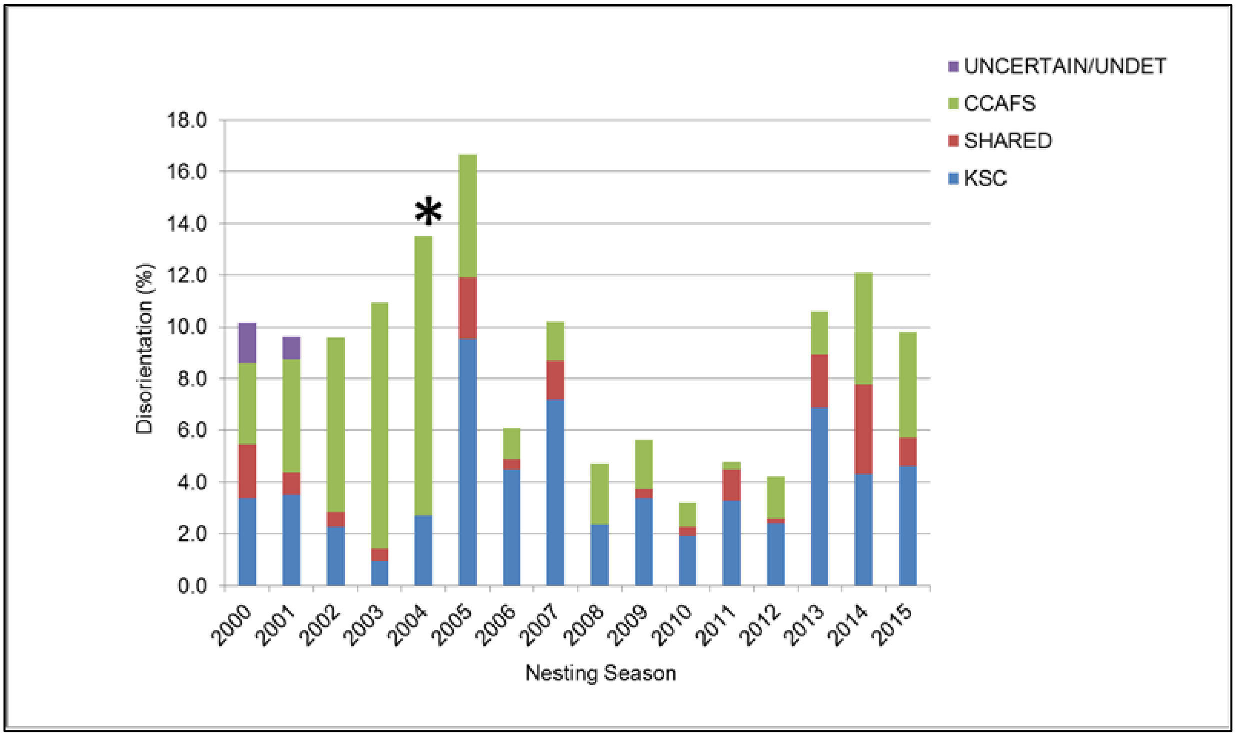

Figure 3-5. Combined disorientation rates of sea turtle hatchlings on KSC.
*= truncated nesting season due to hurricanes, uncertain/undetermined=possible additional disorientations.

Gopher Tortoise

The gopher tortoise is common, wide-spread, and well-studied on KSC (Breininger et al.1991, Breininger et al.1994b, Pike et al. 2005). This species is typically found in dry upland habitats, including sandhills, scrub, xeric oak hammock, and dry pine flatwoods, but also commonly uses disturbed areas such as fields and road shoulders (Auffenberg et al. 1982). The gopher tortoise excavates burrows to use as shelter from weather, predators, and fire. Over 300 species of vertebrate and invertebrate species have been documented using gopher tortoise burrows and, for this reason, the tortoise is considered a keystone species (Eisenberg 1983, Franz 1986). Gopher tortoises prefer uplands that are typically used for development, and they are often found in previously disturbed (ruderal) areas; therefore, conflicts with KSC operations occasionally arise.

Gopher tortoises occur within the boundary of the LC-48 project area; however, density is low and the majority of burrows occur near open areas and adjacent to the maintained right-of-way along Phillips Parkway. The habitat becomes less suitable heading west toward the impoundments. The area could potentially support a more robust tortoise population, but it has not burned since 2011. In order for the habitat to be more suitable, the overstory and mid-story would need to be considerably reduced to allow for light to penetrate the scrub floor. This would promote the growth of herbs and grasses that tortoises need for food and open up space for burrows.

Eastern Indigo Snake

Eastern indigo snakes (*Drymarchon couperi*) have been listed as a Threatened species since 1978. They have large home ranges, eat a wide variety of prey, and use many different habitat types and den sites (Stevenson et al. 2010, Breininger et al. 2011). Radio-tagged indigos in Brevard County tracked between 1998 and 2002 had average home range sizes of 201.7 ha (498.4 ac) for males and 75.6 ha (186.8 ac) for females.

Habitat fragmentation was found to be a critical factor impacting indigo snake population persistence (Breininger et al. 2012). Snakes that occupied areas that were less fragmented by roads and other features had significantly higher survival rates than snakes living in places that were more highly fragmented (Breininger et al. 2004). Road mortality was found to be the most prevalent cause of death in the radio-tagged indigos studied in Brevard County (Breininger et al. 2012). The status of the eastern indigo snake population on KSC is unknown, but it is believed to be more secure than populations that occur outside of protected lands. They have been observed within the general vicinity of the project area and readily use the habitats that are present there.

Wood Stork

Wood storks were listed as Endangered in 1984 primarily due to the loss and degradation of suitable wetlands in south Florida (USFWS 2010). Since being protected, some of the threats to wood stork populations have been reduced, and wood storks have substantially expanded their breeding range northward into Georgia and South Carolina (USFWS 2012a). Based on surveys conducted between 1984 and 2006, the number of nesting pairs has almost doubled, indicating a stable or increasing population (USFWS 2007). As a result, the wood stork status was upgraded to Threatened in 2014.

Aerial surveys for wading birds have been conducted in impoundments and the estuaries on KSC monthly since 1987. The average number of wood storks seen is six to seven per survey (E. Stolen pers. comm.). Wood storks have not nested on KSC since 1991, when freezing temperatures the previous winter killed the majority of mangroves, their primary nesting substrate on KSC. Even though the mangroves have returned, the wood storks have not. Wood stork numbers increase on KSC in the winters when there is an influx of non-resident birds, and they feed more commonly in the freshwater roadside ditches than in the estuarine habitats (B. Bolt per. obs., E. Stolen pers. obs.).

Florida Scrub-jay

The threatened Florida scrub-jay is found in Florida and nowhere else in the world. They live year-round in fairly stable territories, mate for life, and the young stay in their natal territory with the family for several years before establishing territories of their own (Woolfenden and Fitzpatrick 1984). Habitats occupied by Florida scrub-jays are typically oak scrub, oak/palmetto scrub, and coastal scrub, as well as ruderal and disturbed areas in coastal regions. In order for scrub-jays to persist and flourish, the characteristics of the habitat (e.g., vegetation height, thickness of ground cover) must fall within a narrow range that is, ideally, maintained by fire. State-wide, many populations of the Florida scrub-jay continue to decline in spite of legal protection because of habitat loss and degradation caused by the lack of sufficient management.

Although KSC likely has the capacity to support at least 450 scrub-jay family groups, current estimates of population size are 250-350 families (Breininger unpublished data). Scrub-jay habitat is intensively managed on KSC by the USFWS, primarily by controlled burning and mechanical treatment.

Three types of scrub-jay habitats (core, support, and auxiliary) have been defined to categorize the importance and roles of different landscapes for maintaining scrub-jay populations. On KSC, core scrub-jay areas are described as primary habitat (oak scrub on well drained soils) and adjacent secondary habitat (large oak scrub ridges on poorly drained soils) that provide for large, contiguous clusters of territories. Support areas are smaller clusters of primary and secondary habitats outside of important fire management units. These may enhance population size and provide connectivity between population cores. Auxiliary habitats are mostly flatwoods with small scrub oak patches generally outside of fire management units. Auxiliary habitats are population sinks where mortality usually exceeds recruitment, but are considered to have the potential to become core or support habitats with sufficient management.

There are 11.2 ha (27.7 ac) of scrub-jay habitat classified as support within the LC-48 project site and 41.4 ha (102.2 ac) classified as auxiliary (Figure 3-6). There is no core habitat present on site and no Florida scrub-jays were observed during site visits.

Figure 3-6. Potential Florida scrub-jay territory categories within the Launch Complex 48 site.

Southeastern Beach Mouse

The range of the threatened southeastern beach mouse once extended from Ponce Inlet to Miami Beach. Extensive coastal development in unprotected areas has resulted in the loss and fragmentation of those habitats, causing population extirpation from privately owned and most small publically owned lands. Now the mouse can only be found on the contiguous stretch of habitat on CNS, KSC, and CCAFS, with isolated small populations at Archie Carr National Wildlife Refuge and Sebastian Inlet State Park (USFWS 2012b). Southeastern beach mice inhabit the coastal dune and adjoining scrub.

On KSC and adjoining federal properties, the mice occur from the coastal dunes inland to the west side of Phillips Parkway, and are generally found where the sand is suitable for burrows, coastal strand is present, and the water table is not close to the surface. Studies and surveys have been conducted on the southeastern beach mouse population on KSC since the 1970s. Populations appear to have remained stable over the years, likely due to the continuity of the habitat (CNS/KSC/CCAFS) that allows recolonization when subpopulations are extirpated by natural events such as hurricanes and other storms. In a study conducted on KSC between 2003 and 2005 a transect was established within the proposed LC-48 area. Seven beach mice were captured at this transect representing a CPUE of 0.06, slightly below the average CPUE of 0.098 for all KSC transects (Provancha et al. 2005). Age classes captured included mostly adults, but also sub-adults and juveniles; many of the adults from each trapping event were in reproductive condition. Subsequent studies using tracking tubes that record footprints of mice indicate that southeastern beach mice continue to be distributed along the entire CNS/KSC/CCAFS coastline (E. Stolen pers. comm.).

Northern Right Whale

The northern right whale occupies waters off Boston and Canada for feeding during the summer and migrates south during the winter months (Wynne 1999). Females and calves can be found very close to Georgia and Florida shores, the only known right whale calving grounds, between December and March when females give birth to their young (NOAA 2012). In 1994, NMFS designated the coastal waters of Georgia and Florida as right whale critical habitat (Federal Register 1994; Fig. 3-7). Right whales are observed regularly off the Brevard County coast and the Cape Canaveral region is generally considered to be their southern limit, although there are occasional sightings further south (NOAA 2012).

North Atlantic right whales are critically endangered with an estimated population size of 300-400 individuals, but recent analysis of sighting data suggests a slight growth in population size (NOAA 2012). Mortality from boat strikes and fishing gear entanglement are the two major threats to this species, but habitat degradation, contaminants, climate change, and noise are also concerns.

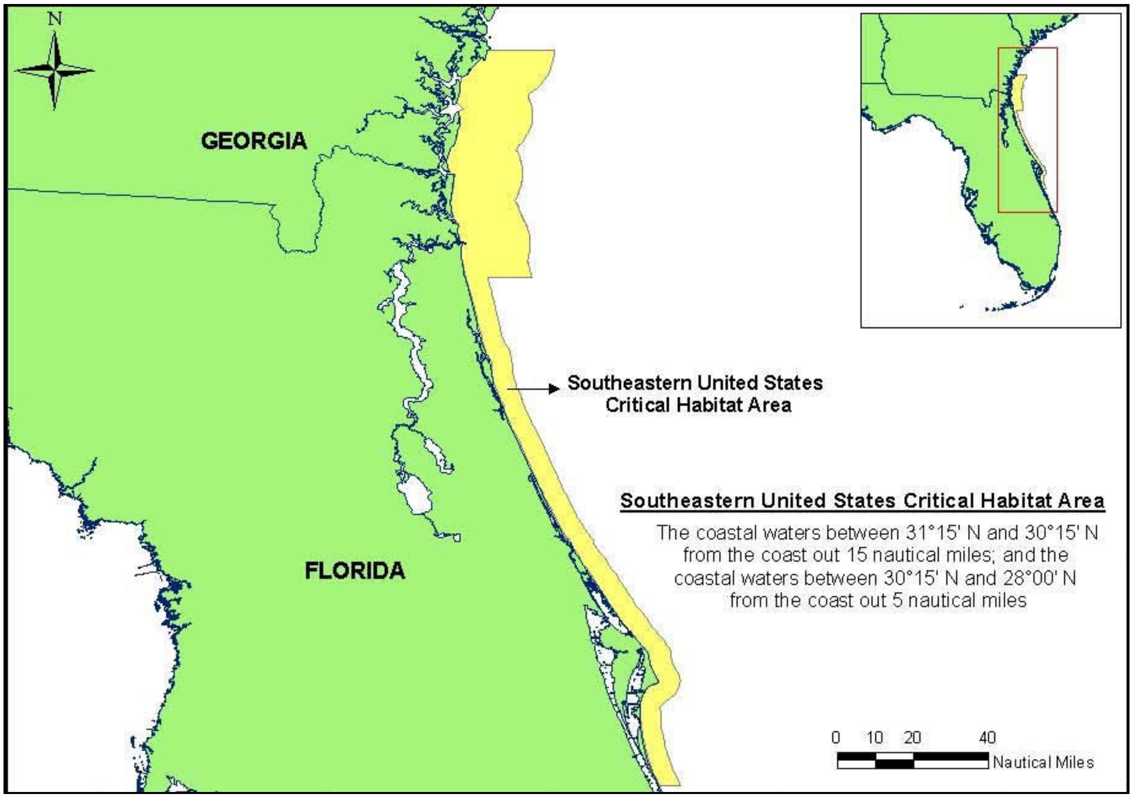

Figure 3-7. Location of designated critical habitat for the northern right whale in the southern part of the range.

3.3.2 Environmental Consequences

Loss of habitat would be the primary impact to wildlife from construction for the Proposed Action. Most of the species that might be directly affected by the development are common on KSC and not legally protected (Breininger et al. 1994). The loss of a maximum of 7.3 ha (18 ac) for Phase 1 and Phase 2 site build-out as described in the Proposed Action is a fraction of the KSC habitat not used for space operations. Additionally, these impact areas are adjacent to areas that are already developed, so fragmentation of undeveloped habitat would be negligible. The impact of construction to the overall wildlife population and biodiversity on KSC from the Proposed Action is expected to be minimal, while local impacts at the site would be moderate. Noise generated during construction activities of the Proposed Action at LC-48 would potentially have discernable, but temporary effects on wildlife occurring nearby. Most wildlife occurring closer to noise sources generated during LC-48 operations would be free to move away or find shelter (e.g., burrows), or relocate to another area; therefore, the impacts would be expected to be moderate.

Potential Impacts to Birds from Lightning Protection Towers

During Phase I, temporary lightning arrestors, 36.5 m (120 ft) tall, would be brought in by launch providers to support individual launch events as required. Four permanent lightning protection towers, anticipated to reach a height of 45.7 m (150 ft) to accommodate potentially larger launch vehicles, would be constructed in Phase II. Guy wires would be installed on the permanent towers for stabilization.

Birds traveling in large flocks during the spring and fall migration seasons, particularly at night, are susceptible to striking tall buildings and towers. Most of these species are not listed as threatened or endangered, but are protected under the Migratory Bird Treaty Act. Evidence suggests that night-migrating songbirds are either attracted to or disoriented by tower obstruction warning light systems, especially during overcast, foggy, or other low visibility conditions (USFWS 2016). The coastline of Florida is used as a guide by birds as they travel during the fall and spring, and KSC bird strike potential is high because of its location along the Atlantic Flyway. Birds moving across the landscape at night outside of migration (e.g., owls and seabirds) may also collide with towers and tower wires.

Current estimates for bird collisions with communication towers in the U.S. are over 6 million per year, and risk appears to increase with infrastructure height (USFWS 2018). The USFWS reports that strike risk is greater with towers that are over 107 m (350 ft) tall, use steady burning lights, have guy wire supports, and are located in areas with frequent inclement weather patterns (i.e., storms, fog), in areas with a higher density of migrating birds, and along ridgelines where the air space impacts bird flight patterns.

In 2008-2009, a lightning protection system (LPS) was constructed at LC-39B as part of the Constellation Program. The system consists of three 181 m (594 ft) tall towers with a network of nine grounding cables extending between the towers and to the ground. Because of the height of the towers, FAA lighting is required. As mitigation for the construction and operation of the lightning protection system, surveys for dead birds were conducted in 2010 during fall migration (36 days) and in 2011 during spring and fall migrations (54 days and 39 days, respectively). A total of 47 birds were found representing 27 different species including songbirds, waterfowl, wading birds, vultures, and grackles (Weiss and Bolt unpublished data).

According to FAA tower lighting requirements, all structures exceeding 60.9 m (200 ft) above ground level must be appropriately marked with tower lights. Since the LC-48 towers would be 45.7 m (150 ft), FAA lighting would not be required, so migrating birds would not be attracted or disoriented by lights. However, since guy wire supports would be installed, the impact of the towers would still be considered moderate. These impacts could be reduced through appropriate mitigation including the use of daytime visual markers on towers, bird flight diverters on guy wires to prevent daytime collisions, minimization of excess wires, and secure attachment of wires to the structure to reduce the likelihood of birds becoming entangled on the tower.

Oceanographic Resources

Although direct impacts are not expected to affect the ocean from the development of LC-48, there is potential for operations to have an effect via components falling into the ocean from launch vehicles. Components would include non-recoverable items (debris) such as jettisoned vehicle stages that are intended to sink to the bottom in ocean areas cleared of shipping or air traffic. It is likely that the density of marine mammals in the AOI would be low and the probability of vehicle components striking animals is minor. Impacts to fisheries and EFH are expected to be insignificant.

Terrestrial Habitats and Vegetation

Site build-out and land alteration of the entire Proposed Action area, although unlikely, would directly impact and permanently alter natural habitats shown in Table 3-2 and Figure 3-3. This worst case development scenario represents a loss of approximately 0.8% of the oak scrub, palmetto scrub, and coastal strand upland habitats currently mapped on KSC. A similar level of impact to wetlands located within the site represents a loss of approximately 0.1% of all mangrove, saltwater scrub-shrub, and impounded brackish water habitats mapped on KSC. It is likely that the actual launch complex development will be closer to the notional concepts shown in Figure 2-2 and Figure 2-3, and impacts to these natural resources would be less than the worst case analysis. Land clearing and creation of new edge habitat could benefit some wildlife species such as the gopher tortoise, but may also allow incursion of non-native invasive vegetation (primarily Brazilian pepper) and numerous non-native grasses.

Operation of LC-48 is not expected to have significant impacts to the composition and structure of adjacent habitats. Depending on site specific environmental conditions at the time of launch, solid propellants in combination with launch deluge water could result in acid deposition and leaf damage (NASA 2014a, Schmalzer et al. 1998). These impacts are expected to occur rarely and have temporary, insignificant impacts on vegetation.

Overall, construction and operation of LC-48 would have moderate impacts on natural habitats that would be partially offset by required Florida scrub-jay habitat compensation and wetland mitigation.

Threatened and Endangered Species

Pursuant to ESA Section 7, the FAA and NASA consulted with NMFS in April 2016 regarding potential impacts to federally listed marine species that could be affected by spacecraft and launch vehicle landing and splashdowns in the Atlantic Ocean and Gulf of Mexico (Appendix D). NASA is currently in consultation with the USFWS Endangered Species Office for the LC-48 project. Impacts to federally protected wildlife species will be analyzed and appropriate mitigation actions will be taken.

Loss of habitat is the primary impact expected to federally protected wildlife (excluding marine animals) from construction of the Proposed Action. Some behavioral responses from launch noise are expected for species residing in habitats immediately adjacent to the launch site. These primarily include startle responses that would result in a short term disruption of normal behavior and movement away from the disturbance, Also, LC-48 operations would result in periodic use of artificial lighting for nighttime activities and site security that may impact animal behavior, particularly that of nesting and hatchling sea turtles. Table 3.4 includes the listed species of concern near the Proposed Action site and these are discussed in the following paragraphs.

Marine Turtles

Construction is expected to take place during daylight hours and would not occur on the beach or primary dunes. Therefore, the marine turtles that nest on KSC beaches and those common in the open water lagoon are not expected to be impacted by construction of the Proposed Action. There is potential for disorientation impacts to nesting and hatchling marine turtles from facility lighting and nighttime launch activity resulting in a moderate impact. All LC-48 infrastructure will comply with the KSC exterior lighting requirements found in the KNPR 8500.1, Rev. E (NASA 2018) and USFWS Biological Opinion (USFWS Log No. 04EF-1000-2016-F-0083) issued to NASA for exterior lighting operation on KSC. The KSC beach is monitored during the nesting season to ensure authorized incidental take associated with hatchling disorientation is not exceeded. In the event authorized incidental take is exceeded, NASA would reinitiate Section 7 Consultation, and any additional mitigation for launch-induced disorientation events would be determined during consultation with the USFWS Endangered Species Office.

Gopher Tortoise

Four of the potentially impacted habitat types (totaling 42.1 ha [104 ac]) are suitable for gopher tortoises: coastal strand, oak scrub, palmetto scrub, and ruderal herbaceous. The expected loss of up to 7.3 ha (18 ac) total of these habitats would constitute a moderate impact that could be lessened by relocation of tortoises from the project area and replacement of ruderal vegetation after the construction is complete. The KSC gopher tortoise policy is to 1) avoid disturbing gopher tortoises or their burrows whenever possible by working with project managers to reconfigure activities; 2) to remove tortoises from harm's way when temporary impacts cannot be avoided so they can remain or be returned to their original home range once the project is completed; or 3) to relocate tortoises away from the project site to nearby suitable areas if the impacts are widespread and permanent.

Eastern Indigo Snake

The eastern indigo snake is the least habitat-specific of all of the protected animals listed in Table 3-4 and may be found in any of the Proposed Action habitats. The required land clearing for both Phase 1 and Phase 2 construction of LC-48 would result in modification of 7.7 ha (19 ac) of potential indigo habitat.. Based on indigo snake radio tracking data in Brevard County, including KSC, this represents 10% of one female indigo's home range and 4% of one male's home range (Breininger et al. 2011). Potential impacts to the eastern indigo are expected to be minimal, but consultation with the USFWS Endangered Species Office is underway to determine required mitigation to address this anticipated habitat loss.

Wood Storks

Wood storks use the impounded wetland habitat types present within the project area for feeding. Nesting has not occurred on KSC since 1991, after freezing temperatures in the late 1980s decimated the mangroves that are the wood storks preferred nesting substrate on KSC. Operations could result in startle responses by wood storks and other wading birds, but impacts are expected to be minimal. If the entire wetlands acreage was developed, there would be a loss of 5 ha (12.4 ac). However, the current preliminary design for LC-48 avoids the wetlands due to required avoidance/minimization requirements and mandatory mitigation of wetlands impacts. If the wetlands were to be developed, wood stork habitat evaluation is imbedded in the wetland permitting process.

Launch operations will likely result in short term startle responses in wood storks, causing them to temporarily abandon feeding activities in adjacent wetlands. Launch activities would not occur frequently enough to significantly or permanently alter wood stork behavior or use of nearby foraging habitat. Therefore, operational impacts are expected to be minimal and will be addressed under consultation with the USFWS Endangered Species Office.

Florida Scrub-jay

There are 52.6 ha (129.9 ac) of potential scrub-jay habitat within the project footprint; none is classified as core habitat and no jays were observed during several site visits. The suitability of scrub-jay habitat is transient due to natural processes and/or active management. The LC-48 area was included in the KSC Florida Scrub-jay Habitat Compensation Plan (NASA 2014) implemented under a USFWS Biological Opinion (FWS Log No. 04EF1000-2013-F-0194) dated 6 November 2013. Constructing Phase 1 and Phase 2 of LC-48 would result in destruction of 6.75 ha (16.7 ac) of support habitat and 0.6 ha (1.5 ac) of auxiliary habitat. Mitigation for support habitat impacts would occur at a 4:1 ratio (hectares of scrub renovated/enhanced for every hectare developed) and auxiliary habitat impacts would be mitigated at a 2:1 ratio. Approximately 28.2 ha (69.7 ac) of Florida scrub-jay habitat restoration would be required to offset LC-48 project impacts. These mitigation activities would take place elsewhere on KSC in potential scrub-jay habitat that is degraded and in need of restoration. The exact location of restoration activities would be determined by MINWR land managers and the NASA Environmental Management Branch.

Effects associated with launch noise are the primary anticipated impact resulting from operation of LC-48. Loud, low frequency noise would likely cause startle responses from jays occupying suitable habitat nearby. This impact would result in temporary, short duration interruption of nominal behaviors. However, birds would return to previous behavior patterns immediately after dissipation of launch noise. Impacts to Florida scrub-jays from construction and operation are anticipated to be moderate.

Southeastern Beach Mouse

There are 7.7 ha (19.1 ac) of coastal strand habitat that could potentially be occupied by beach mice within the project area. The majority of the planned footprint for the launch sites is west of the coastal strand. Southeastern beach mice have also been found within inland oak scrub habitat on KSC, but the numbers have been very low (B. Bolt pers. comm.). There are 19.2 ha (47.4 ac) of oak scrub on site. Construction of Phase 1 and Phase 2 of LC-48 would result in up to 3.2 ha (8 ac) of these habitats being developed for the project. Consultation with the USFWS Endangered Species Office is underway to determine required mitigation to address this anticipated habitat loss. Potential impacts to southeastern beach mice are expected to be moderate.

Northern Right Whale

There would be no impacts to northern right whales from construction of the Proposed Action. Operational impacts from noise and vibration are anticipated to be minimal. There are potential consequences from rocket debris reentry after launch. It is highly unlikely that a right whale would be directly hit by debris because their numbers are low in the AOI. There could be degradation to the marine environment from rocket parts such as fuel tanks that would break apart after hitting the water, sinking quickly, but dispersing contents and substances from their surfaces. Some elements would sink to the bottom intact and degrade over time. These impacts would be classified as minimal for right whales because the corrosion rates would be very slow and the volume of water available to dilute toxins would keep them below dangerous levels (NMFS 2016).

No Action Alternative

Under the No Action Alternative, LC-48 would not be built. Therefore, there would be no impacts to any of the biological resources.

3.4 Cultural Resources

Cultural resources are historic assets associated with human use of an area. Properties are defined by the National Historic Preservation Act of 1966, cultural items are defined by the Native American Graves Protection and Repatriation Act of 1990, archaeological resources are defined by the Archaeological Resources Protection Act of 1979, sacred sites are defined by EO 13007, and collections and associated records are defined by 36 CFR 79. Cultural resources may include locations or landscapes, intangible traditional use sites, or physical remnants associated with past and/or present activities. Physical remnants of cultural resources are usually referred to as archaeological sites or historic properties. KSC has developed an Integrated Cultural Resource Management Plan (ICRMP) that reflects NASA's commitment to the protection of its significant cultural resources; the most recent version of the ICRMP covers the 2014-2018 time period (NASA 2014). The regulatory framework governing preservation and documentation of cultural resources on KSC can be found in the ICRMP and the PEIS (NASA 2016).

3.4.1 Affected Environment

Archaeological Consultants, Inc. (ACI) conducted a cultural resource assessment survey of the LC-48 site during the evaluation of this area as one of the two proposed Commercial Vertical Launch Complex (CVLC) alternatives (ACI 2008). The purpose of the investigation was to locate and identify any cultural resources within the project areas, and to assess their significance in terms of eligibility for listing in the National Register of Historic Places (NRHP).

As shown in Figure 3–8, two recorded archaeological sites (8BR915 and 8BR916), are located in the project area. These sites were identified and recorded during the 1991 KSC-wide predictive model survey of the Launch Complex Area (Option 1) (ACI 1991). The Titusville Beach West #1 Site, 8BR915, was recorded as a surface scatter of aboriginal ceramics with a small subsurface shell midden. The Titusville Beach West #2 Site (8BR916) was recorded as a small coquina midden. Neither site was considered significant in terms of the criteria of eligibility for inclusion in the NRHP.

Archaeological survey of the LC-48 site included ground surface reconnaissance and systematic and judgmental subsurface testing. Testing was conducted at 25 m (82 ft) intervals within the locations of previously recorded sites 8BR915 and 8BR916, at 50 m (164 ft) intervals in the moderate probability areas, and at 100 m (328 ft) intervals or judgmentally within a sample of the remaining low probability areas. A total of 56 shovel tests were excavated. As a result, no evidence of either previously recorded site was found, and no new archaeological sites were discovered. Both 8BR915 and 8BR916 are presumed destroyed. No historic resources, including buildings or structures, are located within the proposed LC-48 boundary. A description of the two previously recorded sites and updated Florida Master Site File (FMSF) forms are in the ACI report (ACI 2008). The Florida State Historic Preservation Officer (SHPO) concurred with the findings of the ACI report in a letter to NASA dated October 17, 2008 (Appendix E).

Figure 3-8. Previously present archaeological sites at proposed Launch Complex 48 site.

3.4.2. Environmental Consequences

The FAA has not established a significance threshold for cultural resources. The development of LC-48 at the proposed project area will have no effect on any archaeological sites or historic resources that are listed, determined eligible, or considered potentially eligible for listing in the NRHP. In a letter dated November 5, 2018, the Florida SHPO concurred with NASA's determination of no effect to historic properties (Appendix E). No impacts are expected to any cultural resources from the Proposed Action.

No Action Alternative

Under the No Action Alternative LC-48 would not be built. Therefore, there would be no land disturbance resulting in impacts to cultural resources.

3.5 Air Quality

Chapter 3.6.1 of the PEIS (NASA 2016) and Section 3.1 of the ERD (NASA 2015a) describe in detail the regulatory context and regional air quality resources for KSC, as well as provide a discussion of types and quantities of air pollutants emitted from NASA's activities on KSC. A brief synopsis is provided below.

3.5.1 Affected Environment

Air quality at KSC is regulated under Federal Clean Air Act regulations (Title 40 CFR Parts 50 through 99) and Florida Administrative Code (FAC) Chapters 62-200 through 62-299.

The EPA sets National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment. The EPA identifies the following six criteria air pollutants for which NAAQS are applicable:

- carbon monoxide (CO)
- lead (Pb)
- nitrogen dioxide (NO_2)
- ozone
- particulate matter (PM10 and PM2.5)
- sulfur dioxide (SO_2)

KSC is located in Brevard County and is classified as an attainment area with NAAQS. Table 3-6 shows federal ambient air quality standards.

Table 3-6. Federal ambient air quality standards.

Pollutant	Average Time	Federal Primary NAAQS	Federal Secondary NAAQS
Carbon Monoxide	8-hour[a] 1-hour[a]	9 ppm 35 ppm	N/A N/A
Lead	Quarterly 3-Month	1.5 µg/m3 0.15 µg/m3[b]	1.5 µg/m3 0.15 µg/m3
Nitrogen Dioxide	Annual 1-hour[d]	0.053 ppm 0.10 ppm	0.053 ppm 0.10 ppm
Ozone	8-hour[h] 1-hour[i]	0.075 ppm 0.12 ppm	0.075 ppm 0.12 ppm
Particulate Matter (PM10)	24-hour[e]	150 µg/m3	150 µg/m3

Pollutant	Average Time	Federal Primary NAAQS	Federal Secondary NAAQS
Particulate Matter (PM2.5)	Annual[f] 24-hour[g]	15 µg/m3 35 µg/m3	15 µg/m3 35 µg/m3
Sulfur Dioxide	Annual 24-hour[a] 1-hour[j] 3-hour	0.03 ppm 0.14 ppm 0.075 ppm N/A	0.5 ppm 0.14 ppm N/A 0.5 ppm

a. Not to be exceeded more than once per year. b. Final rule signed October 15, 2008. c. Annual mean. d. 98th percentile averaged over three years. e. Annual 4th highest daily maximum 8-hour concentration averaged over three years. f. Not to be exceeded more than once per year on average over three years. g. Annual mean averaged over three years. h. 99th percentile of 1-hour daily maximum concentrations averaged over three years. i. EPA revoked the 1-hour ozone standard in all areas, although some areas have continuing obligations under that standard ("anti-backsliding"); the standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is <1. j. The 3-year average of 99th percentile of daily maximum 1-hour average must not exceed 75 ppb. Source: NASA 2015a.

The FDEP classifies KSC as a Title V major source for the potential to emit for the criteria pollutant nitrogen oxide (NO_x), which exceeds the Title V major source threshold of 100-tons per year of NO_x. KSC is considered a minimal source for carbon monoxide, volatile organic compounds (VOCs), particulate matter, sulfur dioxide, and lead emissions. NASA holds a Title V Air Operation Permit which governs the air emissions from those activities. The Title V Air Operation Permit provides a list of emissions units and also shows insignificant emissions units and/or activities. NASA-operated air emission sources are listed on the NASA Title V Air Operation Permit regardless of KSC or CCAFS locations.

The ambient air quality at KSC is predominantly influenced by daily operations such as vehicle traffic, utilities, fuel combustion, and standard refurbishment and maintenance operations. Other operations that occur throughout the year, including launches and prescribed fires, also play a role in the quality of air as episodic events. Stationary point sources of air emissions typically include launch vehicle processing, fueling, and other point sources such as heating/power plants, generators, incinerators, and storage tanks. Mobile sources include support equipment, commercial transport vehicles, rocket launch vehicles, and personal motor vehicles.

Presented below is a summary of air emissions for years 2009 through 2016 for KSC (Table 3-7) of actual tons per year of the NAAQS regulated criteria pollutants and total hazardous air pollutants (HAP) that are included in the current Title V Air Operating Permits.

Table 3-7. KSC history of actual annual emissions (tons per year).

Pollutants	2016	2015	2014	2013	2012	2011	2010	2009
CO	3.209565	4.615386	6.115449	7.216737	9.566955	10.766932	10.385496	11.169308
HAP	0.481	0.620608	0.494365	0.551531	0.548092	0.660688	0.599648	1.164176
NO_X	10.482851	15.349532	23.105867	24.982164	33.99334	38.685013	36.859529	40.1191
PB	0	0	0	0	0	0.00013	0.00031	0.00111
PM	0.681244	1.127629	1.446277	1.694932	2.355932	2.68276	2.545668	2.806149
PM10	0.678	1.076285	1.443928	1.691475	2.348127	2.669978	2.555286	2.803877
PM2.5	0.529171	0.861775	1.254227	1.443872	2.054483	2.346908	2.234567	2.486821
SO_2	0.013569	0.018507	0.022093	0.027068	0.439758	0.518586	0.492052	0.501152
VOC	4.582289	4.717711	3.561213	4.365129	4.682131	6.283344	10.6881	11.16449

Source: FDEP 2017

3.5.2 Environmental Consequences

This section describes the potential impacts to air quality resulting from the Proposed Action and the No Action Alternative. Environmental consequences on local and regional air quality are determined based on changes in regulated air pollutant emissions and upon existing air quality. Per FAA Order 1050.1F, a significant impact on air quality would occur if the action would cause pollutant concentrations to exceed one or more of the NAAQS, as established by the EPA under the Clean Air Act, for any of the time periods analyzed, or to increase the frequency or severity of any such existing violations.

Impacts to air quality would be due to activities associated with the construction activities, ground and launch operations, engine test firing, the occasional operation of generators, and ground vehicle emissions. These effects on air quality on a local and regional scale are expected to be minimal.

Impacts to air quality from construction of the Proposed Action at KSC would be minimal and of short duration. There would be temporary increases in regulated air pollutants in the immediate area of the site during land clearing. Dust from the removal of vegetation and exposure of topsoil and exhaust from heavy machinery would impact local air quality at the site during land clearing. Air pollutants generated could include PM10, sulfur, and nitrogen oxides, and others. These materials would quickly dissipate and the air quality would return to average ambient levels. Particulates and fugitive dust could be controlled with periodic water spraying. Increases in local vehicle and construction and land clearing equipment use would be insignificant. These fugitive emissions would not be substantial enough to change NAAQS attainment status.

Burning of cleared vegetation could occur; the use of controlled burns to dispose of ground cover from land clearing activities is a common practice in Florida. Burning debris emits smoke and ash into the air, reducing air quality. Open burning is a regulated activity and requires authorization from the Florida Division of Forestry and a burn permit from the KSC Duty Office. Burning vegetative debris on KSC requires strict adherence to specific procedures, restrictions, and criteria to be followed during the burning activities.

Impacts to air quality from operations conducted at the proposed LC-48 site are also expected to be minimal and of short duration. Typical activities at the LC-48 site would include engine test fires and launches of SCLVs.

The KSC Title V Air Operation Permit identifies general chemical and solvent use as an insignificant emission source. The highest possible contaminant release scenario would result from the unlikely event of a spill of the entire quantity of liquid propellants. Lesser releases could result from fires or explosions that would consume significant amounts of the propellants. Safety procedures that are in place ensure that there is minimal risk for these events to occur. In addition, spill response planning procedures are in place to minimize spill size and duration, as well as possible exposures to harmful air contaminants.

Because the exact types and quantities of exhaust-generating devices for the Proposed Action are not known, reasonably foreseeable air quality impacts from boilers, hot water generators, and backup electric generators, and non-toxic substances often associated with ground processing activities are addressed here. The capacities for typical operations of the size proposed at the Proposed Action site are estimated to be small, have low fuel usage, and are not expected to produce emissions above potential to emit threshold levels established as major sources of pollution listed in Chapter 62-213.430 F.A.C. For that reason, the emissions are estimated to have minimal air quality impacts. Customers would be required to meet all federal, state, and local air quality requirements, and would apply for their own Title V operating permits if they expected to have any regulated air pollution sources, operations, or processes.

Vehicles proposed for launch at LC-48 would potentially use RP-1, LOX, LO2, LH2, NO2, methane, ethanol, and hybrid solids as propellants. The primary emission products are carbon dioxide (CO_2), carbon monoxide (CO), water vapor (H_2O), and small amounts of nitrogen oxides (NO_x) and particulate matter (PM).

Table 3-8. Estimated Annual Launch Emissions Estimates of Criteria Pollutants (tons per year) at LC-48 Based on Comparison Launch Vehicles.

Emissions (104 launches)	Volatile Organic Compounds	Nitrogen Oxides	Carbon Monoxide	Sulfur Dioxide	PM10	PM2.5
Falcon 1[1]	0	*	614	0	*	*
MM-derived (Minotaur I, 2)[2]	0	0	790	0	102	72
PK-derived (Minotaur IV)[2]	0	0	2,043	0	320	224
Minotaur IV Lite[3]	0	0	2,038	0	641	447
Athena-2[1]	--	312	0.0	0	483	338
Brevard County (2014)[4]	49,787	15,869	114,734	1,307	15,293	5,775

* Too minor to quantify

[1]FAA 2008, [2]USAF 2006, [3]USAF 2009, [4]EPA 2014

Note: Launch PM10 and PM2.5 emissions given for Minotaur launch vehicles are assumed to be 10.3 and 7.2 percent Al_2O_3 respectively (USAF 2004).

Table 3-8 summarizes the criteria air pollutant emissions estimates from comparison launch vehicles at LC-48 annually. Comparison launch vehicles were chosen based on weight of the payload they could carry into orbit. The small payload weight class is considered to be less than or equal to 1,996 kg (4,400 lb). A payload is defined as anything carried by a launch vehicle that is not essential to its flight operations, including spacecraft, cargo, scientific instruments, and experiments (NASA 2009). The largest SCLV considered for LC-48 would be capable of lifting a 1,361 kg (3,000 lb) payload. The comparison vehicles lift from 998 to 2,064 kg (2,200 to 4,550 lb) payloads. Brevard County's emissions from the most recently reported year are included for comparison purposes. Even the highest levels represent small percentages of Brevard County emissions and would not cause an exceedance of any NAAQS.

CO and carbon might appear in the rocket emissions but would readily burn in the ambient air. The resulting CO_2 would disperse in the atmosphere and have no impact on air quality. Ground level concentrations of pollutants are not expected to approach or exceed the NAAQS due to the short period of time the rockets are close to the ground.

Total quantities of criteria pollutants produced during launch or engine test firings are dependent on launch vehicle classes and total number of annual launches and engine tests. The Space Shuttle was larger than all anticipated future launch vehicles at KSC, with the exception of the SLS which will generate a ground cloud larger than the Space Shuttle. Ground clouds generated by the SLS are expected to have similar concentrations of criteria pollutants as the Space Shuttle. Ground clouds produced from future launches at KSC would travel, diffuse, and disperse similarly to those generated in the past (NASA 2016).

Individual launches from small class rockets at LC-48 would be short-term discrete events and rocket emissions released in the lower atmosphere would be rapidly diluted and dispersed by prevailing winds. Effects on ambient air quality at KSC would be minimal.

The increase of emissions related to traffic associated with launch complex operations would be negligible. The modest addition of personnel expected for the Proposed Action could increase traffic emissions intermittently and for short periods of time during launch and test firing operations. However, this increase would not exceed emissions that were associated with traffic volume prior to the end of the Space Shuttle Program.

No Action Alternative

Under the No Action Alternative there would be no construction of a new SCLV launch complex or launches occurring at the Proposed Action site. Therefore, there would be no impacts to Air Quality.

3.6 Climate

Chapter 3.7 of the PEIS (NASA 2016) and Section 3.2 and 3.3 of the ERD (NASA 2015a) describe in detail the climatic conditions at KSC and climate change projections. A concise review is provided in the following sections.

3.6.1 Affected Environment

Climatic conditions in east-central Florida are influenced by latitude and proximity to the Atlantic Ocean and the IRL system. The climate is characterized as subtropical, with summer conditions predominating for nine months of the year. Average temperatures in the summer range between 21^{o} Celsius (C) and 32^{o} C (70^{o} Fahrenheit [F] and 90^{o} F). Winter months are January through March with average temperatures between 4.5^{o} C and 24^{o} C (40^{o} F and 75^{o} F).

Climate Change and Sea Level Rise

Solar irradiance, the greenhouse effect, and earth's reflectivity are the key factors interacting to maintain temperatures on Earth within critical limits. Relatively recent changes in greenhouse gas concentrations (primarily CO_2) have been identified as the principal factor influencing Earth's current climate trends (EPA 2009). Human land use changes and burning of fossil fuels for energy are the major contributors to increases in greenhouse gases that are accelerating the rate of climate change. Impacts include warmer temperatures, rising sea levels, changes in rainfall patterns, and a host of other associated and often interrelated effects. For the KSC region, the average air temperature for the 30-year climate baseline period is 22º C (72º F) (NASA 2015). Climate forecasts indicate that average temperatures will increase by as much as 3.3ºC (6ºF) during the latter part of the century. Other anticipated impacts are described in the KSC Shoreline Protection EA (NASA 2015).

During the last two decades, erosion along the KSC coastline has increased as a result of frequent storm surges from nor'easters, tropical storms, and hurricanes. Erosion may have been exacerbated by effects from rising sea-levels which have exceeded 12.7 cm (5 in) in the last 20 years, as measured at the Trident Pier in the adjacent Port Canaveral. As a result, the area has been categorized as "critically eroded" by the FDEP (FDEP 2016, NASA 2015). Over 1.8 km (1.0 mi) of artificial dune have been created along the KSC coastline to protect space program assets and important wildlife habitat; an additional 9.2 km (5.7 mi) of dune creation is being planned for 2018/2019. On CCAFS, the long-term trend shows that areas south of the modern cape and north of the Cape Canaveral harbor entrance are accreting. Areas north of the modern cape to just south of LC-37 are eroding and areas further north are accreting (Jaeger et al. 2011, NASA 2015).

3.6.2 Environmental Consequences

The FAA has not established a significance threshold for climate. Although the CEQ issued NEPA guidance for considering the effects of climate change and greenhouse gas emissions was withdrawn on March 28, 2017, no additional federal guidance has been released on this topic. Therefore, the climate impacts for this assessment remains based on the latest CEQ issued NEPA guidance until such time as new federal regulatory guidance is provided.

If a proposed action is reasonably anticipated to cause direct emissions of 25,000 mt (55 million lbs) of greenhouse gasses or more on an annual basis, agencies should consider this an indicator that a quantitative and qualitative assessment may be meaningful to decision makers and the public (CEQ Memorandum 18 February 2010). Based on the anticipated minimal and intermittent addition of employees, and the number of SCLV launches that would occur at the launch complex, annual direct emissions should be well under 25,000 mt (55 million lbs). Therefore, the impact of this project to global or regional climate change, including sea level rise, is anticipated to be minimal.

No Action Alternative

Under the No Action Alternative, there would be no construction or SCLV launch operations taking place at the proposed LC-48 location. Therefore, there would be no greenhouse emissions resulting in climate change impacts.

3.7 Hazardous Materials/Hazardous Waste

A hazardous material is any item or agent (biological, chemical, radiological, and/or physical), which has the potential to cause harm to humans, animals, or the environment, either by itself or through interaction with other factors. Hazardous materials are defined and regulated in the U.S. primarily by laws and regulations administered by the EPA under 29 CFR 1910, OSHA under 40 CFR 355, the U.S. Department of Transportation (DOT) under 49 CFR 171-180, the Comprehensive Environmental Response, Compensation, and Liability Act, the Toxic Substance Control Act, the Emergency Planning and Community Right-to-Know Act, and the U.S. Nuclear Regulatory Commission under 10 CFR 20.

Hazardous waste is defined in the Resource Conservation and Recovery Act (RCRA) as any solid, liquid, contained gaseous, or semi-solid waste, or any combination of wastes that could or do pose a substantial hazard to human health or the environment. Waste may be classified as hazardous because of its toxicity, reactivity, ignitability, corrosive properties, or listed status. All hazardous wastes generated on KSC must be managed, controlled, stored, and disposed of according to regulations found in 40 CFR Parts 260 through 282 and FAC Chapter 62-730.

Hazardous materials and solid and hazardous wastes are managed and controlled in accordance with federal, state, and local regulations. KSC has established plans and procedures to implement these regulations. The use, management, and disposal of hazardous materials on KSC are further described in Kennedy NASA Procedural Requirement 8500.1 - KSC Environmental Requirements and United States Air Force (USAF) Management Plan 19-14.

General solid refuse at KSC is collected by a private contractor and disposed of off-site at the Brevard County Landfill, a 78 ha (192 ac) Class I landfill located near the City of Cocoa. KSC has an unlined Class III Landfill with permit restrictions which can only accept construction and demolition debris.

The KSC Spill Prevention, Control, and Countermeasure (SPCC) Plan (KSC-PLN-1919) outlines the criteria established by KSC to prevent, respond to, control, and report spills of oil. Various types and quantities of oil are stored, transported, and handled to support the operations of KSC. The primary objective of the SPCC Plan is to serve as a guide for KSC personnel that are responsible for the prevention, response, control, and reporting of all oil spills. The KSC SPCC Plan describes both the facility-wide and site-specific (KSC-PLN-1920) approaches for preventing and addressing spills.

3.7.1 Affected Environment

Hazardous Materials

Categories of hazardous materials used in support of standard launch and test fire activities include petroleum products, oils, lubricants, VOCs, corrosives, refrigerants, adhesives, sealants, epoxies, and propellants. Multiple liquid propellant types will be accommodated at LC-48 to include oxygen, methane, hydrogen, hypergolic propellants, and RP-1. In addition, high pressure gases such as GN_2 and GHe would also be supported at the site. Management of hazardous materials is the responsibility of each individual launch provider.

Hazardous Waste

Re-entry debris would include non-recoverable items from launch activities such as jettisoned vehicle stages, as well as recoverable items like solid rocket boosters containing residual fuels.

The following paragraphs discuss the presence of known or suspected contaminants near the Proposed Action sites. Solid Waste Management Units (SWMUs) and Potential Release Locations (PRLs) are generally concentrated in operational areas such as the VAB, launch complexes, and the KSC Industrial Area. The most prevalent soil contaminants are petroleum hydrocarbons, RCRA metals, and polychlorinated biphenyls (PCBs). The most prevalent groundwater contaminants are chlorinated solvents and associated degradation products.

KSC has programs to evaluate sites where contamination is present under RCRA and its Hazardous and Solid Waste Amendments. KSC's Remediation Program was initiated in response to an agreement with FDEP in the late 1980s regarding KSC's oldest contamination remediation sites or SWMUs (Wilson Corners and the Ransom Road landfill). Since then, KSC has been working with the EPA and FDEP to identify potential release sites and implement corrective action at those sites as needed. In addition to corrective action sites, the NASA Remediation Group also manages petroleum contamination sites. To date, NASA has identified and investigated approximately 110 SWMU sites and 236 PRLs.

One PRL has been identified within the Proposed Action project area with the potential for contaminated media due to past operations. Two additional PRLs are located adjacent to the Proposed Action project area boundary.

The Radar Wind Profiler Site (PRL #194), is located near Universal Camera Site #12, and bisected by Phillips Parkway running north south through the site. The eastern portion of PRL #194 extends into the Proposed Action area. The former and current usage of this location has been a camera pad for remotely-operated film and video operations, weather and lightning detection monitoring, and access control for launches. A SWMU assessment was conducted in 2012 for PRL #194, and five locations of concern were identified at that time, which were recommended for sampling to confirm the presence or absence of contamination at the site. Potential contaminants at the sites included hydrocarbons, solvents, and PCBs (IHA 2012). Confirmatory sampling was conducted in November 2017 and March 2018. PCBs were detected at two of the five locations of concern. An interim measure was conducted to remove contaminated soils at these two locations. The excavation took place in September 2018, and a total of 3.83 cubic yards of soil were removed. The KSC Remediation Team (in conjunction with FDEP), approved PRL #194 for No Further Action in the December 2018 KSC Remediation Team meeting. The NASA KSC Remediation Group will be submitting a Site Rehabilitation Completion Order to FDEP for final approval of No Further Action status at this location (TetraTech 2018).

The Titusville Beach Service Station (PRL #081Q) was located east of the Proposed Action project area and Phillips Parkway; the service station no longer exists at this location. It was owned and leased out by Gay Beach Development Company and acquired by NASA in 1962. Universal Engineering Sciences conducted soil and groundwater sampling at this location and, based on the results, no further assessment of soils or groundwater was recommended (UES 2003).

A portion of the LC-39A Operations Support Building area (SWMU #111) is located just north of the Proposed Action project area, and a SWMU Assessment was conducted of this site in 2009. Nine LOCs were identified during the investigation that may have impacted the environment negatively. The guard station (LOC #8) is located directly north of the Proposed Action project area. Based on the nature of the identified LOCs, suspected contaminants of concern associated with the different locations of PRL #175 included metals, PCBs, PAHs, TRPHs, VOC and SVOCs. Therefore, the SWMU Assessment Report recommended sampling to confirm the absence or presence of contaminated media at each of these locations (Geosyntec 2009). Confirmatory sampling was conducted in 2018, and LOC #8 was sampled for TRPH and PCBs. The results were less than FDEP Residential Soil Cleanup Target Levels. Therefore, LOC #8 was recommended for No Further Action (TetraTech 2018a).

3.7.2 Environmental Consequences

Due to the size and proximity of KSC fuel storage tanks to waterways, these locations are subject to the SPCC regulations of 40 CFR 112. KSC currently maintains plans for spill prevention, response, and reporting. An active pollution prevention program is also in place to reduce the use of hazardous materials and generation of hazardous waste. The FAA has not established a significance threshold for hazardous materials, solid waste, and pollution prevention.

All generated wastes would be properly containerized, stored, labeled, manifested, shipped, and disposed of in full regulatory compliance. Hazardous wastes generated by users of LC-48 and their contractors would be manifested, shipped, and disposed of under the appropriate user's EPA identification number. Depending upon the way in which LC-48 would be managed moving forward, one of two options exists for waste disposal: 1) NASA would manage LC-48 and the KSC's base environmental contractor would be utilized for waste disposal using NASA's EPA ID #, or 2) the launch complex would be managed by a third party that would handle and dispose of the wastes under their own EPA ID #, or by utilizing a subcontractor for these services under their EPA ID #. Copies of waste management records and manifests would be maintained onsite and provided for review by NASA or regulatory agency review upon request.

The Proposed Action, including construction and operation, should not significantly impact the NASA KSC Remediation Program for managing SWMU or PRL sites, or interfere with ongoing investigations at these locations. Future investigation and sampling operations by the KSC Remediation program would be coordinated with users of LC-48 for the portion of the site located within the Proposed Action project area that is under investigation. Care would be needed during construction, modification, and normal operations in this area to prevent damage to any of the existing remediation program monitoring wells located within the Proposed Action project area.

The Proposed Action would increase the amount of hazardous materials and waste managed at this location. Best Management Practices (BMPs) in place for the handling of hazardous materials and hazardous waste would result in minimal impacts from the Proposed Action.

Impacts from recoverable and non-recoverable components from launch activities are planned to occur in broad ocean areas cleared of shipping or air traffic. Rocket parts such as fuel tanks would break apart after hitting the water, sinking quickly, but dispersing contents and substances from their surfaces. Some elements would sink to the bottom intact and degrade over time. These impacts would be classified as minimal because the corrosion rates would be very slow and the volume of water available to dilute toxins would keep them below dangerous levels (NMFS 2013, NMFS 2016).

Launch failure as a result of rocket malfunction could result in debris and hazardous materials being distributed in the immediate area of the Proposed Action. An investigation was conducted for a rocket launch failure that occurred at the Kodiak Launch Complex Launch Pad 3 in 2016. The malfunction resulted in pieces of solid propellant and other debris spreading over the area consisting of the launch complex. A hazardous materials team performed a detailed search of the affected area to recover debris, including propellant. Additional teams completed follow on searches to confirm removal of all hazardous materials. Afterward, a site investigation of the area revealed that the launch failure did not result in any contamination at the site that would require remediation (FAA 2017). Based upon this data, impacts from launch failure to the environment from the Proposed Action would be classified as minimal.

No Action Alternative

No construction or ground disturbing activities would occur under the No Action Alternative. Therefore, there would be no impacts to sites being investigated under the KSC Remediation program, or an increase in the generation of hazardous materials or waste at this location.

3.8 Water Resources

Chapter 3.4 of the PEIS (NASA 2016) and Section IV of the ERD (NASA 2015a) describe in detail the water resources (water quality, regulations, permitting, etc.) within KSC. A concise review is provided in the following sections.

3.8.1 Affected Environment

Surface Water and Wetlands

The inland surface waters in and surrounding KSC are shallow estuarine lagoons and include portions of the Indian River, Banana River, Mosquito Lagoon, and Banana Creek. The area of Mosquito Lagoon within the KSC boundary and the northernmost portion of the Indian River, and the southernmost portion of the Banana River, from approximately KARS Park south, are designated by the State as Class II, Shellfish Propagation and Harvesting areas. All other surface waters at KSC have been designated as Class III, Recreation and Fish and Wildlife Propagation areas. All surface waters within MINWR are designated as Outstanding Florida Waters (OFW) as required by Florida Statutes for waters within national wildlife refuges. Surface water quality at KSC is generally good, with the best water quality being found adjacent to undeveloped areas of the IRL, such as Mosquito Lagoon and the northernmost portions of the Indian and Banana Rivers (NASA 2015a). Note that since the phytoplankton "superbloom" of 2011 (SJRWMD 2012), water quality may be shifting and long term trends are under investigation.

Florida water bodies that are not attaining water quality criteria for designated uses require the establishment of Total Maximum Daily Loads (TMDLs) to meet and maintain Water Quality Standards. The north IRL segments adjoining KSC have been identified by FDEP as impaired for dissolved oxygen via nutrient nitrogen, and mercury in fish tissue. The north Banana River and Mosquito Lagoon are also impaired for mercury in fish tissue (FDEP 2017a). Both the Indian River (north of the 520 Causeway) as well as the Banana River (north and south of the 520 Causeway), located in close proximity to KSC and CCAFS, have TMDLs determined by FDEP and St. Johns River Water Management District (SJRWMD) to address impairments. Under the TMDL program, Basin Management Action Plans (BMAP) have been developed for specific hydrologic units of the north Indian (FDEP 2013) and Banana Rivers (FDEP 2013a) and stakeholders, including KSC and CCAFS, have been allocated pollutant reduction requirements to improve water quality. The BMAP program is in the first of three, five-year cycles; and, at the end of each cycle, pollutant reduction requirements are reassessed. During the first five year cycle, KSC received no pollutant reduction allocations. These Basin Management Action Plans (BMAPs) do not address mercury. Mercury is considered by FDEP to be a non-point source pollutant distributed via atmospheric deposition and is addressed separately in a statewide TMDL (FDEP 2013b). The site-specific nature of the OFW water quality standard and TMDL/BMAP program is designed to identify and remediate any surface water degradation.

Fresh surface waters within KSC are primarily derived from the surficial groundwater, which is recharged by rainfall. Shallow groundwater supports numerous freshwater wetlands. Some freshwater wetlands represented by narrow interdunal sloughs may be present within the proposed action site but would be too small for identification by aerial photography or by available geographic information system (GIS) mapping resources. These wetlands may be primarily grass dominated marshes or potentially scrub-shrub wetlands due to infrequent burning of the native scrub habitat at this location. Impounded surface waters, saltmarsh and mangrove forests wetlands are located along the northern and northwestern site boundary associated with submerged marsh/Turnbull and Riomar, Tidal soils. Further discussion of these habitats and plant associations are provided in section 3.9.1 of this EA.

Floodplain

Executive Order (EO) 11988 directs agencies to consider alternatives to avoid adverse effects and incompatible development in floodplains. The Proposed Action alternative sites are located across two different Federal Emergency Management Agency (FEMA) flood zone categories, X and X500. Flood Zone X lands are outside of the 100-year and 500-year floodplains. Flood Zone X500 represents areas between the limits of the 100-year and 500-year flood, or certain areas subject to 100-year flood with average depths less than 0.3 m (1 ft), or where the contributing drainage area is less than 2.6 km^2 (1 mi^2).

Due to lack of significant topographic relief, floodplains on KSC extend beyond the coastal dune and wetlands and into portions of all of the upland plant communities. The majority of KSC lies within the 100-year floodplain. FEMA Flood Insurance Rate Map #12009C0255G was examined for the LC-48 location and the site is approximately equally divided between Flood Zone X and Flood Zone X500. Eastward, across Phillips Parkway, to the Atlantic is classified Flood Zone VE, areas subject to inundation by the one percent annual chance flood event with additional hazards due to storm induced velocity wave action. The area west of the site is classified as Flood Zone AE, areas subject to inundation by the one percent annual chance flood event.

Groundwater Sources

The State of Florida has created four categories used to rate the quality of groundwater in a particular area. The criteria for these categories are based on the degree of protection that should be afforded to that groundwater source, with Class G-I being the most stringent and Class G-IV being the least. The groundwater at KSC is classified as Class G-II in most locations and as G-III within the perimeter of LC-39A and B. Class G-II means that groundwater is a potential potable water source and generally has a total dissolved solids content of less than 10,000 mg/l (parts per million [ppm]). Class G-III means that groundwater is a potential non-potable water source; and in the case of the Launch Complexes, has been reclassified as having no reasonable potential as a future source of drinking water.

The subsurface groundwater of KSC is comprised of the surficial aquifer, the intermediate aquifer, and the Floridan aquifer. Recharge to the surficial aquifer system is primarily due to precipitation. Of the approximately 140 cm (55 inches [in]) of precipitation occurring annually, approximately 75% returns to the atmosphere through evapotranspiration. The remainder is accounted for by runoff, base flow, and recharge of the surficial aquifer. However, the quality of water in the KSC aquifer is influenced by the intrusion of saline and brackish surface waters from the Atlantic Ocean and the IRL. This is evident from the high mineral content, principally chlorides, that has been measured in groundwater samples from various KSC surveys.

Groundwater Quality

The quality of water in an aquifer is dependent upon the characteristics of the underlying rocks, the proximity of the aquifer to highly mineralized waters, the presence of residual saline waters, and the presence of chemical constituents in the aquifer and overlying soils.

At the LC-48 site, the surficial aquifer is classified by FDEP as a Class G-II, defined as able to supply water treatable for human consumption. The surficial aquifer does not, nor is planned to, be used to supply potable water to KSC.

Unconsolidated, surficial aquifers are subject to contamination from point sources and from general land use. Contaminants may include trace elements, pesticides, herbicides, and other organics. Urban and agricultural land uses have affected some Florida aquifers (Rutledge 1987, Barbash and Resek 1997). Point source contamination to the KSC surficial aquifer has occurred at certain facilities (NASA 2015a).

Baseline conditions of the KSC surficial aquifer have been studied in some detail (Schmalzer et al. 2000, Schmalzer and Hensley 2001). In the 2001 study, six sample sites were located in each subsystem of the surficial aquifer for a total of 24 sites. Shallow and deep groundwater samples were analyzed for organochlorine pesticides, aroclors, chlorinated herbicides, polycyclic aromatic hydrocarbons, total metals, DO, turbidity, pH, specific conductivity, temperature, total dissolved solids, and total organic carbon. These data suggested that widespread contamination of the surficial aquifer on KSC has not occurred (Schmalzer and Hensley 2001). Site-specific flow of the surficial aquifer is expected to mimic site topography. At the LC-48 site, groundwater flow is west toward the Banana River.

The groundwater quality in the intermediate aquifer system varies from moderately brackish to brackish due to its recharge by upward leakage from the highly mineralized and artesian Floridian Aquifer system, and in some cases from lateral intrusion from the Atlantic Ocean. Groundwater in the semi-artesian Sand and Shell Aquifer is brackish. Groundwater in the Shallow Rock Aquifer is brackish with some sites receiving seawater intrusion. The limited data for the thin Hawthorn Limestone Aquifer indicate that it is moderately brackish (Clark 1987).

The Floridan Aquifer system underlying KSC contains exceedingly mineralized water with high concentrations of chlorides as a result of seawater that was trapped in the aquifer when it formed. The high concentrations of chlorides can also be explained to a lesser degree by induced lateral intrusion (due to inland pumping) and a lack of flushing due to a low proximity to freshwater recharge areas (Clark 1987).

3.8.2 Environmental Consequences

This section describes potential impacts on surface water and groundwater resources as a result of the Proposed Action alternatives. Determination of water resource impacts is based on an analysis of the potential for activities to affect surface water or groundwater quality as defined by applicable laws and regulations. Considered in this analysis is activity-related introduction of contaminants into surface water or groundwater resources, and physical alterations or disturbances of overland surface water flows and groundwater recharge. The FAA has established the following significance thresholds for water resources.

- **Wetlands** – The action would:
    - Adversely affect a wetland's function to protect the quality or quantity of municipal water supplies, including surface waters and sole source and other aquifers;
    - Substantially alter the hydrology needed to sustain the affected wetland system's values and functions or those of a wetland to which it is connected;

    - Substantially reduce the affected wetland's ability to retain floodwaters or storm runoff, thereby threatening public health, safety or welfare (the term welfare includes cultural, recreational, and scientific resources or property important to the public);
    - Adversely affect the maintenance of natural systems supporting wildlife and fish habitat or economically important timber, food, or fiber resources of the affected or surrounding wetlands;
    - Promote development of secondary activities or services that would cause the circumstances listed above to occur; or
    - Be inconsistent with applicable state wetland strategies.
- **Floodplains** – The action would cause notable adverse impacts on natural and beneficial floodplain values. Natural and beneficial floodplain values are defined in Paragraph 4.k of DOT Order 5650.2, *Floodplain Management and Protection*.
- **Surface Waters** – The action would:
    - Exceed water quality standards established by federal, state, local, and tribal regulatory agencies; or
    - Contaminate public drinking water supply such that public health may be adversely affected.
- **Groundwater** – The action would:
    - Exceed groundwater quality standards established by Federal, state, local, and tribal regulatory agencies; or
    - Contaminate an aquifer used for public water supply such that public health may be adversely affected.

Many construction activities can significantly impact surface water quality by increasing run-off from vegetation clearing, soil disturbance, and grading. Exposed soils are more easily transported and can increase turbidity and nutrient loads of surface waters or wetland systems. Compacted soils are less permeable and can increase runoff. These impacts could potentially be significant, but would be lessened to moderate through the use of BMPs.

Infrastructure such as facilities, paved areas, and landscaped areas would alter, to some degree, the hydrological cycle and surface/groundwater quality. Specific site plans for the proposed sites have not yet been finalized, so exact quantities of new impervious surfaces cannot be determined. Impervious surfaces such as roads, sidewalks, parking lots, and buildings reduce the area available for rainwater to percolate into the soil. This has two direct consequences: there is less water available for recharging the local surficial aquifer, while at the same time, the amount of runoff that flows into low-lying areas increases. Stormwater management systems would help mitigate many of the impacts associated with impervious surfaces. However, extreme rainfall events associated with tropical systems would likely exceed the capacity of most stormwater systems, and some runoff could be transported off-site.

Surface Water and Wetlands

Land disturbing activities during construction at the Proposed Action site would have the potential to result in moderate impacts to surface water and wetland resources. However, these impacts would be lessened with the implementation of BMPs required by the FDEP National Pollutant Discharge Elimination System (NPDES) Stormwater Construction Permit and the SJRWMD Environmental Resource Permit (ERP). Generally, efforts are made during the planning and design phase to avoid wetlands to reduce impacts and minimize costs associated with mitigating wetland impacts. Additionally, the ERP process, as well as wetland impact permitting required through the US Army Corps of Engineers, requires minimization and avoidance of wetlands to the maximum extent practicable before construction permits to alter wetlands are authorized. Wetland impacts, including direct loss of habitat, and secondary impacts related to degradation (loss of wetland function and value) of adjacent wetlands not directly impacted by construction, would be ultimately determined during the design and permitting of the Proposed Action. The current preliminary design indicates there will be no direct wetland impacts from the construction of LC-48; only secondary impacts related to a stormwater system outfall structure that will discharge permitted outflows into the receiving surface waters. Appropriate mitigation to offset permitted functional loss of wetlands, if any, would be approved by permitting agencies and incorporated into the permit conditions for the project.

Construction of LC-48 would temporarily increase the amount of erosion and, therefore, pollutants that could migrate to adjacent wetlands and surface water. Employing BMPs such as silt fences, turbidity barriers, and stormwater management systems would reduce surface water and wetland quality impacts to a minimal amount. A stormwater management system would be designed and constructed based on the extent of impervious area and activities proposed at the site.

Surface water discharges from the selected site would be managed according to requirements of the SJRWMD conditions for issuance of Environmental Resource Permits. The SJRWMD Applicants Handbook for Management and Storage of Surface Waters, Chapter 10.3 states: "The post-development peak rate of discharge must not exceed the pre-development peak rate of discharge, and the peak discharge requirement shall be met for the 25-year frequency storm. In determining the peak rate of discharge, a 24-hour duration storm is to be used". In addition, the SJRWMD requires wet detention systems to be designed in a manner that meets applicable water quality standards in SJRWMD Rule 40C-42.026(4). Water quality impacts to the OFW associated with the IRL and MINWR would be minimized by the design, operation, and maintenance of stormwater management systems that would meet or exceed all requirements of the SJRWMD.

Once constructed, activities at the site may require additional permitting under NPDES Stormwater Multi-Sector General Permit for Industrial Activities. This permit is specific to the activities conducted at the site which are identified as Sectors. Sector AB, "Transportation Equipment, Industrial, or Commercial Machinery Manufacturing Facilities" specifically calls out manufacture of "guided missiles and space vehicles and parts".

Additional impacts to surface water from accidental spills of such commodities as fuels, oxidizers, and exhaust products from launch are possible and are launch vehicle specific. During the Shuttle program, deposition of acidic exhaust was found to decrease the background pH by 6 to 7 units in shallow waters up to 1000 m from the pad center, in line with the flame trench at LC-39A and LC-39B. In these areas, pH depression was acute and lethal to organisms utilizing gills for respiration, i.e., fish kills were observed. Minimal effects were observed around the edges of the near-field ground cloud footprint and at depths where buffering and dilution minimize chemical impacts (NASA 2014a).

No Action Alternative

Under the No Action Alternative, there would be no new construction, no additional launches and no change in impervious surface. Therefore, there would be no impacts to surface waters.

Floodplain

Approximately half of the LC-48 site is within floodplain zone X500 which represents areas between the limits of the 100-year and 500-year flood. NASA would ensure that its actions comply with EO 11988, Floodplain Management, to the maximum extent possible. Based on available land for applicable space launch vehicle operations identified in the KSC Master Plan, the current site is the best option to construct LC-48 while meeting all user operational and safety requirements discussed in detail in Section 2.3 of this EA. Therefore, NASA has concluded there is no practicable alternative to constructing LC-48 within a floodplain and this EA serves as NASA's means for facilitating public review as required by EO 11988.

No Action Alternative

Under the No Action Alternative, there would be no new construction, no additional launches and no change in impervious surface. Therefore, there would be no impacts to floodplain.

Groundwater

The groundwater quality at the proposed site will be affected by runoff from new impervious surface, deposition of launch exhaust materials or accidental spills that percolates into the surficial aquifer. The construction of required stormwater management systems, previously discussed, intentionally enhances percolation of water from impervious surfaces to the surficial aquifer and therefore increases the chance of unintended introduction of pollution to the aquifer. Regardless, the Proposed Action would have minimal impact to the groundwater quality, provided that stormwater systems are properly designed and operated. Similar to surface water, impacts to groundwater from accidental spills of such products as fuels, oxidizers, and exhaust products from launch are possible and are launch vehicle specific. The potential local impacts to hydrology and water quality from the construction and operation of LC-48 are summarized in Table 3-9.

No Action Alternative

No construction or ground disturbing activities would occur under the No Action Alternative. Therefore, there would be no impacts causing groundwater degradation.

Table 3-9. General site-specific impacts to hydrology and water quality associated with construction and operations of roads and facilities.

Activity	Impact
Vegetation Clearing	Alters local evapotranspiration processes, exposes soil to wind and rain erosion (turbidity), reduces storage, increases runoff potential, alters surficial aquifer recharge rates.
Soil Disturbance	Alters runoff, storage, and infiltration rates. Increases turbidity potential.
Grading	Alters runoff, storage, and infiltration rates. Increases turbidity potential.
Impervious Surfaces	Alters runoff, storage, and infiltration rates. Alters local evapotranspiration processes. Reduces local surficial aquifer recharge.

Activity	Impact
Landscaping	Alters local evapotranspiration processes, runoff, storage, and infiltration rates. Use of fertilizers and pesticides. Mowing and other maintenance often required.
Irrigation	Alters local evapotranspiration processes, runoff, storage, and infiltration rates. Impacts to surficial aquifer.
Stormwater Conveyance	Alters local evapotranspiration processes, runoff, storage, and infiltration rates. Impacts to surficial aquifer.
Retention Ponds	Alters local evapotranspiration processes runoff, storage, and infiltration rates. Impacts to surficial aquifer.
Vehicle Use	Increased loading of pollutants associated with parking lots, roads, tires, fossil fuel combustion (NO_2, CO, CO_2, grease and oil, polycyclic hydrocarbons, metals).
Ground Processing	Accidental releases of a variety of chemicals could occur during the operational phase of the Proposed Action and potentially affect surface and groundwater quality.
Launch Activity	Deposition of exhaust products during operational phase of the Proposed Action may potentially affect surface and groundwater quality.

3.9 Geology and Soils

Detailed discussions of geology and soils at KSC are available in the KSC PEIS and ERD (NASA 2016, and NASA 2015a). A summary is provided in the following paragraphs.

Florida has a complex geologic history with repeated periods of deposition when the Florida Plateau was submerged under the ocean alternating with erosion when the ocean receded. The oldest formations known to occur beneath the KSC/CCAFS area were deposited in the early Eocene Epoch (56 to 43 million years ago) in an open ocean. The ensuing cycle of erosion and deposition through the ages resulted in surface strata of primarily unconsolidated white to brown quartz sand containing beds of sandy coquina of Pleistocene and Holocene age (NASA 2015a). A detailed description of the geologic process is given in the PEIS (NASA 2016).

Merritt Island formed as a prograding barrier island complex (i.e., one that builds seaward). The eastern edge of Merritt Island along the Mosquito Lagoon and the Banana River is a relict cape aligned with False Cape. Multiple dune ridges interspersed with low-lying areas represent successive stages in this growth. The western portion of Merritt Island is substantially older than the east, and erosion has reduced the western side to a nearly level plain. Cape Canaveral is also part of the prograding barrier island complex, the result of southward growth of an original cape at the site of the present False Cape. Multiple dune ridges on Cape Canaveral are evidence that alternating periods of deposition and erosion occurred there as well.

Soil is a collective term for the inorganic and organic substrate covering bedrock in which vegetation typically grows and a multitude of organisms reside. Soil resources provide a foundation for both plant and animal communities, and these resources are equally important in both terrestrial and aquatic environments (NASA 2015a).

The soils at KSC were mapped by the Soil Conservation Service (SCS); now the Natural Resources Conservation Service (NRCS) and its Florida partners in the soil surveys for Brevard County (USDA 1974) and Volusia County (USDA 1980). Updates to the initial soil mapping effort are maintained and distributed by the Natural Resources Conservation Service (NCRS) on their Web Soil Survey website (NRCS 2107). Fifty-eight soil series and land types occur at KSC, even though Merritt Island is a relatively young landscape (NASA 2015a).

3.9.1 Affected Environment

Soils at the proposed LC-48 site include Palm Beach Sand, Pompano Sand, Submerged Marsh and Impounded Waters (Figure 3-9). The dominant soil onsite is Palm Beach Sand followed by Pompano Sand. These and the other soil map units are identified in Table 3-9 including their coverage (hectares and acres). The units referred to as Submerged Marsh and Impounded Surface Waters have been combined into a single soil map unit, Turnbull and Riomar Soils, Tidal in the latest data from available NRCS (2017; Version 16, September 26, 2017, Brevard County, Florida).

Palm Beach Sand is a nearly level to gently sloping, excessively drained soil associated with old dunes that roughly parallels the Atlantic coastline. It consists of sand mixed with shell fragments. The presence of shell influences the amount of calcium, magnesium and pH of the soil which is typically alkaline. In most years the water table is greater than 10 feet (3 m) below land surface. This mapping unit also includes narrow areas between relict dune ridges with slightly greater slope (5-8%) that can lead to narrow sloughs much lower in elevation than adjacent ridges. Natural communities supported by this soil includes coastal strand and coastal dune with live oak (*Quercus virginiana*), saw palmetto (*Serenoa repens*), red bay (*Persea borbonia*), sea grape (*Cocoloba uvifera*), nakedwood (*Myrcianthes fragrans*), tough buckthorn (*Sideroxylon tenax*) and sea oats (*Uniola paniculata*) common plants growing in these habitats.

Pompano Sand is a nearly level, poorly drained soil generally associated with broad flats and shallow depressions and sloughs. The water table is within 10 in (25.4 cm) of land surface during the wet season in most years with some short-term flooding possible during heavy rainfall events. During the dry season the water table is typically more than 40 in (101.6 cm) below land surface. Typical vegetation communities associated with this soil include cabbage palm (*Sabal palmetto*) with native grasses and hardwood hammock.

Turnbull and Riomar Soils, Tidal are nearly level, very poorly drained soils associated with tidal marshes on marine terraces. These soils are composed of muck, clay and loamy fine sand with a high water table at or above land surface. This soil association is restricted to the northwestern corner and edge of the proposed LC-48 site (Figure 3-9). This area has been previously disturbed by excavation of a borrow-pit, construction of a railroad for the USAF Titan program and dragline work for mosquito control purposes. Native vegetation often found on this soil association consists of needle grass rush (*Juncus roemerianus*), smooth cordgrass (*Spartina alterniflora*), bushy sea-oxeye (*Borrichia frutescens*), marsh hay cordgrass (*S. patens*), glasswort (*Salicornia* spp.), bigleaf sump weed (*Iva frutescens*), and seashore salt grass (*Distichlis spicata*), red mangrove (*Rhizophora mangle*), black mangrove (*Avicennia germinans*), white mangrove

(*Laguncularia racemosa*), sea rocket (*Cakile edentula*), and seashore paspalum (*Paspalum vaginatum*) (USDA 1974). Along edges and within areas of previous soil disturbance, the invasive Brazilian pepper (*Schinus terebinthifolius*) is the dominant vegetation.

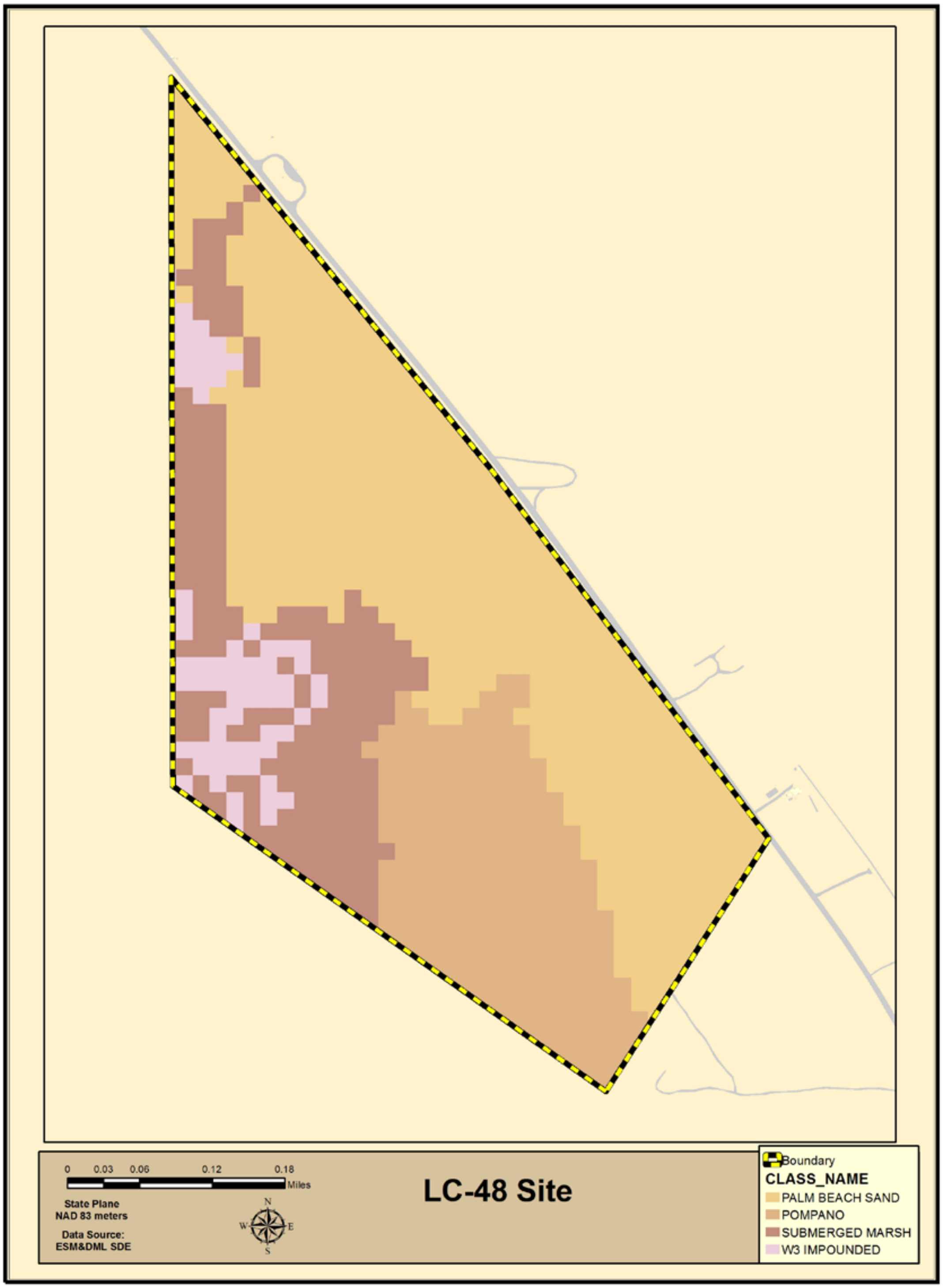

Figure 3-9. Soils distribution at the proposed Launch Complex 48 site.

Table 3-10. Soil types and acreages (US Department of Agriculture [USDA] Soil Conservation Service, 1974) found within the boundary of the LC-48 site.

Description	Area ha (ac)
Palm Beach Sand	27 (68)
Pompano Sand	11 (28)
*Submerged Marsh**	10 (25)
*Impounded Surface Waters**	3 (9)

**Turnbull and Riomar Soils, Tidal*

Hydric soils (italicized in Table 3-10) comprise about 24 ha (62 ac) or approximately 48% of the subject site. Site inspections indicate that the majority of the Pompano Sand mapping unit supports an upland coastal oak woodland and palmetto plant community with some potential for wetlands within swales located between old dune ridges and low flats. None of the soils identified at the site are classified as prime farmland soils.

3.9.2 Environmental Consequences

The Phase 1 and Phase 2 concepts are preliminary designs, so the exact footprint of the proposed launch complex is not fully delineated. In the worst case site development scenario, no more than 7.6 ha (19 ac) of land would be cleared and underlying soils disturbed by construction activities. Native soil profiles within the top several feet would be permanently altered by either leveling, excavation or filling activities associated with land clearing and construction activities. The maximum impact to the dominant soils at the site represents less than 1% of all Palm Beach Sand and Pompano Sand soils mapped on KSC.

Once operational, the launch facility is not expected to have any measurable impacts to soils within or adjacent to the launch complex. Studies conducted at KSC and Cape Canaveral Air Force Station to assess space launch vehicle impacts to the environment from the Titan, Atlas, and Delta launch programs showed short term impacts to soil chemistry (primarily lowered pH) following launches using solid rocket fuel (Schmalzer, et al 1998). Similar but larger geographic area acid deposition impacts were detected following launch of the Space Shuttle. Elevated metals in soils were also detected within near field impact areas at the Space Shuttle launch pads, primarily due to rocket exhaust and sound suppression deluge blasting painted metal structures (NASA 2014a). These operational impacts are not expected to occur at LC-48 due to the small size of the proposed launch vehicles, limited use of solid rocket propellant, and proposed design features eliminating a launch stand or others steel infrastructure on the pad.

The underlying geology of the proposed action area would not be impacted by construction or operation of LC-48. Soils impacted by construction activities are common on KSC and in east-central Florida. Therefore, overall impacts would be considered none to geology and moderate to soils.

No Action Alternative

The No Action Alternative would preclude construction of a new launch facility and would have no impact on geology or soils located on KSC.

3.10 Transportation

A majority of the roads at KSC are the product of the intense federal investment in infrastructure that was made at the dawn of the space program in the 1960's. At that time, Merritt Island was sparsely populated and the space program required significant federal dollars to achieve its ends.

The KSC road network consists of 907 km (564 mi) of roads, including 296 km (184 mi) of paved roads, 611 km (380 mi) of unpaved roads, and many other trails and access roads. Most paved roads on the center are bituminous surface material constructed on a lime rock base and compacted soil sub-grade. Typical design standards for primary roads and highways on the center include 3.6 m (12 ft) wide lanes with sand stabilized turf shoulders. KSC's main arterials, Kennedy Parkway SR 3 and NASA Parkway, are separated by 9 to 12 m (30 to 40 ft) and 3 to 3.6 m (10 to 20) foot medians respectively. Kennedy Parkway serves as the primary north-south arterial connecting the Industrial Area and the LC-39 area. It can be accessed from the north where it intersects with US 1 south of Oak Hill and from Titusville via SR 406/402. The southernmost entrance and exit for KSC is Kennedy Parkway on north Merritt Island.

NASA Parkway provides access to CCAFS to the east and Titusville via the Indian River Bridge to the west. Secondary and access roads to specific facilities are designed to accommodate the anticipated type of traffic and payloads that reach each facility. NASA Parkway is the primary entrance and exit for cargo, tourists, and personnel to KSC. The four-lane road originates on the mainland in Titusville as SR 405 and crosses the IRL onto KSC. After passing through the Industrial Area, the NASA Parkway reduces to two lanes of traffic, crosses the Banana River, and enters CCAFS, serving as the Air Force installation's west access road (KSC Master Plan, 2013).

3.10.1 Affected Environment

Transportation of the SCLV, cargo, and payloads to LC-48 would occur over roadways and involve accessing the site from the south by way of Kennedy Parkway to Saturn Causeway and on to Phillips Parkway as the primary route of transportation. Alternative routes include transportation from the west over NASA Parkway to Phillips Parkway, and from the Cape Canaveral Air Force gate on Phillips Parkway to the LC-48 site.

Payload operations entail the transportation of launch vehicles and hazardous materials across KSC to the launch complex for final integration or stowage, and the payloads could be fueled with propellants. There may potentially be Self-Contained Atmospheric Protection Ensemble support for fuel/oxidizer spills as well as security for transportation. Payloads with science experiments are transported for late stowage; these can include animals or other sensitive biological elements.

3.10.2 Environmental Consequences

The Proposed Action would result in the continuation of many of the modes of transportation presently occurring at KSC but potentially in greater amounts. LC-48 could accommodate up to 104 launches per year. Short- and long-term minor adverse effects would be expected. Short-term increases in traffic would result from construction worker commutes during construction, modification activities of the new facilities, and launch preparation activities to the site. Long-term effects would be primarily due to additional worker commutes and changes in traffic patterns near more centralized activities at KSC and the launch complexes. Increased traffic volumes and changes in traffic patterns would have minor effects, and there would be some long-term beneficial effects from upgrades in infrastructure leading to the site.

The Proposed Action is not expected to cause appreciable changes in the overall traffic volume at KSC, however, some components could affect the level of service at intersections or roadways both on and off the facilities. Transportation impacts are classified as minimal due to increased traffic on roadways in support of the launches predicted to take place each year. The PEIS (NASA 2016) assessed the effects of proposed KSC operations and construction on traffic and transportation during for a planning horizon of 2012 - 2032. No additional evaluation under tiered NEPA would be required unless the project met certain criteria including addition or closure of roadways or access control points, or construction of greater than 92,900 m^2 (1,000,000 ft^2). The proposed LC-48 action does not meet these criteria and therefore no traffic study is necessary.

No Action Alternative

The No Action Alternative would result in no changes in the impact to traffic and transportation. KSC operations and the current levels of activities would continue, and traffic patterns and transportation would remain unchanged when compared to existing conditions (NASA 2016). Road improvements would not be necessary.

3.11 Utilities

The Proposed Action project area would require access to electric, fiber connectivity, water, sewer, and high-pressure gases. Development of the new launch complex would include activities such as construction of roads, upgrading and installing aboveground and underground utilities, site lighting, paging and area warning system, excavation, foundation pouring, the building of a clean pad and modification of existing infrastructures.

LC-48 will be able to accommodate a number of liquid propellants, including liquid oxygen, liquid methane, liquid hydrogen, and RP-1. High pressure gasses (GN_2 & GHe) will be allowed at this site. KSC will be able to provide the Universal Propellant Servicing System (UPSS) to provide propellant loading skids, VJ pipes, and propellant manifold connections. KSC currently has available two LCH_4 storage containers (41,639 liters [L]) / (11,000 gallons [gal]) each), and three LOX storage containers (20,441 L [5400 gal] each). Power and communication hookups will be available on LC-48. Customers would need to provide their own lightning protection, cameras, lighting, access ladders/platforms, umbilical towers, and launch control systems.

KSC is a retail electricity, natural gas, and fuel oil customer. The Utilities Systems land use classification at KSC includes land and facilities associated with KSC utilities infrastructure and systems (i.e., water, wastewater, gas, electrical, chilled water, medium temperature hot water, communications and sewer systems). Utility easements help to define patterns and impacts associated with the development of utility systems and the overall land use pattern (NASA 2015a).

3.11.1 Affected Environment

Drinking Water

KSC operates a consecutive, non-transient, non-community, subpart H, public water systems which meet all requirements of FDEP and EPA Safe Drinking Water Act regulation. The City of Cocoa is the provider of potable water to both KSC and CCAFS systems. The City of Cocoa operates the Claude H. Dyal Water Treatment Plant that treats the raw water primarily from a Floridan Aquifer wellfield located in east Orange County, and has the ability to also draw surface water from the Taylor Creek Reservoir, located in Brevard County. The City has a Consumptive Use Permit (CUP) with the St. Johns River Water Management

District allowing withdrawal of up to 45 million L (12 million gal) per day from the aquifer. Because KSC and CCAFS are consecutive systems, CUPs are not required. Water from the Dyal Plant is transmitted to KSC and CCAFS via interconnects at the southern end of each system. The distribution systems of KSC and CCAFS are also connected at the NASA Causeway and at the northern extreme of the system near Launch Complex 41. Throughout KSC and CCAFS there are various storage systems and secondary pump systems to supply water needs for fire suppression, launch activities, and potable water (NASA 2015a; Blue Origin 2016). The replacement of certain water lines throughout KSC is ongoing, with the fifth and last phase scheduled to be completed in 2017. Pipeline replacement includes critical water mains, facility service lines and fire hydrants, as well as the replacement of KSC's primary pump station (KSC Master Plan, 2017b).

Potable water is currently unavailable in the LC-48 vicinity. The water main running north south along Phillips Parkway is a non-potable main, segregated from the potable distribution system at both KSC and CCAFS. This water is suitable for fire suppression and deluge systems. The nearest potable water is the 4" line at LC-41, a portion of the CCAFS potable distribution system. FDEP permitting would be required to extend the potable water distribution system to LC-48.

Domestic and Industrial Wastewater

The majority of domestic wastewater at KSC and CCAFS is treated at the Cape Canaveral Air Force Station Regional Waste Water Treatment Facility (RWWTF), operated by the USAF under FDEP permit FL0102920. The RWWTF meets all FDEP and EPA requirements under Florida Administrative Code and the Clean Water Act, respectively. A minor portion of domestic wastewater is treated by On Site Treatment and Disposal Systems (OSTDS) generally located at outlying facilities beyond the extent of the domestic wastewater collection and transmission systems. Both KSC and CCAFS operate extensive collection and transmission systems consisting of lift station, gravity and force mains, pretreatment systems, surge tanks and aeration basins. Domestic wastewater from KSC is pumped to CCAFS across the NASA Causeway to the RWWTF.

Industrial wastewater at KSC is either disposed of under an industrial wastewater permit with FDEP, or is discharged to the domestic wastewater system under a strictly managed system of review. KSC LC-39A and LC-39B each have industrial wastewater systems for disposal of deluge water which operate under permits. These systems are designed with two basins that collect approximately 2.6 million L (700,000 gal) of deluge each and hold it for treatment and testing prior to discharge to percolation ponds. The deluge systems of LC-40 and LC-41, in the vicinity of LC-48, discharge to the domestic wastewater system. These systems are also designed with holding basins where deluge is held for testing and treating prior to discharge. The process that governs discharge of industrial wastewater to the domestic wastewater system at KSC is the Process Waste Questionnaire/Technical Response Package (PWQ/TRP) system. An industrial wastewater stream must be evaluated by this process and accepted for treatment at the RWWTF prior to discharge. Some minor sources of industrial wastewater can be discharged to grade under the Kennedy Industrial Wastewater Inventory. Examples include discharge of potable or fire suppression water, chlorinated or flushing water for water main construction, and similar water without additives.

At the LC-48 area, no domestic wastewater service is currently available. The nearest connection point is LC-41. Industrial wastewater, such as deluge water, at LC-48 would require either an FDEP permit to discharge or a PWQ/TRP to discharge to the RWWTF. Extension of the collection and transmission system to LC-48 would require FDEP Permit. Domestic wastewater may discharge to the RWWTF or be treated by OSTDS. Construction of an OSTDS would require Florida Department of Health (FDOH) permit. OSTDS are strongly discouraged at KSC and CCAFS due their association with non-point source nutrient transport to surface water. The nearby Banana River is identified as impaired for nutrients by FDEP, has an established Total Maximum Daily Load (TMDL) for nutrients and is currently under BMAPs at both KSC and CCAFS to reduce nutrient loading to the River.

Stormwater

Stormwater runoff from constructed impervious area of greater than 836 m^2 (9000 ft^2) requires treatment to reduce associated pollutants and the attenuation of potential flooding impacts. As facilities are improved or built, stormwater systems must be built or upgraded to be consistent with the requirements of FAC 40C-4. Construction of LC-48 would be required to submit plans for stormwater treatment systems to the SJRWMD as part of the Environmental Resource Permit (ERP) application process and receive permits prior to beginning construction.

Natural Resources and Energy

The electrical power for KSC is purchased from FPL at 115 kV and stepped down to 13.8 kV at two locations to serve KSC. The center owns and maintains the 13.8 kV medium voltage distribution system, which would serve the Proposed Action project area.

In a unique public-private partnership between FPL and NASA that demonstrates a commitment to bringing clean-energy solutions to the state of Florida, solar photovoltaic power facilities have been constructed at KSC. This partnership is helping to provide clean, renewable power to Florida residents and to support America's space program by supplying electricity directly to KSC and reducing reliance on fossil fuels toward improving the environment (KSC 2017).

An FPL solar array located in the southern portion of KSC produces an estimated 10 megawatts of clean, emissions-free power for FPL customers, which is equivalent to serving approximately 1,100 homes. A separate solar facility of approximately one megawatt located in the Industrial Area provides clean power directly to Kennedy Space Center and is helping NASA meet its renewable energy goals. Additional solar photovoltaic power facilities are planned for the future (KSC 2017).

A natural gas distribution infrastructure was built in 1994 to support the activities at KSC. The system was expanded in 1999 to CCAFS. Natural gas is used as the main fuel source for heating plants at the VAB and at the KSC Industrial Area, providing hot water for building heating and domestic hot water purposes. The main pipeline runs through KSC property but is owned by Florida City Gas, the local natural gas utility. The main 12" natural gas pipeline enters KSC where NASA and Kennedy Parkways intersect. Florida City Gas is responsible for the gas main from its station off of NASA Parkway up to and including meters to various facilities in the VAB and industrial areas of KSC. Contractors on KSC are responsible for operation and maintenance of natural gas systems downstream of the meter stations (KSC 2017).

Communications

A communications duct bank currently runs along Phillips Parkway, with a section leading into the center of the Proposed Action project area. Communications manholes are located along Phillips Parkway, but none currently exist within the project area boundary.

3.11.2 Environmental Consequences

The FAA has not established a significance threshold for natural resources and energy supply. Impacts to electricity, natural gas, communications, and solid waste infrastructure at KSC would be moderate. These utilities and services are currently available at or within reasonable proximity to the Proposed Action site. Connections would be installed to high pressure GN2 and GHe3 lines along Phillips Parkway with stub-up service to the site. Some utilities ducts and infrastructure would need to be laid and tie-ins established during construction, but additional demands on these services would be readily absorbed. Existing substations and wastewater treatment plants would have sufficient capacities for anticipated needs. Industrial wastewater such as deluge water or similar discharges not listed as an approved discharge in the KIWI would have the potential for moderate impacts. However, these impacts would be mitigated by obtaining an FDEP Industrial Wastewater Permit as required and adhering to permit conditions. Water supply impacts during construction would be minimal since potable and non-potable water resources are available near the proposed site. Impacts to water supply and treatment to support on site operations are classified as moderate.

No Action Alternative

The No Action Alternative would result in no upgrades to the existing utilities infrastructure and the water resources would not be affected by construction or operations from new projects described under the Proposed Action. KSC operations regarding water resources and the current demand of utilities would remain unchanged.

3.12 Health and Safety

It is NASA policy to provide a safe and healthy work environment for its workforce. KSC complies with applicable regulations of other federal agencies exercising regulatory authority over NASA in specific areas (e.g., the Department of Labor's OSHA), and the DOT, as well as internal NASA safety policies and requirements. In the event of conflicting standards or regulations, the more stringent requirements are applicable.

3.12.1 Affected Environment

The areas in and around KSC that could be affected by launches, test operations, and transport are the subject of health and safety concerns. Range safety regulations for KSC and the Air Force are contained in NASA NPR 8715.5A and AFSPCMAN 91-710, which incorporate information that Range Safety organizations review, approve, and monitor; safety holds on all prelaunch and launch operations are imposed when necessary. The objective of the Range Safety Program is to ensure that the general public, personnel, environment, and area resources are provided an acceptable level of safety, and that all aspects of prelaunch and launch operations adhere to public laws. Hazardous materials such as propellants, ordnance, chemicals, and booster/payload components are transported in accordance with U.S. DOT regulations for interstate shipment of hazardous substances (Title 49 CFR 100-199). All personnel involved in the handling of hazardous materials and hazardous waste receive safety and environmental awareness training concerning the property handling techniques and spill response activities for these hazardous materials (USAF 2015).

KSC, CCAFS, the City of Cape Canaveral, and Brevard County have a mutual-aid agreement in the event of an emergency. During launch activities, CCAFS maintains communication with KSC, Brevard County Emergency Management, the Florida Marine Patrol, the U.S. Coast Guard, and the State coordinating agency, the Division of Emergency Management. Range Safety monitors launch surveillance areas to ensure that the risk to people, aircraft, and surface vessels is within acceptable limits. Control areas and airspace are closed to the public as required (USAF 1998).

Emergency medical services for KSC and CCAFS personnel are provided by the KSC Occupational Health Facility staff. Additional health care services are available at nearby public hospitals in Titusville, Rockledge, and Cocoa Beach. Fire and police protection on KSC are provided by private contractors. Fire services on CCAFS are provided by contractors, and police services for the installation are provided by the Air Force military police.

3.12.2 Environmental Consequences

Potential adverse effects to human health and safety could occur during construction and facility modifications, and industrial operations attributed to the Proposed Action. Compliance with OSHA regulations and other recognized standards would be implemented during the construction/modification and operational phases. Construction contractors would comply with OSHA regulations, other recognized standards, and applicable NASA and CCAFS regulations or instructions prescribed for the control and safety of personnel and visitors to the job site.

Daily industrial operations would result in the continuation of many of the types of noise presently occurring at KSC and CCAFS. The loudest noise generated at LC-48 would result from test fires and launches. Operators are required by OSHA and NASA regulations to be equipped with hearing protection devices. Therefore, human health and safety would not be adversely impacted by general construction related hazards or daily operations occurring at the site. With the implementation of safety and health plans, and environmental protection measures, potential health risks to project personnel and the public from construction and launch operations would be minimal.

Physical hazards typical for outdoor environments are present in the proposed project areas and have the potential to adversely impact the health and safety of personnel. To provide for the health and safety of workers and visitors who may be exposed to hazards during construction, federal OSHA regulations would be implemented, and health and safety plans would be developed and implemented. To minimize the potential adverse impacts from hazards during construction and operations, awareness training would be incorporated into the worker health and safety protocol. With the additional implementation of safety and health plans, and environmental protection measures, potential health risks to project personnel and the public from construction/ modifications and operations would be minimal.

The potential exists for re-entry debris that may include non-recoverable items from launch activities such as jettisoned vehicle stages, as well as recoverable items like solid rocket boosters. On average, one non-functional spacecraft, launch vehicle orbital stage, or other piece of cataloged debris has fallen back to Earth every day for more than 40 years. The majority of these objects do not survive the intense reentry environment. For the minority of those which do survive whole or in part, most fall harmlessly into the oceans and sparsely populated regions (NASA 2017). Under the Proposed Action, re-entry debris would have minimal impacts to the environment.

Commercial entities that use KSC would be required to comply with all applicable safety regulations for storage, use, and transfer of toxic and hazardous materials associated with their projects. In the Proposed Action, the frequency with which hazardous materials are used, handled, transported, etc., would be increased. As a result of the increase in exposure and the activities related to these materials, the risks associated with them are also slightly increased. The importance of adhering to proper safety procedures must be viewed as a top priority for future operations to minimize the risks of accidental release and personnel exposure. Due to the regulatory and safety requirements inherent in the industry and the nature of expected operations, it is considered likely that sufficient engineering and administrative controls would mitigate the risks associated with the presence of these materials to the lowest possible level.

Explosive site safety actions at KSC must account for public safety distances and may require temporary road closures. The north end Corrosion Atmospheric Exposure Facility site falls within the QD for LC-48 Phase 2. Some operations at LC-48 might require temporary removal of personnel from this facility. Any such mitigation measures would need to be addressed by submitting an explosive operations plan for review by the KSC Program Manager for Explosive Safety (Robert Russo, personal communication). Coordination between LC-48 users and the KSC Explosive Safety Manager would then determine handling, permitting, transportation, siting, and storage for each commodity to account for public safety. Following this coordination, explosive safety elements would be met and there would be no significant impact.

The severity of an unplanned event is unlikely to increase. The probability of an accidental release would increase due to the increased activities and quantity of materials, but best practices would ensure this increased risk is minimal. Due to the potential storage of significant quantities of hazardous commodities on site, NASA requires LC-48 users to submit documentation of worst case storage and processing scenario possibilities and how spills/releases would be managed and contained. If reasonable and prudent measures are taken, operations associated with the Proposed Action would result in minimal impacts to health and safety, with the probability of a major spill kept at a minimum (NASA 2016).

No Action Alternative

Under the No Action Alternative, there would be no increased health and safety risks, orbital debris, or re-entry debris compared to the current operating conditions at KSC.

3.13 Socioeconomics

A detailed overview of the current socioeconomic conditions for both the KSC vicinity and the state of Florida is provided in the KSC PEIS (NASA 2016). It identifies socioeconomic issues that would be sensitive to changes affected by the KSC Master Plan (NASA 2013) for a multi-user spaceport over a 20-year period (2012-2032).

3.13.1 Affected Environment

The KSC PEIS (NASA 2016) presents data for Brevard and Volusia counties and compares them to demographic and economic data for the State of Florida. Potential impacts with the greatest likelihood, magnitude, duration, and extent would occur in Brevard and Volusia counties. Brevard County has an estimated population of approximately 543,376 according to the 2010 census. The median household income for 2016 in Brevard County was $51,184 (Data USA 2018). According to Bureau of Labor statistics, unemployment rate has dropped from 11.4 to 3.4 percent since 2011.

The proposed action at LC-48 represents one of many notional components that were considered in KSC PEIS. NASA estimates a possible the creation of 140 jobs related to the construction of LC-48. The operation of the site offers a range of 100 to 300 jobs at full build out with two pads.

3.13.2 Environmental Consequences

The FAA has not established a significance threshold for socioeconomics, however, FAA Order 1050.1F identifies factors to consider when evaluating impacts. For socioeconomics, the factors to consider are whether the Proposed Action would have the potential to:

- Induce substantial economic growth in an area, either directly or indirectly (e.g., through establishing projects in an undeveloped area);
- Disrupt or divide the physical arrangement of an established community;
- Cause extensive relocation when sufficient replacement housing is unavailable;
- Cause extensive relocation of community businesses that would cause severe economic hardship for affected communities;
- Disrupt local traffic patterns and substantially reduce the levels of service of roads serving an airport and its surrounding communities; or
- Produce a substantial change in the community tax base.

Overall, the direct, economic impacts resulting from the Proposed Action would be positive. The LC-48 would create beneficial moderate impacts due to the creation of jobs and labor income over the next two decades. Indirect and long-term impacts from this project on the local economy depend on factors such as awareness and financial commitment to utilizing the LC-48 site. If the commitment is sustained over the long-term, indirect economic impacts could be significant. Future employees at LC-48 would represent new purchasing power that would support additional jobs at local retail and service establishments in the area. The KSC PEIS (NASA 2016) described the larger multiplier effect associated with consumer spending of employees directly supported by new programs such as the Proposed Action.

No Action Alternative

Should the proposed project not be implemented, no socioeconomic changes would occur in Brevard or Volusia counties. There would be no change to employment, population, income, housing, economic activity, or quality of life. Fluctuations would occur at rates consistent with historical patterns.

3.14 Environmental Justice and Children's Environmental Health and Safety

In accordance with Executive Order 12898, the CEQ issued guidance for federal agencies to make achieving environmental justice part of their mission by identifying and addressing disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations. FAA Order 1050.1F, which is consistent with U.S. DOT Order 56.10 on Environmental Justice, establishes the requirements for assessing environmental justice impacts. Under EO 13045, Protection of Children from Environmental Health Risks and Safety Risks, dated April 21, 1997, federal agencies are encouraged to consider potential impacts of proposed actions on the safety or environmental health of children.

3.14.1 Affected Environment

As described in detail in the KSC PEIS (NASA 2016), the population inhabiting the Region of Influence (ROI) for the Proposed Action (Brevard County and Volusia County) is not comprised of greater than 50% minorities and does not exceed the percentage of minorities as compared to the rest of Florida. In addition, the poverty level coupled with median household income levels are lower or comparable to the rest of Florida, and the majority of the population is living well above the poverty level as defined by the U.S. Department of Health and Human Services. Therefore, disproportionate impacts to either minorities or low-income residents in the ROI would not occur.

The nearest location containing a moderate concentration of children is the KSC Child Development Center, located approximately 6.4 to 12.8 km (4 to 8 miles) away from the Proposed Action sites. This is a child care center and pre-school service available for children ages six weeks to five years old. There are no other schools, daycare facilities, playgrounds, or other places where children are concentrated within KSC.

3.14.2 Environmental Consequences

The FAA has not established a significance threshold for environmental justice and children's environmental health and safety. However, FAA Order 1050.1F identifies factors to consider when evaluating impacts (see Section 3.13.2). As described in detail in the KSC PEIS (NASA 2016), the population inhabiting the Region of Influence (ROI) for the Proposed Action (Brevard County and Volusia County) is not comprised of greater than 50% minorities and does not exceed the percentage of minorities as compared to the rest of Florida. In addition, the poverty level coupled with median household income levels are lower or comparable to the rest of Florida, and the majority of the population is living well above the poverty level as defined by the U.S. Department of Health and Human Services. Therefore, disproportionate impacts to either minorities or low-income residents in the ROI would not occur.

Impacts to children's environmental health and safety were evaluated in terms of the potential for high and adverse environmental consequences resulting from the project to disproportionately affect children. The only location where children are concentrated in the vicinity of the project area is at the KSC Child Development Center, which is approximately 6 to 13 km (4 to 8 mi) from the proposed site locations. Children at the Center may be exposed to increased noise levels during launches. However, noise levels are expected to be short in duration and greatly diminished at that distance from the launch pads. Therefore, the Proposed Action would not pose disproportionately high or adverse impacts to children's environmental health or safety. The No Action Alternative would not impact children.

No Action Alternative

Under the No Action Alternative LC-48 would not be built. There would be no SCLV launches from the proposed LC-48 location on KSC. Therefore, no impact on Environmental Justice or Children's Health and Safety would occur as a result of the implementation of the No Action Alternative.

3.15 Section 4(f) Properties

The overall land use and management objectives at KSC are to maintain the Nation's space mission operations while supporting alternative land uses that are in the Nation's best interest. This EA considers impacts under Section 4(f) of the DOT Act, which has been recodified and renumbered as 49 U.S.C. Section 303(c). Any project that receives funding from or requires the approval of the DOT, including the FAA approval of a license or permit, must be analyzed for compliance with Section 4(f). In accordance with FAA Order 1050.1F, the FAA will not approve any program or project that requires the use of any Section 4(f) property determined by the officials having jurisdiction thereof, unless no feasible and prudent alternative exists to the use of such land and such program, and the project includes all possible planning to minimize harm resulting from the use. Section 4(f) properties include publicly owned parks, recreation areas, and wildlife or waterfowl refuges, or any publicly or privately owned historic site listed or eligible for listing on the NRHP. When private institutions, organizations, or individuals own parks, recreational areas, or wildlife and waterfowl refuges, Section 4(f) does not apply to these properties, even if such areas are open to the public. However, a privately owned property may be protected under Section 4(f) when it is located on long-term leased public land or a public easement.

3.15.1 Affected Environment

Section 4(f) properties located at KSC but not within the proposed LC-48 boundary include LC-39A, LC-39B, the Crawlerway, a portion of the KSC railroad track, the Vehicle Assembly Building, Launch Control Center, Press Site Flag Pole, Central Instrumentation Facility, Headquarters Building, and Operations and Checkout Building, all of which are listed on the NRHP. All of these facilities are listed on or eligible for listing on the NRHP, making them Section 4(f) properties. Section 4(f) properties directly adjacent to KSC include CCAFS (listed on NRHP), MINWR, and CNS. MINWR and CNS property within KSC boundaries along with the section of Indian River Lagoon National Scenic Byway located within MINWR are also considered Section 4(f) properties.

3.15.2 Environmental Consequences

Impacts to Section 4(f) properties can include physical use (e.g., an actual physical taking of Section 4(f) property through purchase of land or a permanent easement, physical occupation of a portion or all of the property, or alteration of structures or facilities on the property) or constructive use. Constructive use occurs when the impacts of a project on a Section 4(f) property (e.g., noise) are so severe that the activities, features, or attributes that qualify the property for protection under Section 4(f) are substantially impaired (see FAA Order 1050.1F, Appendix B-2). Impacts would be significant if the action involves more than a minimal physical use of a Section 4(f) resource or constitutes a constructive use based on an FAA determination that the project would substantially impair a Section 4(f) resource.

No Section 4(f) properties would be impacted by construction activity. Due to the proximity of LC-39A to the proposed LC-48 site, it would experience noise from SCLV launches and engine tests. Due to the long history of launches at CCAFS and KSC, Section 4(f) properties in the area have previously experienced noise from launches. In addition, LC-39A is an active launch pad currently under lease to SpaceX. Most of the launch vehicles that have launched and currently do launch from CCAFS and KSC produce more thrust and louder noise than would occur under the Proposed Action. Given KSC and nearby CCAFS are active launch sites, and because the noise level would only increase temporarily, the FAA has determined the Proposed Action would not result in a use of any Section 4(f) property. Therefore, the Proposed Action would not result in significant impacts on a Section 4(f) resource.

There is a possibility of temporary restricted access on sections of KSC managed by MINWR and CNS, as have occurred for recent and past space programs. This is dependent upon the launch trajectory, fuel loads, and on the volume of visitor traffic. Access is coordinated between KSC security, MINWR, and CNS by monitoring to ensure parking lot thresholds are not exceeded, and roadways allow for emergency egress for any form of emergency associated with large crowds.

No Action Alternative

Under the No Action Alternative, NASA would not construct LC-48, and SCLV launches and engine testing would not occur at the proposed site. Therefore, no Section 4(f) property impacts would occur.

4.0 CUMULATIVE IMPACTS

Federal regulations implementing NEPA require that federal agencies include an analysis of potential cumulative effects of a proposed action. CEQ regulations implementing the procedural provisions of NEPA define cumulative effects as follows (40 CFR Part 1508.7):

> The impact on the environment, which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what entity (federal or non-federal) or person undertakes such other actions. This includes those that may be "individually minimal but collectively significant actions taking place over time."

4.1 Projects Considered for Potential Cumulative Effects

Future development and activities that may occur at or near the Proposed Action were researched and considered. Projects planned at CCAFS, Port Canaveral, and KSC including Exploration Park and the Visitor Complex are discussed in the following paragraphs. Many of these actions involve federal agency agreements or funding and have already had required NEPA documents prepared or would be required to go through NEPA coordination and documentation.

The future land use plan for KSC promotes the most efficient use of land area resources balanced with an understanding of development suitability and capacity. KSC's transition to a multi-user spaceport advocates compatible relationships between adjacent land uses, encourages infill development, and preserves environmentally sensitive areas. Current actions at KSC include Exploration Ground Systems (EGS, formerly GSDO) leading the center's transformation from a historically government-only launch complex to a spaceport with activity involving government and commercial vehicles alike. The program's primary objective is to prepare the center to process and launch the next-generation vehicles and spacecraft designed to achieve NASA's goals for space exploration.

Under a 20-year Commercial Space Launch Act agreement between NASA and SpaceX, LC-39A is being used for processing and launch of Falcon 9 vehicles, and was also modified to support launch of the Falcon Heavy vehicle. In 2015, SpaceX constructed a 4,645 m2 (50,000 ft2) Falcon Integration Hangar at the entrance to 39A.

LC-39B is under the process of redevelopment for the SLS rocket and Orion spacecraft. The pad was returned to a clean design after removal of the Fixed Service Structure. This will allow multiple types of vehicles to launch from LC-39B arriving at the pad with service structures on the mobile launch platform rather than custom structures on the pad. NASA has announced LC-39B would be available to commercial users during times when it is not needed by SLS.

KSC's newest launch pad, designated LC-39C, is designed to accommodate Small Class Vehicles. Located in the southeast area of the LC-39B perimeter, this new concrete pad measures about 15 m (50 ft) wide by about 30 m (100 ft) long. Launch Pad 39C will serve as a multi-purpose site allowing companies to test vehicles and capabilities in the smaller class of rockets, making it more affordable for smaller companies to break into the commercial spaceflight market. As part of this capability, NASA's Ground Systems Development and Operations Program developed a universal propellant servicing system, which can provide liquid oxygen and liquid methane fueling capabilities for a variety of small class rockets. This system is slated for operational readiness in the summer of 2016.

With the addition of Launch Pad 39C, KSC can offer the following processing and launching features for companies working with small class vehicles (maximum thrust up to 200,000 lbs):

- Processing facilities – i.e. Vehicle Assembly Building
- Vehicle/payload transportation (KAMAG, flatbed trucks, tugs, etc.) from integration facility to pad
- Launch site
- Universal propellant servicing system (liquid oxygen, liquid methane)
- Launch control center/mobile command center options

Blue Origin is operating a manufacturing facility in Exploration Park Phase 2. The site consists of 56 ha (139 ac) located on the west side of Space Commerce Way and includes site manufacturing and processing facility that supports development of reusable launch vehicles utilizing rocket-powered Vertical Take-off and Vertical Landing systems (GSDO 2017). There are also plans for additional development by Blue Origin on a parcel of land south of the current site for expansion of their manufacturing, assembly, and test facilities.

OneWeb has built a 9,290 m^2 (100,000 ft^2) satellite spacecraft integration facility at Exploration Park (GSDO 2017, Space Florida 2017). A U.S. subsidiary of a Swiss aerospace company, RUAG Space USA Inc., is opening a spacecraft parts manufacturing plant in Titusville. Initially they will manufacture satellite structure for OneWeb. RUAG will be a tenant of the Port Canaveral Logistics Center in south Titusville.

Space Florida has announced that cargo airline FedEx Express will set up operations at the SLF. FedEx Express, a subsidiary of courier company FedEx Corporation will be the first commercial aircraft of its kind to be located at the SLF (FedEx 2017).

Increased flight operations at the SLF would involve construction of new facilities and increased flight operations at the SLF in the following broad categories: commercial spaceflight program and mission support aviation, aviation test operations including unmanned aerial vehicles, airborne research and technology development and demonstration, parabolic flight missions, testing and evaluation of experimental spacecraft, ground based research and training, and development and demonstration of future supersonic passenger flight vehicles. To take full advantage of the capabilities of the SLF, new construction would occur at both the south- field and mid-field sites.

Virgin Galactic’s space tourism spinoff company, Virgin Orbit, has developed LauncherOne to serve the small-satellite industry. LauncherOne is a two-stage, expendable, LOX/RP-1 rocket that launches from a dedicated 747-400 carrier aircraft. It may operate from multiple locations including KSC. LauncherOne will be capable of placing a 300 kg (661 lbs) payload into a sun-synchronous orbit and a 450 kg (992 lbs) payload into an equatorial orbit (Virgin Orbit 2017).

The Visitor Complex at KSC plans construction of a new Gateway to Space Exhibit to provide cutting-edge space and simulator design capabilities that will immerse visitors in a themed interactive environment of NASA’s past and future. The new exhibit will offer an enlightening, educational, inspiring, and entertaining experience for visitors of all ages.

There are also plans to add more exhibits of space-flown vehicles, including a SpaceX Dragon capsule that hauled cargo to the International Space Station. There could also be a revamp of the Launch Complex 39 observation gantry into an activity learning center that might include a Mars simulation and a launch viewing center.

A new IDP is currently being written that will align the future vision for CCAFS and Patrick Air Force Base with the priority of achieving short- and long-term sustainability of the installation. The 45th Space Wing Mission Statement is "One team…delivering assured space launch, range, and combat capabilities for the Nation" with a vision of becoming the "World's Premier Gateway to Space" (USAF 2017). Future development would be guided by sustainability, and increases in launch tempo and associated support activities would occur sustainably and compatibly with the efficient use of land and energy, the conservation of natural resources and the safe operation of launch vehicles and processing facilities. New facilities and launch complexes would be developed as to minimize any potential impact or compatibility with current facilities and the environment.

SpaceX has built two additional landing pads at Landing Zone 1 (LZ-1), formerly LC-13, on CCAFS to support landing operations. Operations at LZ-1 include landing of up to three booster stage vehicles, post-flight and safing of the vehicles, and Dragon static fire testing.

SpaceX recently rebuilt LC-40 at CCAFS after the Falcon 9 static fire mishap in September 2016. LC-40 is needed for Falcon 9 missions so that final elements on LC-39A can be completed for Falcon Heavy missions. A Dragon resupply mission to the International Space Station (ISS) was successfully launched from LC-40 on December 15, 2017. Twelve Falcon 9 launches occurred from LC-40 in 2018.

Blue Origin is constructing an Orbital Launch Site at LC-11 and LC-36 on CCAFS. The facility will support testing of rocket engines, integration of launch vehicles, and launches of liquid fueled, heavy-lift class orbital vehicles.

Moon Express has negotiated an agreement to use LC-17 and LC-18 from the USAF at CCAFS. Several buildings at LC-17 will be renovated including a former spacecraft integration building and an engineering building. Test stands will be constructed to support work for its spacecraft engines. LC-18 will be used as a test flight area for tethered and free-flight tests of Moon Express landers.

Space Florida holds an FAA Launch Site Operator License for LC-46. This allows Space Florida to offer the site for launches of solid and liquid propellant launch vehicles to launch operators for several types of vertical launch vehicles. The proposed launch vehicles and their payloads would be launched into low earth orbit or geostationary orbit. All vehicles are expected to carry payloads, including satellites (FAA 2008).

Orbital ATK launched a Minotaur IV rocket from LC-46 on August 26, 2017. LC-46 will be used by NASA for the Orion Ascent Abort-2 test mission. This mission, scheduled for 2019, will launch an Orion mock-up using a first stage booster from a Peacekeeper missile modified by Orbital Sciences Corporation to demonstrate a successful abort under the highest aerodynamic loads it will experience in flight.

The short-term forecast for CCAFS and KSC includes launches from LC-37B, LC-39A, LC-41, and LC-46. LC-37 is used to launch communications and global positioning system (GPS) satellites aboard the Delta IV launch vehicle. A Delta IV Heavy launched the Parker Solar Probe on August 12, 2018. Another satellite in the Wideband Global Satcom system is scheduled to be launched in March 2019.

There were two satellite missions launched on the SpaceX Falcon 9 from LC-39A in 2018, and twelve in 2017 including ISS resupply missions, a U.S. Government National Reconnaissance Office (NRO) intelligence satellite, the USAF X-37B, and various communications satellites. SpaceX successfully launched the Falcon Heavy rocket on its maiden flight from LC-39A on February 6, 2018.

LC-41 is currently used by United Launch Alliance for Atlas V launches. An Orbital ATK unmanned resupply Cygnus spacecraft was flown from LC-41 to the ISS in April 2017. A communications satellite was launched in August, as well as the Advanced Extremely High Frequency military communications satellite on October 17, 2018.

ULA is developing the Vulcan Centaur launch vehicle to provide a more versatile and cost competitive space launch vehicle while maximizing the use of existing space launch infrastructure. The Vulcan Centaur will contain a larger diameter booster tank than the Atlas V, use new BE-4 booster engines that consume liquid oxygen and liquid natural gas for the first stage, multiple solid rocket motor configurations. ULA plans to launch the Vulcan Centaur vehicle from LC-41. Vulcan Centaur Program modifications will occur at LC-41, the Vertical Integration Facility and the Solid Motor Assembly and Readiness Facility.

Space Florida proposes to develop a non-federal launch site that is state-controlled and state-managed. Under the Proposed Action, Space Florida would construct and operate a commercial space launch site known as the Shiloh Launch Complex consisting of two vertical launch facilities and two off-site operations support areas. The proposed 80 ha (200 ac) launch complex would accommodate up to 24 launches per year as well as up to 24 static fire engine tests or wet dress rehearsals per year. The vehicles to be launched include liquid fueled, medium- to heavy-lift class orbital and suborbital vertical launch vehicles. FAA is the lead agency in the development of an EIS for the proposed launch site.

The Canaveral Harbor or Port Canaveral is a man-made, deepwater port located on the barrier island north of the City of Cape Canaveral. A summary of the Port's future development plans includes but is not limited to the following (Port Canaveral 2017).

Internal road and pier improvements are ongoing and more are planned including replacement of the outdated drawbridge on SR 401. In addition, a SR 528 widening project is tentatively scheduled to start in 2022. The road will be expanded from four to six lanes from Interstate 95 to Port Canaveral to accommodate projected passenger and cargo traffic generated by Port expansion projects.

A project to deepen the channel to 13 m (44 ft) has been underway since 2005 and is nearing completion. Due to its expanding cargo operations and the construction of larger vessels, the Port has initiated a study looking at the feasibility of deepening the channel.

Cruise ship activity continues to increase with additional homeport ships including some of the largest in the world. Port Canaveral is currently the world's second busiest cruise port for multi-day embarkation. With more travelers taking to the water and new cruise ships continuing to be built, the Port's cruise industry is set to expand even further. Recent developments include the new Cruise Terminal One, and multi-million dollar renovations to Cruise Terminals Five, Eight, and Ten. Carnival, Disney, Royal Caribbean, and Norwegian Cruise lines all sail out of Port Canaveral.

Port Canaveral continues to develop facilities and capacity to become a premier cargo port. The first quarter of 2017 saw significant increases in vehicle, slag, salt and petroleum imports. New cargo services in 2016 included Blue Stream, a weekly container service connecting Central Florida with Europe, Central America and the Caribbean. In 2016 an auto processing company, AutoPort, opened a 14.7-acre terminal for new vehicles arriving at the docks.

SpaceX now occupies a 4,957 m^2 (53,360 ft^2) facility in Port Canaveral, Florida that is designated for the refurbishing of rockets for reuse. SpaceX has taken on a 5-year lease of the facility located just north of the Port at 620 Magellan Road. In addition, they are using a facility in an industrial park in Cocoa on Cidco

Road for manufacturing support. Area 59 on CCAFS is utilized for Dragon capsule processing. SpaceX will also be developing an operations area on Roberts Road at KSC. The campus will include a launch and landing control center, a booster and fairing processing and storage facility and utilities yard.

4.2 Cumulative Impact Analysis on Resources

Cumulative impacts result from the incremental effect of an action when added to other past, present, and reasonably foreseeable future actions, regardless of the proponent undertaking these actions. Minimal or negligible impacts from individual projects may, over a period of time, become collectively significant. Past, current, and future launch vehicle processing operations at KSC and CCAFS, along with present and future actions occurring on a regional basis, must be considered when evaluating cumulative impacts. The construction of new facilities and associated infrastructure or modification of existing facilities and infrastructure, and operations associated with the proposed facilities would be consistent with existing KSC and CCAFS activities and pose no new types of impacts.

As described in Section 3, no direct or indirect impacts were identified for cultural resources or environmental justice. When considered with other past, present, and foreseeable future actions, the Proposed Action would not contribute to any cumulative effects associated with these resource categories and, therefore, were not carried forward for detailed cumulative impacts analysis.

Under the No Action Alternative there would be no change in baseline conditions for the resources evaluated in this EA. Existing conditions at KSC and CCAFS would continue as described in Section 3. No new cumulative impacts would be expected.

4.2.1 Land Use and Visual Resources

Development of LC-48 site would be expected to have a moderate cumulative effect on land use due to the undeveloped nature of the area and the land use designation of Vertical Launch. Previously the area was considered Operational Buffer/Conservation and managed by MINWR for wildlife and habitat diversity. Development of the site would have a measurable effect, however, relatively few natural areas on KSC are being converted to operational use. Mitigation for impacts to these sites could be accomplished through habitat restoration in other degraded areas. There would also be an impact on prescribed burn and wildlife habitat management activities which would require increased coordination between facility operators and MINWR. Launch site restrictions in KCA-4205 state there will be no prescribed burning on KSC/MINWR that will place smoke within a 2-mile radius of an identified critical spaceflight hardware, payload processing facility or launch site when a smoke-sensitive payload is present. The agreement is being updated and will reduce the smoke restriction to a 1-mile radius. These restrictions, or smoke exclusion buffers currently exist (see maps in Appendix F) and are not limited to the LC-48 site. KSC would mitigate the impacts from these restrictions by working with MINWR and launch site users to increase prescribed burning opportunities.

Overall, cumulative impacts to Land Use would be moderate and easily absorbed by consolidation of operations into small geographic areas with compatible uses during future land use planning. No significant adverse cumulative impacts to Visual Resources or Coastal Zone Management would occur as a result of the Proposed Action.

4.2.2 Noise

There would be no significant increase in cumulative impacts from noise in the region due to the Proposed Action. Variations in timing and location of construction activities would result in noise generation being spread out and intermittent, lasting only for the duration of the construction project. Minimal effects of operational activities from use of heavy equipment, processing of spacecraft, test fires, and launch operations would contribute to the overall cumulative noise impacts from other noise sources in the area. Industrial activities would be spread out spatially, aircraft operations would be infrequent, and launches would not occur simultaneously, therefore cumulative noise impacts would not be significant.

4.2.3 Biological Resources

The majority of impacts on biological resources from implementation of the Proposed Action would be moderate. Disturbance of natural vegetation would be limited to small areas. Moderate impacts to gopher tortoises, beach mice, and Florida scrub-jays would result from construction activities and would be lessened by mitigation and conservation measures. Cumulative impacts to biological resources are expected to be insignificant.

4.2.4 Air Quality

The most routinely influential air quality fluctuations are created by the emissions from automobiles entering and departing KSC. However, an increase in emissions from traffic due to the Proposed Action and foreseeable actions in the region are not expected to exceed that experienced at KSC in the past or result in cumulative impacts. Also, the atmospheric emissions associated with SCLV launches and engine testing are intermittent and quickly dispersed. Long-term cumulative air quality impacts in the lower atmosphere are not expected to be significant.

The Proposed Action added to past, present, and reasonably foreseeable actions in the region would result in minimal, temporary increases in air emissions. This incremental contribution to cumulative air quality impacts from the Proposed Action would not be significant.

4.2.5 Climate

Impacts on climate from direct emissions resulting from the Proposed Action are expected to be minimal. Individual sources of anthropogenic greenhouse gas emissions resulting from construction and operations of the LC-48 site alone would not be large enough to accelerate regional climate change. Therefore, contributions from this project would not be significant. An appreciable impact would only result when combined with other greenhouse gas emissions from man-made activities on a global scale.

4.2.6 Hazardous Materials/Hazardous Waste

Although many hazardous materials and wastes are known to accumulate in the environment, it is not expected that there would be any cumulative effects caused by environmental contamination as a result of the Proposed Action. Continued implementation of BMPs for the handling and disposal of hazardous materials and waste in compliance with RCRA regulations would limit the potential for impact. Safeguards would be in place to minimize the release of toxic chemicals in the environment, and rapid spill response plans would ensure that unintended releases would be cleaned up quickly. Therefore, the Proposed Action is not expected to result in cumulative impacts due to hazardous materials and waste.

4.2.7 Water Resources

With the implementation of stormwater management systems, development of the site would have a moderate cumulative effect on hydrology and water quality. Regionally, vegetated lands are increasingly being covered by impervious surfaces (i.e., buildings, parking lots, roadways) resulting in increased runoff and limiting replenishment of groundwater. Although stormwater management has been implemented for construction efforts since the 1990s, these retention and detention ponds are generally not able to accommodate large amounts of water associated with heavy rainfall, resulting in some excess runoff flowing into wetlands, ditches, and the IRL. However, quantities are generally episodic and can be absorbed by the lagoon system.

The cumulative effects on surface water quality in the IRL from the development of the LC-48 location would be moderate. Even with stormwater management plans implemented, heavy rains would cause runoff at each site. Eventually, stormwater could reach the IRL, although some of the sediment would have settled out and the concentrations of other pollutants would be reduced. Additional percolation associated with stormwater treatment or potential industrial wastewater permit may have a moderate cumulative effect on groundwater flow and composition.

4.2.8 Geology and Soils

No impacts to the geology of KSC would result from the Proposed Action. Therefore, no significant incremental impacts to the regional geology would be expected. There would be moderate impact to soils due to construction and land disturbance at the Proposed Action site. Cumulative impacts on soils from construction activities would not be significant as these soils are common locally and regionally.

4.2.9 Transportation

Increases in traffic during construction of the Proposed Action would be short-term with only minimal adverse effects. Increases in traffic and any changes in traffic patterns due to operations would also be minimal and not expected to result in cumulative impacts to regional transportation.

4.2.10 Utilities

The cumulative effects on utilities and services as a result of the Proposed Action combined with current and future KSC and CCAFS actions would be moderate, measurable but within the capacity of the system. The existing potable water, electrical, communications, natural gas, and solid waste facilities are expected to be able to accommodate any associated increased demand. Industrial wastewater, such as deluge water, at LC-48 would require either an FDEP permit to discharge or a PWQ/TRP to discharge to the RWWTF adding a moderate cumulative effect to either groundwater in the first case, or to the domestic wastewater system in the second case.

4.2.11 Health and Safety

Minimal adverse impacts to worker health and safety during construction and operation of the Proposed Action would be expected. Contractor and operations personnel would be required to follow and implement OSHA, and NASA or USAF safety standards to establish and maintain a safe working environment. Explosive site safety plans would be submitted and approved prior to test fire and launch operations taking place. There would be no cumulative impact to worker or public health and safety as a result of the Proposed Action.

4.2.12 Socioeconomics

Cumulative impacts from the Proposed Action would potentially be beneficial to KSC, CCAFS, and surrounding communities. There would be increased employment opportunities during construction and operation of the proposed site that would potentially augment other businesses and industries in the local communities.

4.2.13 Section 4(f) Properties

Section 4(f) properties would experience impacts (noise), but the impacts would not be considered a "use" (i.e., constructive use) of the property. Section 4(f) properties could experience restricted access during launches. Industrial activities and launches at KSC and CCAFS would be separated spatially and would not occur simultaneously, therefore cumulative impacts to Section 4(f) properties in the region would not be significant.

5.0 LIST OF PREPARERS AND CONTRIBUTORS

The following persons prepared the EA and provided insight into specific resource areas.

Table 5-1. Preparers of this Environmental Assessment.

NAME	TITLE	AREA OF CONTRIBUTION
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David Thorpe	Master Planner	Proposed action

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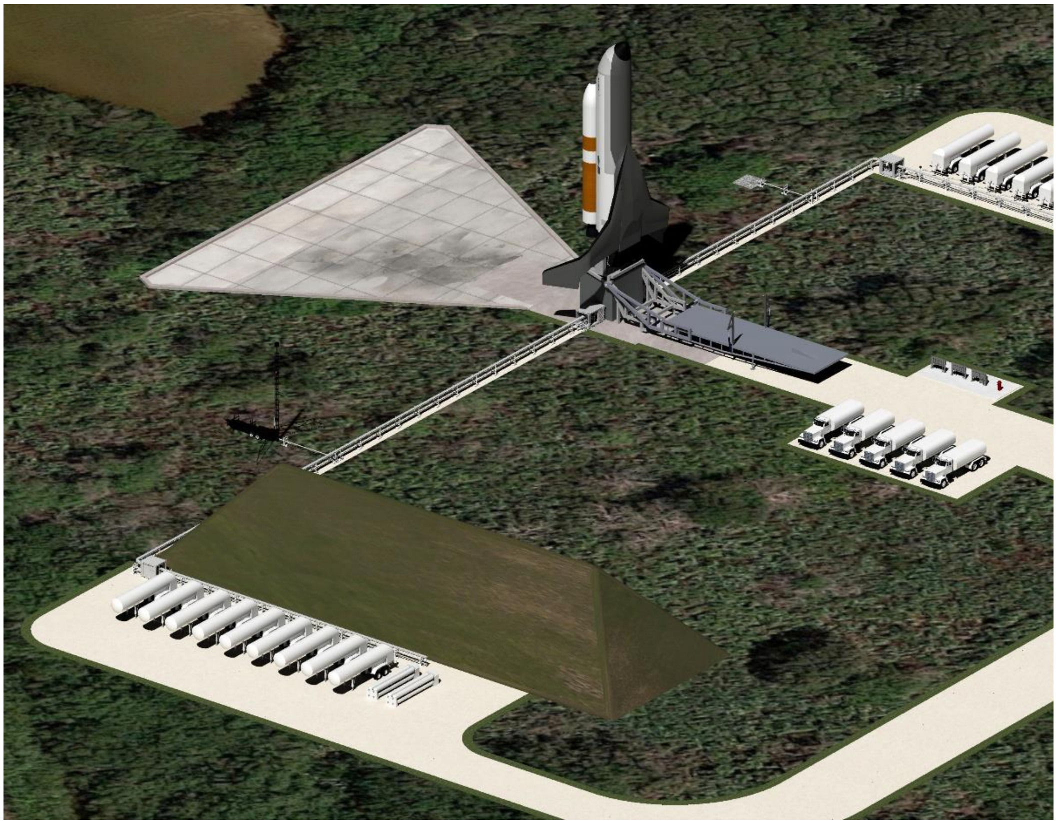
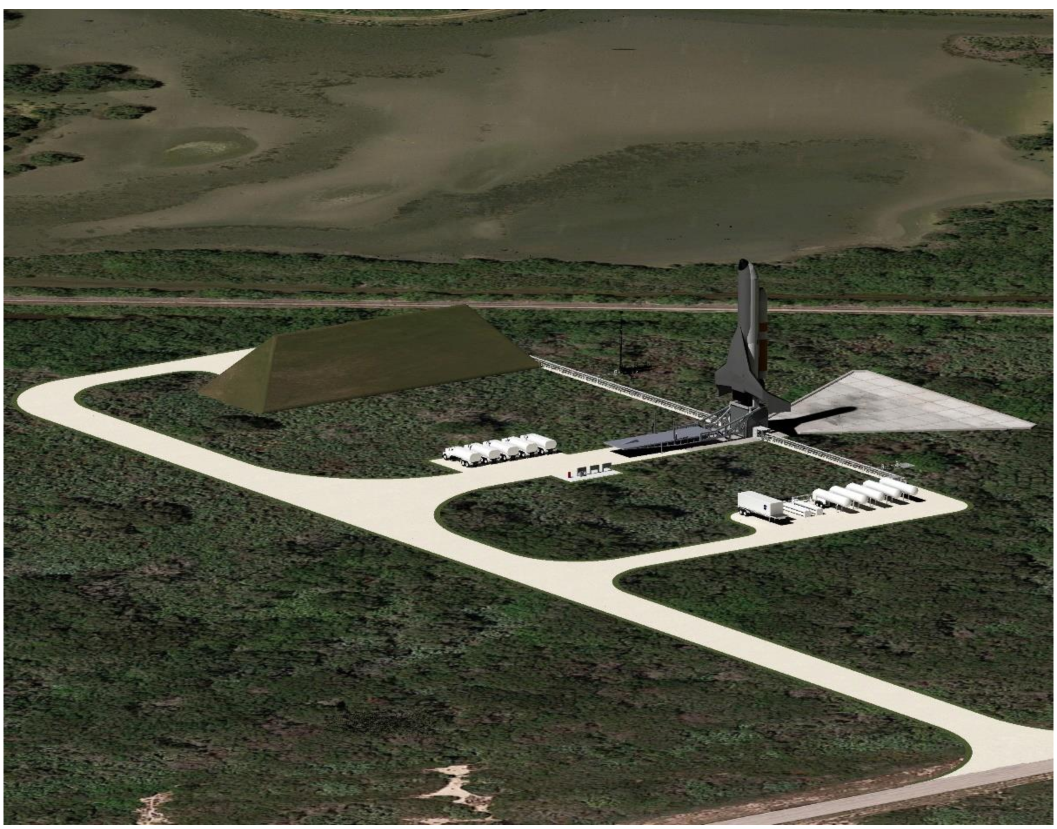
Appendix A. Additional renderings of proposed Launch Complex-48





Appendix B. U.S.Fish and Wildlife 2016 Biological Opinion

FWS Log No. 04EF1000-2016-89

United States Department of the Interior

U. S. FISH AND WILDLIFE SERVICE

7915 BAYMEADOWS WAY, SUITE 200
JACKSONVILLE, FLORIDA 32256-7517

IN REPLY REFER TO:
FWS Log No. 04EF1000-2016-F-0083

April 4, 2017

Mr. Glenn Semmel
Chief, Environmental Management Branch
SI-E3, NASA
Kennedy Space Center, FL 32899
(Attn: John Schaffer)

Dear Mr. Semmel:

This document is the Fish and Wildlife Service's (Service) Biological Opinion (BO) based on our review of the Biological Assessment (BA) for the proposed update of the Kennedy Center Master Plan development. The Kennedy Center Master Plan describes a 20-year transformation of the facility from a single, government-user launch complex to a multi-user spaceport. Kennedy Space Center (KSC) has prepared a Biological Assessment in support of re-initiation of consultation for artificial lighting impacts on nesting loggerhead sea turtle (*Caretta caretta*), green sea turtle (*Chelonia mydas*), leatherback sea turtle (*Dermochelys coriacea*), hawksbill sea turtle (*Eretmochelys imbricata*), and Kemp's ridley sea turtle (*Lepidochelys kempii*), per Section 7 of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 et seq.). Your request for formal consultation was received on December 30, 2015, and the final BA was provided on April 4, 2016.

KSC has determined that the proposed revision of the plan may affect, and is likely to adversely affect, the loggerhead, green, leatherback, hawksbill, and Kemp's ridley sea turtles. The Service concurs with your determination. A complete administrative record is on file at the Ecological Service Office in Jacksonville, Florida.

CONSULTATION HISTORY

January 6, 2017 - KSC Environmental Branch submitted comments for review and consideration on the draft Conservation Measures, Reasonable and Prudent Measures and Terms and Conditions.

October 25, 2016 - The Service submitted via email to the KSC Environmental Branch the draft Conservation Measures, Reasonable and Prudent Measures and Terms and Conditions for the Opinion for review and comment.

April 29, 2016 - The Service and KSC Environmental Branch coordinated on the 2016 Nesting Season Protocol and agreed to continue implementing the Terms and Conditions of the 2009 Biological Opinion.

February 2016 - The Service and KSC Environmental Branch discussed the Biological Assessment (BA). The Service submitted comments on the BA and the Environmental Branch updated the BA and provided additional Conservation Measures in the project description.

December 31, 2015 - KSC Environmental Branch submitted a request to update the Interim Biological Opinion (BO), issued in 2009 and revised Biological Assessment for the proposed Kennedy Space Center Master Plan.

DESCRIPTION OF THE PROPOSED ACTION

To address the potential impacts to listed species during space launch operations at KSC, the Service has engaged in formal consultations since 1993. The most recent consultation addressing sea turtles and lighting impacts, the Interim Biological Opinion (BO), was issued in 2009. The Interim BO describes the history of the continuing lighting impacts and initiation of light management plans for particular areas, such as, launch complexes on KSC. The Interim BO was to support KSC through 2010, when the Constellation Program was expected to be in full swing, with clear plans for Launch Complex (LC) 39A and B. The NASA Authorization Act of 2010 cancelled the Constellation Program and in September 2011, President Obama announced its replacement by the Space Launch System, under the U.S. National Space Policy.

The recently completed Kennedy Space Center (KSC) Master Plan builds upon earlier planning efforts as an update to describe how KSC will transform over the next 20 years to become a multi-user spaceport supporting government, commercial and other space launch users and providers. The Master Plan describes KSC's future state, along with the supporting business focused implementation and operating framework necessary to enable this transformation. (KSC Master Plan)

Under the KSC multi-user space port both NASA and commercial launch activities will occur in the same operational areas used during the Shuttle Program. Operational areas with light sources near the KSC beaches, dune restoration site and nesting beach kilometer locations are detailed in the sections below.

Launch Complex 39A

Launch Complex 39A (LC-39A) was the primary launch site for the Shuttle Program and the site of the final launch on July 8, 2011. This complex came under lease to SpaceX in 2014. SpaceX is one of several commercial companies that deliver payloads to the International Space Station on behalf of NASA and is also one of several companies striving to develop a vehicle to support future NASA missions.

Some minor modifications to LC-39A pad have been made but the service structure and many associated lighting features remain in place. SpaceX has constructed a Horizontal Integration Facility (HIF) on the crawlerway, just outside the perimeter gate and conducting other related infrastructure updates in preparation for launch in 2016. For the construction period, KSC required SpaceX to submit a light management plan for the 2015 nesting season. Construction projects within the HIF were observed by MINWR and KSC support staff to have no light trespass during night time activities through the beginning of nesting season. From late July through the end of season exterior lighting was needed for pad upgrades. Lighting was directed where needed and in compliance with the plan. Work is expected to be complete in 2017 and SpaceX will then move into their launch operational phase in the same year.

Launch Complex 39B

The original LC-39B fixed launch structure was identical to LC-39A. The structure was retrofitted as a clean pad to support the recently constructed mobile launcher (ML). Currently, the ML is located north of the Vehicle Assembly Building (VAB), approximately 5.6 km (3.5 miles) west of the beach. The process will be for the ML to be picked up by the crawler, moved to the VAB for rocket assembly, and then moved to the pad in preparation for launch. Immediately after launch, the ML will be returned to the VAB site. The ML lighting was designed and implemented in accordance with the KSC Exterior Lighting Guidance. The combination of the turtle friendly lighting on the ML and the clean pad design resulted in a substantial reduction at this launch pad.

Launch Complex 39C

LC-39C is a new Small Class Vehicle Launch Pad (Figure 1) located inside the southeast area of the LC-39B perimeter. The new concrete pad measures about 50 feet wide by about 100 feet long and will serve as a multi-purpose site for companies to test vehicles and capabilities in the smaller class of rockets. Launch activities from this pad will be conducted during daylight hours only.

Future Potential Launch Complexes

The KSC Master Plan identifies several notional launch site areas that could be developed for additional vertical launch operations. These areas are located north of LC-39B and south of LC-39A based on a Site Evaluation Study performed in 2007 addressing small/medium launch vehicles and described in the Draft Programmatic Environmental Impact Statement for Center-Wide Operations at KSC (Draft KSC PEIS for Center-Wide Operations 2016).

Beach House

The Beach House, a historic property utilized by astronauts prior to launch and as a meeting facility for KSC personnel, is located near the southern end of the KSC property. There is permanently posted signage on the interior and exterior of the facility as well as information sheets explaining lighting responsibilities for persons occupying this building.

Corrosion Test Facility

The Corrosion Test Facility (CTF) is located on the primary dune 1 km (0.6 mi) north of the False Cape. The purpose of the CTF is to provide a site to measure the effects of atmospheric exposure along the Atlantic coast. A number of different kinds of structures and materials are tested by government and commercial entities at this facility. No exterior lighting is required or used at this site. This facility is used during daylight hours only. A sign is posted next to the exits reminding Staff to turn off all lights and close blinds when leaving the support building.

Eagle Four Security Post
Eagle Four is a security tower located west of the primary dune at the border between CNS and KSC. This is also the delineation between the secure area and public use area of KSC. Stairway egress lighting was retrofitted with Low Pressure Sodium (LPS) fixtures and is typically "off". No other exterior lighting is present. A sign is posted next to the exits reminding Staff to turn off all lights and close blinds when leaving the support building.

Road Block Guard Shack
This facility provides observational visibility necessary for boundary security. Lighting that enables full color rendition is required for the safety and security of Security Officers that supervise access within the gates of KSC. Guard Shacks on Beach Road have the status to occupy as required, which to support launch operation roadblocks for LC-39A, LC-39B on KSC and LC-41 on CCAFS. There are not launches scheduled on KSC before 2018 but will likely become more active once space vehicle launches resume at LC- 39A and LC-39B. Current lighting plan is for lights out unless in use, and when in use lights out when not manned.

Other KSC Artificial Light Sources
The KSC Light Management Assessment Report (Mercadante and Provancha, 2013) documented an extensive survey of KSC lighting and addressed artificial light sources that potentially contribute to light pollution across the Center. Light sources throughout KSC have also been identified each year during lighting surveys conducted in compliance with the 2009 Interim BO (Service 2009a) and results from those surveys are found in Appendix A of the KSC Biological Assessment.

Off-Site Launch Complexes
The Cape Canaveral Air Force Station is located immediately south of KSC and the LC-40 and LC-41 are the closest to KSC property and managed by CCAFS. LC-41 is 0.5 km (0.3 miles) landward of the KSC nesting beach and LC-40 is ~0.75 km (0.5 miles) SW of the southern boundary of the KSC beach. These areas are included in the nighttime lighting surveys.

Other Off-Site Source
The KSC Light Management Assessment Report (Mercadante and Provancha, 2013) documented an extensive survey of KSC lighting, and also addressed distant light sources. They noted lights or glow clearly visible from the cities of Titusville and New Smyrna/Daytona from the KSC secured beach.

Conservation Measures

To ensure continued reduction of artificial lighting impacts on nesting sea turtles, KSC will continue to implement the following measures that were outlined as terms and conditions in the

2009 Interim Biological Opinion and has committed to the additional conservation measures. All conservation measures listed below will be considered as a part of the project description and used in the following analysis for the effects of the actions. Conservation measures are binding commitments from the agency to implement as described below.

CM 1: Exterior Lighting Plan Requirements and NEPA Lighting Review

Environmental Management Branch (EMB) developed the KSC Exterior Lighting Requirement guidance (ELG) for exterior lighting installation and use at KSC in 1995. This guidance document was last revised in 2009. The document is provided to all KSC Facility Managers, lighting project engineers and managers, and is posted on both an internal and external webpage. This document serves to inform project proponents, regardless of whether the proponent is NASA, private industry or other governmental agency, of the lighting requirements set forth in the 2009 Interim Biological Opinion and how to ensure that their project is compliant with these requirements. The Service has reviewed the updated version and provided comments for the 2016 update.

EMB staff conduct NEPA reviews on all new lighting actions including new projects, existing facility refurbishments, and maintenance actions through the KSC Checklist NEPA Process.

The updated ELG will require all new facilities, newly leased facilities and major facility modifications to develop and implement a site specific Lighting Operations Manual (LOM) to be reviewed and approved by the NASA EMB and Service prior to the construction.

Project Proponent shall submit a lighting plan to EMB, direct coordination via email or formal meetings occur depending on the complexity and level of compliance of the project.

- New large scale construction projects and launch pad plans will be reviewed by the Service. The updated ELG will require all new facilities, newly leased facilities and major facility modifications to develop and implement a site specific Lighting Operations Manual (LOM) approved by the NASA EMB and Service.

- Small scale projects that meet the ELG will be reviewed by KSC Environmental Planning staff. Variances will be reviewed by both KSC and FWS.

For existing facilities or projects that are found to be non-compliant, EMB initiates a compliance action. Actions range from a telephone call or email to immediately rectify the issue, to meetings with senior level managers for more complex issues. Prime contacts for compliance assurance are Facility Managers for existing facilities and Project Managers for proposed facilities.

CM 2: Facility Coordination and Education during the Sea Turtle Nesting Season

EMB shall provide routine coordination and nesting season updates to the facility and the non-government agencies. EMB shall attend quarterly meetings to the Facility Management (FM). The FMs shall post weekly bulletins to building tenants and include sea turtle notes provided to them by EMB throughout the season.

EMB requires training of pertinent personnel including but limited to FMs and PMs on nesting sea turtles. The trainings are held on site by invited guests and staff or at the CCAFS every two years.

EMB shall disseminate pamphlets and posters to all lobbies and most break rooms at the beginning of the season and periodically updates supplies through the season.

EMB posts video clips on the KSC Communicator, an online Center-wide web portal and written notifications in the KSC daily news throughout the season.

CM 3: Lighting Surveys

KSC will perform 5 nighttime surveys during the nesting season. EMB support contractor has performed annual routine night time lighting surveys throughout the sea turtle nesting season since 2010. In addition, the USFWS MINWR staff will also provide updates on observations of artificial lighting visible from the nesting beach while conducting predator control/monitoring. EMB and support contractor coordinated with Service in the 2015 nesting season to modify lighting surveys to reduce manual surveys and add sky glow meter data.

Sky glow meter data will provide supplemental information to the nighttime survey reports. In 2015/2016, twelve Unihedron light loggers were installed along the beach at KSC kilometers 24, 26, 30, 33, and CNS Grid 93, 42. Loggers on the KSC beach are checked for physical damage/debris and data are downloaded routinely.

Going forward, EMB will develop a long term monitoring program of sky quality as it pertains to artificial light photo pollution visible from the KSC nesting beach using permanent light meter sampling stations. The MINWR staff or EMB support contractor will monitor adult and hatchling disorientation incidents within the affected area. EMB contractor will analyze sky quality and sea turtle nesting/hatching behavior to enhance KSC planning and management of the nesting beach. This monitoring will provide a baseline from which to assess trends in photo pollution as lighting improvements at KSC are implemented over time.

CM 4: Reporting and Compliance

Monthly nesting and disorientation reports shall be provided and reviewed by EMB.

KSC ensures specific facilities, including but not limited to those listed above in the project description, found to be commonly non-compliant are contacted by phone at the beginning of each season. At the FM meeting in April, EMB provides information to send out in the weekly Facility update regarding nesting season protocol.

EMB directed the support Contractor to provide a report on existing conditions on KSC. The report was generated to identify both positive and negative actions and locate artificial light sources that can be seen from the action area (9.8 km section of beach) and is attached in Appendix D.

EMB will prepare an annual activity report for submittal to Service at the end of each calendar year to include all actions taken to retrofit or eliminate existing light sources, to identify newly constructed/leased or modified facility LOM approved for the previous year, and provide other information pertinent to BO compliance.

CM 5: KSC Amber LED Lighting Fixtures and Retrofitting

KSC has recently approved the Facilities Services Contractor to stock a true amber LED lamp to replace street, parking lot and general safety area lighting lamps as they become non-functional. Approving this fixture for Center-wide application and maintaining a bench stock will facilitate rapid change-out of older, disruptive area lighting that contributes indirect lighting visible from the nesting beach.

EMB will use the data from the Activity Report listed in the CM #3 (including historic and future nighttime surveys) to generate and maintain a prioritized list of retrofit lighting projects and will specifically identify those proposed for retrofitting each calendar year.

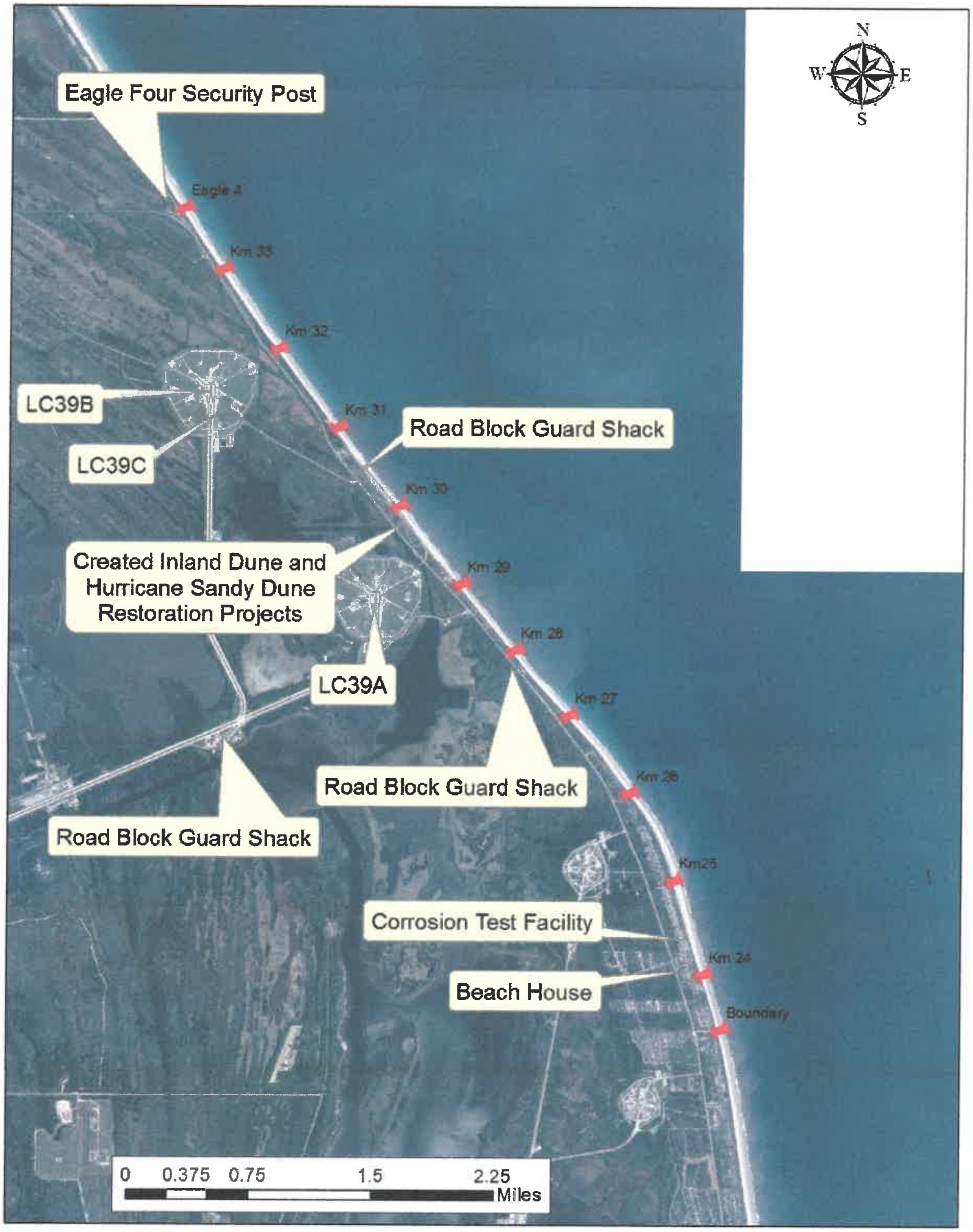


Figure 1. Facilities with light sources near the KSC beaches, dune restoration site and nesting beach kilometer locations

STATUS OF THE SPECIES/CRITICAL HABITAT

This section provides pertinent biological and ecological information for loggerhead sea turtle, green sea turtle, leatherback sea turtle, hawksbill sea turtle, and Kemp's ridley sea turtle, as well as information about their status and trends throughout their entire range. We use this information to assess whether a federal action is likely to jeopardize the continued existence of the above-mentioned species.

SEA TURTLES

Status of the Species/Critical Habitat

Loggerhead Sea Turtle

The loggerhead sea turtle was federally listed as a threatened species on July 28, 1978 (43 Federal Register [FR] 32800). The Service and the National Marine Fisheries Service (NMFS) listed the Northwest Atlantic Ocean (NWAO) distinct population segment (DPS) of the loggerhead sea turtle as threatened on September 22, 2011 (76 FR 58868). The loggerhead occurs throughout the temperate and tropical regions of the Atlantic, Pacific, and Indian Oceans.

The loggerhead sea turtle grows to an average weight of about 200 pounds and is characterized by a large head with blunt jaws. Adults and subadults have a reddish-brown carapace. Scales on the top of the head and top of the flippers are also reddish-brown with yellow on the borders. Hatchlings are a dull brown color (NMFS 2009a). The loggerhead feeds on mollusks, crustaceans, fish, and other marine animals. The loggerhead may be found hundreds of miles out to sea, as well as in inshore areas such as bays, lagoons, salt marshes, creeks, ship channels, and the mouths of large rivers. Coral reefs, rocky places, and ship wrecks are often used as feeding areas.

Within the Northwest Atlantic, the majority of nesting activity occurs from April through September, with a peak in June and July (Williams-Walls *et al.* 1983, Dodd 1988, Weishampel *et al.* 2006). Nesting occurs within the Northwest Atlantic along the coasts of North America, Central America, northern South America, the Antilles, Bahamas, and Bermuda, but is concentrated in the southeastern U.S. and on the Yucatán Peninsula in Mexico on open beaches or along narrow bays having suitable sand (Sternberg 1981, Ehrhart 1989, Ehrhart *et al.* 2003, NMFS and Service 2008).

Critical habitat has been designated for the NWAO DPS of the loggerhead sea turtle (U.S. Fish and Wildlife Service 2014)

Green Sea Turtle

The green sea turtle was federally listed on July 28, 1978 (43 FR 32800). Breeding populations of the green turtle in Florida and along the Pacific Coast of Mexico are listed as endangered; all other populations are listed as threatened. The green sea turtle has a worldwide distribution in tropical and subtropical waters. The green sea turtle grows to a maximum size of about four feet and a weight of 440 pounds. It has a heart-shaped shell, small head, and single-clawed flippers. The carapace is smooth and colored gray, green, brown and black. Hatchlings are black on top and white on the bottom (NMFS 2009b). Hatchling green turtles eat a variety of plants and animals, but adults feed almost exclusively on seagrasses and marine algae.

Major green turtle nesting colonies in the Atlantic occur on Ascension Island, Aves Island, Costa Rica, and Surinam. Within the U.S., green turtles nest in small numbers in the U.S. Virgin Islands and Puerto Rico, and in larger numbers along the east coast of Florida, particularly in Brevard, Indian River, St. Lucie, Martin, Palm Beach, and Broward Counties (NMFS and Service 1991). Nesting also has been documented along the Gulf coast of Florida from Escambia County through Santa Rosa County in northwest Florida and from Pinellas County through Collier County in southwest Florida (FWC 2009a).

Most green turtles spend the majority of their lives in coastal foraging grounds. These areas include fairly shallow waters both open coastline and protected bays and lagoons. While in these 22 areas, green turtles rely on marine algae and seagrass as their primary diet constituents, although some populations also forage heavily on invertebrates. These marine habitats are often highly dynamic and in areas with annual fluctuations in seawater and air temperatures, which can cause the distribution and abundance of potential green turtle food items to vary substantially between seasons and years (Carballo *et al.*, 2002). Many prey species that are abundant during winter and spring periods become patchy during warm summer periods. Some species may altogether vanish during extreme temperatures, such as those that occur during El Niño Southern Oscillation events (Carballo *et al.*, 2002).

Open beaches with a sloping platform and minimal disturbance are required for nesting.

Critical habitat for the green sea turtle has been designated for the waters surrounding Culebra Island, Puerto Rico, and its outlying keys.

Leatherback Sea Turtle

The leatherback sea turtle was federally listed as an endangered species on June 2, 1970 (35 FR 8491). Leatherbacks have the widest distribution of the sea turtles; nonbreeding animals have been recorded as far north as the British Isles and the Maritime Provinces of Canada and as far south as Argentina and the Cape of Good Hope (Pritchard 1992). Foraging leatherback excursions have been documented into higher-latitude subpolar waters. They have evolved physiological and anatomical adaptations (Frair *et al.* 1972, Greer *et al.* 1973) that allow them to exploit waters far colder than any other sea turtle species would be capable of surviving.

The adult leatherback can reach four to eight feet in length and weigh 500 to 2,000 pounds. The carapace is distinguished by a rubber-like texture, about 1.6 inches thick, made primarily of tough, oil-saturated connective tissue. Hatchlings are dorsally mostly black and are covered with tiny scales; the flippers are edged in white, and rows of white scales appear as stripes along the length of the back (NMFS 2009c). Jellyfish are the main staple of its diet, but it is also known to feed on sea urchins, squid, crustaceans, tunicates, fish, blue-green algae, and floating seaweed. This is the largest, deepest diving of all sea turtle species.

Leatherback turtle nesting grounds are distributed worldwide in the Atlantic, Pacific and Indian Oceans on beaches in the tropics and sub-tropics. The Pacific Coast of Mexico historically supported the world's largest known concentration of nesting leatherbacks.

The leatherback turtle regularly nests in the U.S. Caribbean in Puerto Rico and the U.S. Virgin Islands. Along the U.S. Atlantic coast, most nesting occurs in Florida (NMFS and Service 1992). Leatherback nesting has also been reported on the northwest coast of Florida (LeBuff 1990, FWC 2009a); and in southwest Florida a false crawl (non-nesting emergence) has been observed on Sanibel Island (LeBuff 1990). Nesting has also been reported in Georgia, South Carolina, and North Carolina (Rabon *et al.* 2003) and in Texas (Shaver 2008).

Adult females require sandy nesting beaches backed with vegetation and sloped sufficiently so the distance to dry sand is limited. Their preferred beaches have proximity to deep water and generally rough seas.

Marine and terrestrial critical habitat for the leatherback sea turtle has been designated at Sandy Point on the western end of the island of St. Croix, U.S. Virgin Islands (50 Code of Federal Regulations (CFR) 17.95).

Hawksbill Sea Turtle

The hawksbill sea turtle was federally listed as an endangered species on June 2, 1970 (35 FR 8491). The hawksbill is found in tropical and subtropical seas of the Atlantic, Pacific, and Indian Oceans. The species is widely distributed in the Caribbean Sea and western Atlantic Ocean.

Data collected in the Wider Caribbean reported that hawksbills typically weigh around 176 pounds or less; hatchlings average about 1.6 inches straight length and range in weight from 0.5 to 0.7 ounces. The carapace is heart shaped in young turtles, and becomes more elongated or egg-shaped with maturity. The top scutes are often richly patterned with irregularly radiating streaks of brown or black on an amber background. The head is elongated and tapers sharply to a point. The lower jaw is V-shaped (NMFS 2009d).

Within the continental U.S., hawksbill sea turtle nesting is rare and is restricted to the southeastern coast of Florida (Volusia through Miami-Dade Counties) and the Florida Keys (Monroe County) (Meylan 1992, Meylan *et al.* 1995). However, hawksbill tracks are difficult to differentiate from those of loggerheads and may not be recognized by surveyors. Therefore, surveys in Florida likely underestimate actual hawksbill nesting numbers (Meylan *et al.* 1995). In the U.S. Caribbean, hawksbill nesting occurs on beaches throughout Puerto Rico and the U.S. Virgin Islands (NMFS and Service 1993).

Critical habitat for the hawksbill sea turtle has been designated for selected beaches and/or waters of Mona, Monito, Culebrita, and Culebra Islands, Puerto Rico.

Kemp's Ridley Sea Turtle

The Kemp's ridley sea turtle was federally listed as endangered on December 2, 1970 (35 FR 18320). The Kemp's ridley, along with the flatback sea turtle (*Natator depressus*), has the most geographically restricted distribution of any sea turtle species. The range of the Kemp's ridley includes the Gulf coasts of Mexico and the U.S., and the Atlantic coast of North America as far north as Nova Scotia and Newfoundland.

Adult Kemp's ridleys, considered the smallest sea turtle in the world, weigh an average of 100 pounds with a carapace measuring between 24-28 inches in length. The almost circular carapace has a grayish green color while the plastron is pale yellowish to cream in color. The carapace is often as wide as it is long. Their diet consists mainly of swimming crabs, but may also include fish, jellyfish, and an array of mollusks.

The majority of nesting for the entire species occurs on the primary nesting beach at Rancho Nuevo, Mexico (Marquez-Millan 1994). Outside of nesting, adult Kemp's ridleys are believed to spend most of their time in the Gulf of Mexico, while juveniles and subadults also regularly occur along the eastern seaboard of the U.S. (Service and NMFS 1992). There have been rare instances when immature ridleys have been documented making transatlantic movements (NMFS and Service 1992). It was originally speculated that ridleys that make it out of the Gulf of Mexico might be lost to the breeding population (Hendrickson 1980), but data indicate that many of these 25 turtles are capable of moving back into the Gulf of Mexico (Henwood and Ogren 1987). In fact, there are documented cases of ridleys captured in the Atlantic that migrated back to the nesting beach at Rancho Nuevo (Schmid and Witzell 1997, Schmid 1998, Witzell 1998).

Hatchlings, after leaving the nesting beach, are believed to become entrained in eddies within the Gulf of Mexico, where they are dispersed within the Gulf and Atlantic by oceanic surface currents until they reach about 7.9 inches in length, at which size they enter coastal shallow water habitats (Ogren 1989).

No critical habitat has been designated for the Kemp's ridley sea turtle.

Life History

Loggerhead Sea Turtle

Loggerheads are long-lived, slow-growing animals that use multiple habitats across entire ocean basins throughout their life history. This complex life history encompasses terrestrial, nearshore, and open ocean habitats. The three basic ecosystems in which loggerheads live are the:

1. Terrestrial zone (supralittoral) - the nesting beach where both oviposition (egg laying) and embryonic development and hatching occur.
2. Neritic zone - the inshore marine environment (from the surface to the sea floor) where water depths do not exceed 656 feet (200 meters). The neritic zone generally includes the

continental shelf, but in areas where the continental shelf is very narrow or nonexistent, the neritic zone conventionally extends to areas where water depths are less than 656 feet.

3. Oceanic zone - the vast open ocean environment (from the surface to the sea floor) where water depths are greater than 656 feet.

Maximum intrinsic growth rates of sea turtles are limited by the extremely long duration of the juvenile stage and fecundity. Loggerheads require high survival rates in the juvenile and adult stages, common constraints critical to maintaining long-lived, slow-growing species, to achieve positive or stable long-term population growth (Congdon *et al.* 1993, Heppell 1998, Crouse 1999, Heppell *et al.* 1999, 2003, Musick 1999).

Numbers of nests and nesting females are often highly variable from year to year due to a number of factors including environmental stochasticity, periodicity in ocean conditions, anthropogenic effects, and density-dependent and density-independent factors affecting survival, somatic growth, and reproduction (Meylan 1982, Hays 2000, Chaloupka 2001, Solow *et al.* 2002). Despite these sources of variation, and because female turtles exhibit strong nest site fidelity, a nesting beach survey can provide a valuable assessment of changes in the adult female population, provided that the study is sufficiently long and effort and methods are standardized (Meylan 1982, Gerrodette and Brandon 2000, Reina *et al.* 2002).

Loggerheads nest on ocean beaches and occasionally on estuarine shorelines with suitable sand. Nests are typically laid between the high tide line and the dune front (Routa 1968, Witherington 1986, Hailman and Elowson 1992). Wood and Bjorndal (2000) evaluated four environmental factors (slope, temperature, moisture, and salinity) and found that slope had the greatest influence on loggerhead nest-site selection on a beach in Florida. Loggerheads appear to prefer relatively narrow, steeply sloped, coarse-grained beaches, although nearshore contours may also play a role in nesting beach site selection (Mortimer 1982; Provancha and Ehrhart 1987).

The warmer the sand surrounding the egg chamber, the faster the embryos develop (Mrosovsky and Yntema 1980). Sand temperatures prevailing during the middle third of the incubation period also determine the sex of hatchling sea turtles (Mrosovsky and Yntema 1980). Incubation temperatures near the upper end of the tolerable range produce only female hatchlings while incubation temperatures near the lower end of the tolerable range produce only male hatchlings.

Loggerhead hatchlings pip and escape from their eggs over a one to three day interval and move upward and out of the nest over a two to four day interval (Christens 1990). The time from pipping to emergence ranges from four to seven days with an average of 4.1 days (Godfrey and Mrosovsky 1997). Hatchlings emerge from their nests en masse almost exclusively at night, and presumably using decreasing sand temperature as a cue (Hendrickson 1958, Mrosovsky 1968, Witherington *et al.* 1990). Moran *et al.* (1999) concluded that a lowering of sand temperatures below a critical threshold, which most typically occurs after nightfall, is the most probable trigger for hatchling emergence from a nest. After an initial emergence, there may be secondary emergences on subsequent nights (Carr and Ogren 1960, Witherington 1986, Ernest and Martin 1993, Houghton and Hays 2001).

Hatchlings use a progression of orientation cues to guide their movement from the nest to the marine environments where they spend their early years (Lohmann and Lohmann 2003). Hatchlings first use light cues to find the ocean. On naturally lighted beaches without artificial lighting, ambient light from the open sky creates a relatively bright horizon compared to the dark silhouette of the dune and vegetation landward of the nest. This contrast guides the hatchlings to the ocean (Daniel and Smith 1947, Limpus 1971, Salmon *et al.* 1992, Witherington and Martin 1996, Witherington 1997, Stewart and Wyneken 2004).

Loggerheads in the Northwest Atlantic display complex population structure based on life history stages. Based on mitochondrial deoxyribonucleic acid (mtDNA), oceanic juveniles show no structure, neritic juveniles show moderate structure and nesting colonies show strong structure (Bowen *et al.* 2005). In contrast, a survey using microsatellite (nuclear) markers showed no significant population structure among nesting populations (Bowen *et al.* 2005), indicating that while females exhibit strong philopatry, males may provide an avenue of gene flow between nesting colonies in this region.

Green Sea Turtle

Green sea turtles deposit from one to nine clutches within a nesting season, but the overall average is about 3.3 nests. The interval between nesting events within a season varies around a mean of about 13 days (Hirth 1997). Mean clutch size varies widely among populations. Average clutch size reported for Florida was 136 eggs in 130 clutches (Witherington and Ehrhart 1989). Only occasionally do females produce clutches in successive years. Usually two or more years intervene between breeding seasons (NMFS and Service 1991). Age at sexual maturity is believed to be 20 to 50 years (Hirth 1997).

Leatherback Sea Turtle

Leatherbacks nest an average of five to seven times within a nesting season, with an observed maximum of 11 nests (NMFS and Service 1992). The interval between nesting events within a season is about nine to 10 days. Clutch size averages 80 to 85 yolked eggs, with the addition of usually a few dozen smaller, yolkless eggs, mostly laid toward the end of the clutch (Pritchard 1992). Nesting migration intervals of two to three years were observed in leatherbacks nesting on the Sandy Point National Wildlife Refuge, St. Croix, U.S. Virgin Islands (McDonald and Dutton 1996). Leatherbacks are believed to reach sexual maturity in six to 10 years (Zug and Parham 1996).

Hawksbill Sea Turtle

Hawksbills nest on average about 4.5 times per season at intervals of approximately 14 days (Corliss *et al.* 1989). In Florida and the U.S. Caribbean, clutch size is approximately 140 eggs, although several records exist of over 200 eggs per nest (NMFS and Service 1993). On the basis of limited information, nesting migration intervals of two to three years appear to predominate. Hawksbills are recruited into the reef environment at about 14 inches in length and are believed to begin breeding about 30 years later. However, the time required to reach 14 inches in length is unknown and growth rates vary geographically. As a result, actual age at sexual maturity is unknown.

Kemp's Ridley Sea Turtle

Nesting occurs from April into July during which time the turtles appear off the Tamaulipas and Veracruz coasts of Mexico. Precipitated by strong winds, the females swarm to mass nesting emergences, known as "arribadas or arribazones," to nest during daylight hours. The period between Kemp's ridley arribadas averages approximately 25 days (Rostal *et al.* 1997), but the precise timing of the arribadas is highly variable and unpredictable (Bernardo and Plotkin 2007). Clutch size averages 100 eggs and eggs typically take 45 to 58 days to hatch depending on temperatures (Marquez-Millan 1994, Rostal 2007).

Some females breed annually and nest an average of one to four times in a season at intervals of 10 to 28 days. Analysis by Rostal (2007) suggested that ridley females lay approximately 3.1 nests per nesting season. Interannual remigration rate for female ridleys is estimated to be approximately 1.8 (Rostal 2007) to 2.0 years (Marquez-Millan *et al.* 1989). Age at sexual maturity is believed to be between 10 to 17 years (Snover *et al.* 2007).

Population Dynamics

Loggerhead Sea Turtle

The loggerhead occurs throughout the temperate and tropical regions of the Atlantic, Pacific, and Indian Oceans. However, the majority of loggerhead nesting is at the western rims of the Atlantic and Indian Oceans. The most recent reviews show that only two loggerhead nesting beaches have greater than 10,000 females nesting per year (Baldwin *et al.* 2003, Ehrhart *et al.* 2003, Kamezaki *et al.* 2003, Limpus and Limpus 2003, Margaritoulis *et al.* 2003): South Florida (U.S.) and Masirah (Oman). Those beaches with 1,000 to 9,999 females nesting each year are Georgia through North Carolina (U.S.), Quintana Roo and Yucatán (Mexico), Cape Verde Islands (Cape Verde, eastern Atlantic off Africa), and Western Australia (Australia). Smaller nesting aggregations with 100 to 999 nesting females annually occur in the Northern Gulf of Mexico (U.S.), Dry Tortugas (U.S.), Cay Sal Bank (Bahamas), Sergipe and Northern Bahia (Brazil), Southern Bahia to Rio de Janerio (Brazil), Tongaland (South Africa), Mozambique, Arabian Sea Coast (Oman), Halaniyat Islands (Oman), Cyprus, Peloponnesus (Greece), Island of Zakynthos (Greece), Turkey, Queensland (Australia), and Japan.

The loggerhead is commonly found throughout the North Atlantic including the Gulf of Mexico, the northern Caribbean, the Bahamas archipelago, and eastward to West Africa, the western Mediterranean, and the west coast of Europe.

The major nesting concentrations in the U.S. are found in South Florida. However, loggerheads nest from Texas to Virginia. Total estimated nesting in Florida, where 90 percent of nesting occurs, has fluctuated between 52,374 and 98,602 nests per year from 2009-2013 (FWC 2014, http://myfwc.com/media/2786250/loggerheadnestingdata09-13.pdf). About 80 percent of loggerhead nesting in the southeast U.S. occurs in six Florida counties (Brevard, Indian River, St. Lucie, Martin, Palm Beach, and Broward Counties). Adult loggerheads are known to make considerable migrations between foraging areas and nesting beaches (Schroeder *et al.* 2003, Foley *et al.* 2008). During non-nesting years, adult females from U.S. beaches are distributed in waters off the eastern U.S. and throughout the Gulf of Mexico, Bahamas, Greater Antilles, and Yucatán.

From a global perspective, the U.S. nesting aggregation is of paramount importance to the survival of the species as is the population that nests on islands in the Arabian Sea off Oman (Ross 1982, Ehrhart 1989). The status of the Oman loggerhead nesting population, reported to be the largest in the world (Ross 1979), is uncertain because of the lack of long-term standardized nesting or foraging ground surveys and its vulnerability to increasing development pressures near major nesting beaches and threats from fisheries interaction on foraging grounds and migration routes (Possardt 2005). The loggerhead nesting aggregations in Oman and the U.S. account for the majority of nesting worldwide.

Green Sea Turtle

The majority of nesting occurs along the Atlantic coast of eastern central Florida, with an average of 10,377 each year from 2008 to 2012 (B. Witherington, Florida Fish and Wildlife Conservation Commission, pers. comm., 2013). In the U.S. Pacific, over 90 percent of nesting throughout the Hawaiian archipelago occurs at the French Frigate Shoals, where about 200 to 700 females nest each year (NMFS and Service 1998b). Elsewhere in the U.S. Pacific, nesting takes place at scattered locations in the Commonwealth of the Northern Marianas, Guam, and American Samoa. In the western Pacific, the largest green turtle nesting aggregation in the world occurs on Raine Island, Australia, where thousands of females nest nightly in an average nesting season (Limpus *et al.* 1993). In the Indian Ocean, major nesting beaches occur in Oman where 30,000 females are reported to nest annually (Ross and Barwani 1995).

Leatherback Sea Turtle

A dramatic drop in nesting numbers has been recorded on major nesting beaches in the Pacific. Spotila *et al.* (2000) have highlighted the dramatic decline and possible extirpation of leatherbacks in the Pacific.

The East Pacific and Malaysia leatherback populations have collapsed. Spotila *et al.* (1996) estimated that only 34,500 females nested annually worldwide in 1995, which is a dramatic decline from the 115,000 estimated in 1980 (Pritchard 1992). In the eastern Pacific, the major nesting beaches occur in Costa Rica and Mexico. At Playa Grande, Costa Rica, considered the most important nesting beach in the eastern Pacific, numbers have dropped from 1,367 leatherbacks in 1988-1989 to an average of 188 females nesting between 2000-2001 and 2003-2004. In Pacific

Mexico, 1982 aerial surveys of adult female leatherbacks indicated this area had become the most important leatherback nesting beach in the world. Tens of thousands of nests were laid on the beaches in 1980s, but during the 2003-2004 seasons a total of 120 nests were recorded. In the western Pacific, the major nesting beaches lie in Papua New Guinea, Papua, Indonesia, and the Solomon Islands. These are some of the last remaining significant nesting assemblages in the Pacific. Compiled nesting data estimated approximately 5,000 to 9,200 nests annually with 75 percent of the nests being laid in Papua, Indonesia.

However, the most recent population size estimate for the North Atlantic alone is a range of 34,000 to 94,000 adult leatherbacks (TEWG 2007). In Florida, the number of nests has been increasing since 1979 (Stewart *et al.* 2011). The average annual number of nests in the 1980s was 63 nests, which rose to 263 nests in the 1990s and to 754 nests in the 2000s (Stewart *et al.* 2011). In 2012, 1,712 nests were recorded statewide (http://myfwc.com/research/wildlife/sea-turtles/nesting/).

Nesting in the Southern Caribbean occurs in the Guianas (Guyana, Suriname, and French Guiana), Trinidad, Dominica, and Venezuela. The largest nesting populations at present occur in the western Atlantic in French Guiana with nesting varying between a low of 5,029 nests in 1967 to a high of 63,294 nests in 2005, which represents a 92 percent increase since 1967 (TEWG 2007). Trinidad supports an estimated 6,000 leatherbacks nesting annually, which represents more than 80 percent of the nesting in the insular Caribbean Sea. Leatherback nesting along the Caribbean Central American coast takes place between Honduras and Colombia. In Atlantic Costa Rica, at Tortuguero, the number of nests laid annually between 1995 and 2006 was estimated to range from 199 to 1,623.

In Puerto Rico, the main nesting areas are at Fajardo on the main island of Puerto Rico and on the island of Culebra. Between 1978 and 2005, annual population growth rate was estimated to be 1.10 percent (TEWG 2007). Recorded leatherback nesting on the Sandy Point National Wildlife Refuge on the island of St. Croix, U.S. Virgin Islands between 1990 and 2005, ranged from a low of 143 in 1990 to a high of 1,008 in 2001 (Garner et al. 2005). In the British Virgin Islands, annual nest numbers have increased in Tortola from zero to six nests per year in the late 1980s to 35 to 65 nests per year in the 2000s (TEWG 2007).

The most important nesting beach for leatherbacks in the eastern Atlantic lies in Gabon, Africa. It was estimated there were 30,000 nests along 60 miles of Mayumba Beach in southern Gabon during the 1999-2000 nesting season (Billes et al. 2000). Some nesting has been reported in Mauritania, Senegal, the Bijagos Archipelago of Guinea-Bissau, Turtle Islands and Sherbro Island of Sierra Leone, Liberia, Togo, Benin, Nigeria, Cameroon, Sao Tome and Principe, continental Equatorial Guinea, Islands of Corisco in the Gulf of Guinea and the Democratic Republic of the Congo, and Angola. In addition, a large nesting population is found on the island of Bioko (Equatorial Guinea) (Fretey et al. 2007).

Hawksbill Sea Turtle

About 15,000 females are estimated to nest each year throughout the world with the Caribbean accounting for 20 to 30 percent of the world's hawksbill population. Only five regional populations remain with more than 1,000 females nesting annually (Seychelles, Mexico, Indonesia, and two in Australia) (Meylan and Donnelly 1999). Mexico is now the most important region for hawksbills in the Caribbean with about 3,000 nests per year (Meylan 1999). In the U.S. Pacific, hawksbills nest only on main island beaches in Hawaii, primarily along the east coast of the island of Hawaii. Hawksbill nesting has also been documented in American Samoa and Guam (NMFS and Service 1998c).

Kemp's Ridley Sea Turtle

Most Kemp's ridleys nest on the coastal beaches of the Mexican states of Tamaulipas and Veracruz, although a small number of Kemp's ridleys nest consistently along the Texas coast (TEWG 1998). In addition, rare nesting events have been reported in Alabama, Florida, Georgia, South Carolina, and North Carolina. Historical information indicates that tens of thousands of ridleys nested near Rancho Nuevo, Mexico, during the late 1940s (Hildebrand 1963). The Kemp's ridley population experienced a devastating decline between the late 1940s and the mid-1980s. The total number of nests per nesting season at Rancho Nuevo remained below 1,000 throughout the 1980s, but gradually began to increase in the 1990s. In 2009, 16,273 nests were documented along the 18.6 miles of coastline patrolled at Rancho Nuevo, and the total number of nests documented for all the monitored beaches in Mexico was 21,144 (Service 2009b). In 2010, a total of 13,302 nests were documented in Mexico (Service 2010). In addition, 207 and 153 nests were recorded during 2009 and 2010, respectively, in the U.S., primarily in Texas.

Status and Distribution

Loggerhead Sea turtle

Five recovery units have been identified in the Northwest Atlantic based on genetic differences and a combination of geographic distribution of nesting densities, geographic separation, and geopolitical boundaries (NMFS and Service 2008). Recovery units are subunits of a listed species that are geographically or otherwise identifiable and essential to the recovery of the species. Recovery units are individually necessary to conserve genetic robustness, demographic robustness, important life history stages, or some other feature necessary for long-term sustainability of the species. The five recovery units identified in the Northwest Atlantic are:

1. Northern Recovery Unit (NRU) - defined as loggerheads originating from nesting beaches from the Florida-Georgia border through southern Virginia (the northern extent of the nesting range);
2. Peninsula Florida Recovery Unit (PFRU) - defined as loggerheads originating from nesting beaches from the Florida-Georgia border through Pinellas County on the west coast of Florida, excluding the islands west of Key West, Florida;
3. Dry Tortugas Recovery Unit (DTRU) - defined as loggerheads originating from nesting beaches throughout the islands located west of Key West, Florida;

4. Northern Gulf of Mexico Recovery Unit (NGMRU) - defined as loggerheads originating from nesting beaches from Franklin County on the northwest Gulf coast of Florida through Texas; and
5. Greater Caribbean Recovery Unit (GCRU) - composed of loggerheads originating from all other nesting assemblages within the Greater Caribbean (Mexico through French Guiana, The Bahamas, Lesser Antilles, and Greater Antilles).

The mtDNA analyses show that there is limited exchange of females among these recovery units (Ehrhart 1989, Foote et al. 2000, NMFS 2001, Hawkes et al. 2005). Based on the number of haplotypes, the highest level of loggerhead mtDNA genetic diversity in the Northwest Atlantic has been observed in females of the GCRU that nest at Quintana Roo, Mexico (Encalada et al. 1999, Nielsen et al. 2012).

Nuclear DNA analyses show that there are no substantial subdivisions across the loggerhead nesting colonies in the southeastern U.S. Male-mediated gene flow appears to be keeping the subpopulations genetically similar on a nuclear DNA level (Francisco-Pearce 2001).

Historically, the literature has suggested that the northern U.S. nesting beaches (NRU and NGMRU) produce a relatively high percentage of males and the more southern nesting beaches (PFRU, DTRU, and GCRU) a relatively high percentage of females (e.g., Hanson *et al.* 1998, NMFS 2001, Mrosovsky and Provancha 1989). The NRU and NGMRU were believed to play an important role in providing males to mate with females from the more female-dominated subpopulations to the south. However, in 2002 and 2003, researchers studied loggerhead sex ratios for two of the U.S. nesting subpopulations, the northern and southern subpopulations (NGU and PFRU, respectively) (Blair 2005, Wyneken *et al.* 2005). The study produced interesting results. In 2002, the northern beaches produced more females and the southern beaches produced more males than previously believed. However, the opposite was true in 2003 with the northern beaches producing more males and the southern beaches producing more females in keeping with prior literature. Wyneken *et al.* (2005) speculated that the 2002 result may have been anomalous; however, the study did point out the potential for males to be produced on the southern beaches. Although this study revealed that more males may be produced on southern recovery unit beaches than previously believed, the Service maintains that the NRU and NGMRU play an important role in the production of males to mate with females from the more southern recovery units.

The NRU is the second largest loggerhead nesting aggregation in the Northwest Atlantic. Annual nest totals from northern beaches averaged 5,215 nests from 1989-2008, a period of near-complete surveys of NRU nesting beaches (NMFS and Service 2008), representing approximately 1,272 nesting females per year (4.1 nests per female, Murphy and Hopkins 1984). The loggerhead nesting trend from daily beach surveys showed a significant decline of 1.3 percent annually. Nest totals from aerial surveys conducted by the South Carolina Department of Natural Resources showed a 1.9 percent annual decline in nesting in South Carolina since 1980. Overall, there is strong statistical data to suggest the NRU has experienced a long-term decline (NMFS and Service 2008).

The PFRU is the largest loggerhead nesting assemblage in the Northwest Atlantic. A near complete nest census of the PFRU undertaken from 1989 to 2007 reveals a mean of 64,513 loggerhead nests per year representing approximately 15,735 females nesting per year (4.1 nests per female, Murphy and Hopkins 1984) (FWC 2008d). This near-complete census provides the best statewide estimate of total abundance, but because of variable survey effort, these numbers cannot be used to assess trends. Loggerhead nesting trends are best assessed using standardized nest counts made at INBS sites surveyed with constant effort over time. In 1979, the Statewide Nesting Beach Survey (SNBS) program was initiated to document the total distribution, seasonality, and abundance of sea turtle nesting in Florida. In 1989, the INBS program was initiated in Florida to measure seasonal productivity, allowing comparisons between beaches and between years (FWC 2009b). Of the 190 SNBS surveyed areas, 33 participate in the INBS program (representing 30 percent of the SNBS beach length).

INBS nest counts from 1989–2010 show a shallow decline. However, recent trends (1998–2010) in nest counts have shown a 25 percent decline, with increases only observed in the most recent 6-year period, 2008–2013 although there was no trend observed (FWC/FWRI 2014). The analysis that reveals this decline uses nest-count data from 345 representative Atlantic-coast index zones (total length = 187 miles) and 23 representative zones on Florida's southern Gulf coast (total length = 14.3 miles). The spatial and temporal coverage (annually, 109 days and 368 zones) accounted for an average of 70 percent of statewide loggerhead nesting activity between 1989 and 2010.

The NGMRU is the third largest nesting assemblage among the four U.S. recovery units. Nesting surveys conducted on approximately 186 miles of beach within the NGMRU (Alabama and Florida only) were undertaken between 1995 and 2007 (statewide surveys in Alabama began in 2002). The mean nest count during this 13-year period was 906 nests per year, which equates to about 221 females nesting per year (4.1 nests per female, Murphy and Hopkins 1984; FWC 2008d). Evaluation of long-term nesting trends for the NGMRU is difficult because of changed and expanded beach coverage. Loggerhead nesting trends are best assessed using standardized nest counts made at INBS sites surveyed with constant effort over time. There are 12 years (1997- 2008) of Florida INBS data for the NGMRU (FWC 2008d). A log-linear regression showed a significant declining trend of 4.7 percent annually (NMFS and Service 2008).

The DTRU, located west of the Florida Keys, is the smallest of the identified recovery units. A near-complete nest census of the DTRU undertaken from 1995 to 2004, excluding 2002, (nine years surveyed) reveals a mean of 246 nests per year, which equates to about 60 females nesting per year (4.1 nests per female, Murphy and Hopkins 1984) (FWC 2008d). Surveys after 2004 did not include principal nesting beaches within the recovery unit (i.e., Dry Tortugas National Park). The nesting trend data for the DTRU are from beaches that are not part of the INBS program, but are part of the SNBS program. There are nine years of data for this recovery unit. A simple linear regression accounting for temporal autocorrelation revealed no trend in nesting numbers. Because of the annual variability in nest totals, a longer time series is needed to detect a trend (NMFS and Service 2008).

The GCRU is composed of all other nesting assemblages of loggerheads within the Greater Caribbean. Statistically valid analyses of long-term nesting trends for the entire GCRU are not available because there are few long-term standardized nesting surveys representative of the region. Additionally, changing survey effort at monitored beaches and scattered and low-level nesting by loggerheads at many locations currently precludes comprehensive analyses. The most complete data are from Quintana Roo and Yucatán, Mexico, where an increasing trend was reported over a 15-year period from 1987-2001 (Zurita *et al.* 2003). However, since 2001, nesting has declined and the previously reported increasing trend appears not to have been sustained (NMFS and Service 2008). Other smaller nesting populations have experienced declines over the past few decades (e.g., Amorocho 2003).

Recovery Criteria (only the Demographic Recovery Criteria are presented below; for the Listing Factor Recovery Criteria, please see NMFS and Service 2008)

1. Number of Nests and Number of Nesting Females

    a. Northern Recovery Unit

        i. There is statistical confidence (95 percent) that the annual rate of increase over a generation time of 50 years is 2 percent or greater resulting in a total annual number of nests of 14,000 or greater for this recovery unit (approximate distribution of nests is North Carolina =14 percent [2,000 nests], South Carolina =66 percent [9,200 nests], and Georgia =20 percent [2,800 nests]); and 37

        ii. This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).

    b. Peninsular Florida Recovery Unit

        i. There is statistical confidence (95 percent) that the annual rate of increase over a generation time of 50 years is statistically detectable (one percent) resulting in a total annual number of nests of 106,100 or greater for this recovery unit; and

        ii. This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).

    c. Dry Tortugas Recovery Unit

        i. There is statistical confidence (95 percent) that the annual rate of increase over a generation time of 50 years is three percent or greater resulting in a total annual number of nests of 1,100 or greater for this recovery unit; and

ii. This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).

d. Northern Gulf of Mexico Recovery Unit

i. There is statistical confidence (95 percent) that the annual rate of increase over a generation time of 50 years is three percent or greater resulting in a total annual number of nests of 4,000 or greater for this recovery unit (approximate distribution of nests (2002-2007) is Florida= 92 percent [3,700 nests] and Alabama =8 percent [300 nests]); and

ii. This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).

e. Greater Caribbean Recovery Unit

i. The total annual number of nests at a minimum of three nesting assemblages, averaging greater than 100 nests annually (e.g., Yucatán, Mexico; Cay Sal Bank, Bahamas) has increased over a generation time of 50 years; and

ii. This increase in number of nests must be a result of corresponding increases in number of nesting females (estimated from nests, clutch frequency, and remigration interval).

2. Trends in Abundance on Foraging Grounds A network of in-water sites, both oceanic and neritic, across the foraging range is established and monitoring is implemented to measure abundance. There is statistical confidence (95 percent) that a composite estimate of relative abundance from these sites is increasing for at least one generation.

3. Trends in Neritic Strandings Relative to In-water Abundance Stranding trends are not increasing at a rate greater than the trends in in-water relative abundance for similar age classes for at least one generation.

The Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle was signed in 2008 (NMFS and Service 2008), and the Recovery Plan for U.S. Pacific Populations of the Loggerhead Turtle was signed in 1998 (NMFS and Service 1998e).

Green Sea Turtle

Annual nest totals documented as part of the Florida SNBS program from 1989-2008 have ranged from 435 nests laid in 1993 to 12,752 in 2007. The nest count for 2013 was more than twice the count from 2007 with a total of 36,195 nests recorded (http://myfwc.com/research/wildlife/seaturtles/nesting/statewide/). Nesting occurs in 26 counties with a peak along the east coast, from Volusia through Broward Counties. Although the SNBS program provides information on distribution and total abundance statewide, it cannot be used to assess trends because of variable survey effort. Therefore, green turtle nesting trends are best assessed using standardized nest counts made at INBS sites surveyed with constant effort over time (1989-2009). Green sea turtle nesting in Florida is increasing based on 19 years (1989-2009) of INBS data from throughout the state (FWC 2009a). The increase in nesting in Florida is likely a result of several factors, including: (1) a Florida statute enacted in the early 1970s that prohibited the killing of green turtles in Florida; (2) the species listing under the Act afforded complete protection to eggs, juveniles, and adults in all U.S. waters; (3) the passage of Florida's constitutional net ban amendment in 1994 and its subsequent enactment, making it illegal to use any gillnets or other entangling nets in State waters; (4) the likelihood that the majority of Florida green turtles reside within Florida waters where they are fully protected; (5) the protections afforded Florida green turtles while they inhabit the waters of other nations that have enacted strong sea turtle conservation measures (e.g., Bermuda); and (6) the listing of the species on Appendix I of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which stopped international trade and reduced incentives for illegal trade from the U.S.

Recovery Criteria

The U.S. Atlantic population of green sea turtles can be considered for delisting if, over a period of 25 years, the following conditions are met:

1. The level of nesting in Florida has increased to an average of 5,000 nests per year for at least six years. Nesting data must be based on standardized surveys;

2. At least 25 percent (65 miles) of all available nesting beaches (260 miles) is in public ownership and encompasses at least 50 percent of the nesting activity;

3. A reduction in stage class mortality is reflected in higher counts of individuals on foraging grounds;

4. All priority one tasks identified in the recovery plan have been successfully implemented.

The Recovery Plan for U.S. Population of Atlantic Green Turtle was signed in 1991 (NMFS and Service 1991), the Recovery Plan for U.S. Pacific Populations of the Green Turtle was signed in 1998 (NMFS and Service 1998b), and the Recovery Plan for U.S. Pacific Populations of the East Pacific Green Turtle was signed in 1998 (NMFS and Service 1998a).

<u>Leatherback Sea Turtle</u>

Declines in leatherback nesting have occurred over the last two decades along the Pacific coasts of Mexico and Costa Rica. The Mexican leatherback nesting population, once considered to be the world's largest leatherback nesting population (historically estimated to be 65 percent of the worldwide population), is now less than one percent of its estimated size in 1980. (Spotila *et al.* 1996) estimated the number of leatherback sea turtles nesting on 28 beaches throughout the world from the literature and from communications with investigators studying those beaches. The estimated worldwide population of leatherbacks in 1995 was about 34,500 females on these beaches with a lower limit of about 26,200, and an upper limit of about 42,900. This is less than one-third the 1980 estimate of 115,000. Leatherbacks are rare in the Indian Ocean and in very low numbers in the western Pacific Ocean. The largest population is in the western Atlantic. Using an age-based demographic model, (Spotila *et al.* 1996) determined that leatherback populations in the Indian Ocean and western Pacific Ocean cannot withstand even moderate levels of adult mortality and that the Atlantic populations are being exploited at a rate that cannot be sustained. They concluded that leatherbacks are on the road to extinction and further population declines can be expected unless action is taken to reduce adult mortality and increase survival of eggs and hatchlings.

In the U.S., nesting populations occur in Florida, Puerto Rico, and the U.S. Virgin Islands. In Florida, the SNBS program documented an increase in leatherback nesting numbers from 98 nests in 1988 to between 800 and 900 nests per season in the early 2000s (FWC 2009a, Stewart and Johnson 2006). Although the SNBS program provides information on distribution and total abundance statewide, it cannot be used to assess trends because of variable survey effort. Therefore, leatherback nesting trends are best assessed using standardized nest counts made at INBS sites surveyed with constant effort over time (1989-2009). An analysis of the INBS data has shown a substantial increase in leatherback nesting in Florida since 1989 (FWC 2009b, TEWG Group 2007).

Recovery Criteria

The U.S. Atlantic population of leatherbacks can be considered for delisting if the following conditions are met:

1. The adult female population increases over the next 25 years, as evidenced by a statistically significant trend in the number of nests at Culebra, Puerto Rico, St. Croix, U.S. Virgin Islands, and along the east coast of Florida;
2. Nesting habitat encompassing at least 75 percent of nesting activity in U.S. Virgin Islands, Puerto Rico, and Florida is in public ownership; and
3. All priority one tasks identified in the recovery plan have been successfully implemented. The Recovery Plan for Leatherback Turtles in the U.S. Caribbean, Atlantic, and Gulf of Mexico was signed in 1992 (NMFS and Service 1992), and the Recovery Plan for U.S. Pacific Populations of the Leatherback Turtle was signed in 1998 (NMFS and Service 1998d).

Hawksbill Sea Turtle

The hawksbill sea turtle has experienced global population declines of 80 percent or more during the past century and continued declines are projected (Meylan and Donnelly 1999). Most populations are declining, depleted, or remnants of larger aggregations. Hawksbills were previously abundant, as evidenced by high-density nesting at a few remaining sites and by trade statistics.

Recovery Criteria

The U.S. Atlantic population of hawksbills can be considered for delisting if, over a period of 25 years, the following conditions are met:

1. The adult female population is increasing, as evidenced by a statistically significant trend in the annual number of nests on at least five index beaches, including Mona Island and Buck Island Reef National Monument;
2. Habitat for at least 50 percent of the nesting activity that occurs in the U.S. Virgin Islands and Puerto Rico is protected in perpetuity;
3. Numbers of adults, subadults, and juveniles are increasing, as evidenced by a statistically significant trend on at least five key foraging areas within Puerto Rico, U.S. Virgin Islands, and Florida; and
4. All priority one tasks identified in the recovery plan have been successfully implemented.

The Recovery Plan for the Hawksbill Turtle in the U.S. Caribbean, Atlantic, and Gulf of Mexico was signed in 1993 (NMFS and Service 1993), and the Recovery Plan for U.S. Pacific Populations of the Hawksbill Turtle was signed in 1998 (NMFS and Service 1998c).

<u>Kemp's Ridley Sea Turtle</u>

Today, under strict protection, the population appears to be in the early stages of recovery. The recent nesting increase can be attributed to full protection of nesting females and their nests in Mexico resulting from a binational effort between Mexico and the U.S. to prevent the extinction of the Kemp's ridley, and the requirement to use Turtle Excluder Devices (TEDs) in shrimp trawls both in the U.S. and Mexico.

The Mexico government also prohibits harvesting and is working to increase the population through more intensive law enforcement, by fencing nest areas to diminish natural predation, and by relocating most nests into corrals to prevent poaching and predation. While relocation of nests into corrals is currently a necessary management measure, this relocation and concentration of eggs into a "safe" area is of concern since it can reduce egg viability.

Recovery Criteria

The goal of the recovery plan is for the species to be reduced from endangered to threatened status. The Recovery Team members feel that the criteria for a complete removal of this species from the endangered species list need not be considered now, but rather left for future revisions of the plan. Complete removal from the federal list would certainly necessitate that some other instrument of protection, similar to the MMPA, be in place and be international in scope. Kemp's ridley can be considered for reclassification to threatened status when the following four criteria are met:

1. Continuation of complete and active protection of the known nesting habitat and the waters adjacent to the nesting beach (concentrating on the Rancho Nuevo area) and continuation of the bi-national protection project;
2. Elimination of mortality from incidental catch in commercial shrimping in the U.S. and Mexico through the use of TEDs and achievement of full compliance with the regulations requiring TED use;
3. Attainment of a population of at least 10,000 females nesting in a season; and
4. Successful implementation of all priority one recovery tasks in the recovery plan.

The Recovery Plan for the Kemp's Ridley Sea Turtle was signed in 1992 (Service and NMFS 1992). Significant new information on the biology and population status of Kemp's ridley has become available since 1992. Consequently, a full revision of the recovery plan has been completed by the Service and NMFS. The Bi-National Recovery Plan for the Kemp's Ridley Sea 42 turtle (2011) provides updated species biology and population status information, objective and measurable recovery criteria, and updated and prioritized recovery actions.

<u>Common threats to sea turtles in Florida</u>

Anthropogenic factors that impact hatchlings and adult female turtles on land, or the success of nesting and hatching include: beach erosion; armoring and nourishment; artificial lighting; beach cleaning; increased human presence; recreational beach equipment; beach driving; coastal construction and fishing piers; exotic dune and beach vegetation; and poaching. An increased human presence at some nesting beaches or close to nesting beaches has led to secondary threats such as the introduction of exotic fire ants (*Solenopsis* spp.), feral hogs (*Sus scrofa*), dogs (*Canis familiaris*), and an increased presence of native species (e.g., raccoons (*Procyon lotor*), armadillos (*Dasypus novemcinctus*), and opossums (*Didelphis virginiana*), which raid nests and feed on turtle eggs. Although sea turtle nesting beaches are protected along large expanses of the western North Atlantic coast, other areas along these coasts have limited or no protection.

Anthropogenic threats in the marine environment include oil and gas exploration and transportation; marine pollution; underwater explosions; hopper dredging; offshore artificial lighting; power plant entrainment or impingement; entanglement in debris; ingestion of marine debris; marina and dock construction and operation; boat collisions; and poaching and fishery interactions. On April 20, 2010, an explosion and fire on the Mobile Offshore Drilling Unit Deepwater Horizon MC252 occurred approximately 50 miles southeast of the Mississippi Delta. A broken well head at the sea floor resulted in a sustained release of oil, estimated at 35,000 and 60,000 barrels per day. On July 15, the valves on the cap were closed, which effectively shut in the well and all sub-sea containment systems. Damage assessment from the sustained release of oil is ongoing and the Service does not have a basis at the present time to predict the complete scope of effects to sea turtles range-wide.

Fibropapillomatosis, a disease of sea turtles characterized by the development of multiple tumors on the skin and internal organs, is also a mortality factor, particularly for green turtles. This disease has seriously impacted green turtle populations in Florida, Hawaii, and other parts of the world. The tumors interfere with swimming, eating, breathing, vision, and reproduction, and turtles with heavy tumor burdens may die.

Artificial lighting

Experimental field work by Witherington (1992a) directly implicated artificial lighting in deterring sea turtles from nesting. In these experiments, both green and loggerhead turtles showed a significant tendency to avoid stretches of beach with artificial lights that have predominantly blue and green wavelengths. Because adult females rely on visual brightness cues to find their way back to the ocean after nesting, those turtles that nest on lighted beaches may be disoriented by artificial lights and have difficulty finding their way back to the ocean. In the lighted-beach experiments described by Witherington (1992a), few nesting turtles returning to the sea were misdirected by lighting; however, those that were, spent a large portion of the night wandering in search of the ocean. In some cases, nesting females have ended up on coastal highways and been struck by vehicles. However, turtles returning to the sea after nesting are not misdirected nearly as often as hatchlings emerging on the same beaches (Witherington and Martin 1996).

Under natural conditions, hatchling sea turtles, which typically emerge from nests at night, move toward the brightest, most open horizon, which is over the ocean. However, when bright light sources are visible on the beach, they become the brightest spot on the horizon and attract hatchlings in the wrong direction, making them more vulnerable to predators, desiccation, entrapment in debris or vegetation, and exhaustion, and often luring them onto roadways and parking lots where they are run over. Artificial lights can also disorient hatchlings once they reach the water. Hatchlings have been observed to exit the surf onto land where lighting is nearby (Daniel and Smith 1947, Carr and Ogren 1960, Witherington 1986). Artificial beachfront lighting from buildings and streetlights is a well-documented cause of hatchling disorientation (loss of bearings) and misorientation (incorrect orientation) on nesting beaches (McFarlane 1963, Philibosian 1976, Mann 1978, Florida Fish and Wildlife Conservation Commission unpubl. data).

Extensive research has demonstrated that visual cues are the primary sea finding mechanism for hatchlings (Carr and Ogren 1960, Ehrenfeld and Carr 1967, Mrosovsky and Carr 1967, Mrosovsky and Shettleworth 1968, Dickerson and Nelson 1989, Witherington and Bjorndal 1991). Loggerhead, green and hawksbill hatchlings demonstrate a strong preference for short-wavelength light (Witherington and Bjorndal 1991, Witherington 1992b). Green and hawksbill turtles were most strongly attracted to light in the near-ultraviolet to yellow region of the spectrum and were weakly attracted or indifferent to orange and red light. Loggerheads were most strongly attracted to light in the near-ultraviolet to green region and showed differing responses to light in the yellow region of the spectrum depending on light intensities. At intensities of yellow light comparable to a full moon or a dawn sky, loggerhead hatchlings showed an aversion response to yellow light sources, but at low, nighttime intensities, loggerheads were weakly attracted to yellow light.

ENVIRONMENTAL BASELINE

The "Environmental Baseline" section summarizes information on status and trends of nesting sea turtle specifically within the action area. These summaries provide the foundation for our assessment of the effects of the proposed action, as presented in the "Effects of the Action" section.

Status of the Species in the Action Area and vicinity

KSC is located at the northern end of the highest concentration of loggerhead sea turtle nesting in the Western Hemisphere. The following paragraphs discuss the nesting season and status from the four species of federally protected sea turtles have been documented as nesting on the beaches of KSC and MINWR or in the vicinity: the loggerhead, green, leatherback, and hawksbill sea turtle.

Loggerhead Sea Turtle

Nesting season for loggerhead sea turtle for southern Florida Atlantic beaches begins in extends from March 15 through November 30. Incubation ranges from about 45 to 95 days. Between 655 and 1,586 loggerhead nests were deposited annually on KSC/MINWR from 2000 through 2016.

Green Sea Turtle

The green sea turtle nesting and hatching season for southern Florida Atlantic beaches extends from May 1 through November 30. Incubation ranges from about 45 to 75 days. Between 2 and 103 green turtle nests were deposited annually on KSC/MINWR from 2000 through 2016.

Leatherback Sea Turtle

The leatherback sea turtle nesting and hatching season for Southern Florida Atlantic beaches extends from February 15 through November 15. Incubation ranges from about 55 to 85 days. Between 0 and 1 leatherback turtle nests were deposited annually on KSC/MINWR from 2000 through 2016.

Hawksbill Sea Turtle

The hawksbill sea turtle nesting and hatching season for Southern Florida Atlantic beaches extends from June 1 through December 31. Incubation lasts approximately 60 days.
Hawksbill sea turtle nesting is rare and restricted to the southeastern coast of Florida (Volusia through Dade Counties) and the Florida Keys (Monroe County) (Meylan 1992, Meylan *et al.* 1995). However, hawksbill tracks are difficult to differentiate from those of loggerheads and may not be recognized by surveyors. Therefore, surveys in Florida likely underestimate actual hawksbill nesting numbers (Meylan *et al.* 1995). Although no hawksbill nests have ever been recorded in

Brevard County, one was reported at the Canaveral National Seashore in Volusia County in 1982 (Meylan *et al.* 1995). Therefore, the potential exists for such an occurrence at KSC/MINWR.

History of Disorientation/Misorientation in the Action Area and vicinity

The first observations of hatchling disorientations were recorded on KSC/MINWR beach in 1989. In 1990, sea turtle disorientation events began to be routinely observed and 36 disorientation events were recorded that year. Seven out of the 36 appeared to be caused by LC 39A and 39B. In 1991, 12 of the 42 nests most likely disoriented because of LC 39A and 39B facility lighting. In 1992, seven of the 46 disorientation events appeared to be caused by LC 39A and 39B. Since then, hatchling disorientation and misorientation incidents are routinely documented on the KSC/MINWR beach. Disorientation and misorientation reports may be underreported because the tracks of hatchlings are easily obscured by rain or windblown sand. The number of hatchling disorientation/misorientation incidents may be higher than what was actually observed and reported. To assess the success of light management activities, KCS has used a standard monitoring and reporting protocol for disorientations/misorientations to estimate the percentage of all nests laid that produce hatchlings compared to those that are misdirected on an annual basis.

Most disorientations recorded are attributed to lighting from the Space Shuttle LCs. In 1999, three hurricanes caused erosion of approximately 600 meters of dune front. Following the damage from these hurricanes, the dune profile was lower and absent of vegetation, and the effect of the lighting from the Space Shuttle LCs in 2000 substantially increased the number of hatchling disorientation events. NASA in collaboration with MINWR continues to restore and re-vegetate the dune.

During the summer of 2010, an inland dune (locally referred to as the Pilot Dune) was constructed at a highly degraded site behind the primary dune between LC-39A and LC-39B, east of Phillips Parkway. The new dune is 221 m (725 ft) long, 24 m (80 ft) wide, and 4.6 m (15 ft) tall. The purpose of that dune was to minimize light trespass from the LC-39 complex and thus improving conditions for sea turtle nesting. The stretch of primary dune adjacent to this area was severely compromised by activities associated with railroad operations, and during the last several years by wash overs and inundation from storm surges. Vegetation planting on the constructed dune occurred in April 2011 to improve sea turtle habitat. Post construction sampling showed successful vegetative establishment and colonization by beach mice and tortoises (Bolt et al. 2012). The dune does provide visual screening of some KSC infrastructure for at least this small stretch of beach, a section that continues to experience serious erosion of the beach face which has moved westerly over 30 m in the last decade.

NASA completed an Environmental Assessment for a KSC shoreline protection program (NASA 2015) in 2013 to ensure protection of high value launch infrastructure threatened by persistent and worsening beach erosion between launch complexes 39A and 39B (Figure 1). The preferred alternative selected involved the construction of a large secondary dune behind the existing primary dune in areas most vulnerable to erosion and flooding. These areas are located along the northern

5.8 km (3.6 mi) of the KSC shoreline roughly between beach kilometer stations 27 and 33 (Figure 1). Hurricane Sandy recovery funds enabled the restoration of the most severely damaged section of KSC beach along approximately 1.75 km of degraded primary and secondary dune between kilometer stations 29 and 31 (Figure 1). Native, salt-tolerant dune vegetation was planted along the dune crest and side slopes to stabilize the constructed dune and facilitate habitat restoration and provide a barrier from light trespass from the LC-39 Area.

In 2009, the Service issued an Interim BO for the lighting operations for the proposed Light Constellation Plan. To further minimize incidental take associated with lighting from the proposed operations, the Service listed a number of Terms and Conditions within the Interim BO. The Service acknowledged that some adverse impacts would occur to some number of sea turtles and would continue due to KSC light sources that are necessary for conducting nighttime launch operations, human safety and national security and issued an incidental take statement to KSC, which was not to exceed 3% for hatchlings and 3% for nesting females on the KSC beach.

Since the BO has been in effect, the level of incidental take at KSC has ranged from 2% to 5%. In 2013, a study conducted by contractors reviewed the status of the Terms and Conditions KSC BO and provided an assessment of the issues related to lighting use at KSC. In addition, the report updated the KSC Lighting Guidance, and provided a template for the specific Light Operations Manual (LOM).

KSC reinitated the 2009 BO based on new planning efforts and developed a suite of conservation measures to address the future facilities and the recent increase in disorientation rates. According to the 2016 Sea Turtle Hatchling Disorientation Report that we received on January 25, 2017, the hatchling disorientation rate at KSC was recorded at 0%. Of the five disorientations, all occurred from a light source at Cape Canaveral Air Force Station's Pad 41 Area.

Factors Affecting Species' Environment within the Action Area

This analysis describes factors affecting the environment for in the action area. There are no State, tribal, local or private actions affecting the species or that will occur contemporaneously with this consultation. Federal actions have taken place within the action areas that have impacted sea turtles. These projects sometimes resulted in incidental take anticipated through section 7 of the Act. The impacts associated with some of these projects resulted in the loss of occupied habitat or habitat suitable for occupation within the action area.

EFFECTS OF THE ACTION

Effects of the action refer to the direct and indirect effects of an action on the species or proposed critical habitat that would be added to the environmental baseline, along with the effects of other activities that are interrelated or interdependent with that action. 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. Indirect effects are those that are caused by the proposed action and are later in time, but are still reasonably certain to occur. Indirect effects can be both spatial and temporal in nature. In contrast to direct effects, indirect effects can often be more subtle, and may affect species and habitat quality over an extended period, long after project activities have been completed. Indirect effects are of particular concern for long-lived species such as sea turtles, because project-related effects may not become evident in individuals or populations until years later.

In the "Environmental Baseline" section above, we discussed the numbers of turtles that are likely to nest within the action area based on previous nesting data collected at KSC and the adjacent MINWR. We also discussed the percentage of hatchling and adults disorientation reports that have been recorded from 1992. Because these sources constitute the best available information, we have used the estimates to derive the percentage of likely misorientation and disorientation reports for the following analyses. We acknowledge, however, that not all individuals disorient or that misorientation during future spaceport construction activities or during operations and maintenance will be detected by surveys and reported. The inability to detect all killed or injured individuals is largely due to sea turtles spending much of their lives in the ocean, with females coming ashore each year to nest. Another confounding factor is that scavengers may locate carcasses before monitors and either remove them from the site or dismember them to the extent that the cause of death cannot be determined.

As discussed in the status of the species section under common threats, research has shown that females will avoid highly illuminated beaches and postpone nesting. Artificial lights have also resulted in hatchling mortality as disoriented hatchlings move toward these light sources rather than the ocean. Exterior lighting by the proposed action has the potential to directly and indirectly affect nesting sea turtles and hatchlings. Extensive research has demonstrated that the principal component of the sea-finding behavior of emergent hatchlings is a visual cue (Carr and Ogren 1960, Dickerson and Nelson 1989, Witherington and Bjorndal 1991). Artificial lighting can be detrimental to sea turtles in several ways; either through misorientation, when hatchings emerge from a nest they are directed to an artificial light source away from the sea, or disorientation, a loss of bearings of hatchling or adult sea turtles (Witherington and Martin 1996). Field observations have also shown a correlation between lighted beaches and reduced loggerhead and green sea turtle nesting (Mortimer 1982, Raymond 1984, Mattison *et al.* 1993).

Since 1995, KSC has taken an aggressive approach to minimize the impacts on sea turtles caused by exterior lighting by implementing guidance for lighting installation. In 2001, managers at KSC initiated a "Turtle mode" lighting plan that consisted of turning off the majority of lights at each Pad unless there were specific operational requirements. However, security lighting was increased around the Shuttle launch pads. The increased lighting accounted for a hatchling disorientation increase from 3-6% to 10%. Light sources that were major causes of disorientations and/or misorientations were identified.

The Space Shuttle LC 39A and 39B, and CCAFS's LC 37, 40, and 41 continue to be the main cause of disorientations and/or misorientations at KSC. Implementation of the "Turtle mode" lighting plan minimized the number of sea turtle disorientations and decreased the rate to 3%. In 2016, KSC revised the ELR guidelines to reflect the most recent FWC lighting guidelines. In addition to address the potential of direct and indirect lighting effects at future facilities, LOMs shall be required for new, large construction projects within the KSC. LOMs will be coordinated with the Service in order to ensure that lighting issues for that particular site are addressed from design to post construction (CM1).

For the Master Plan, KSC has offered a suite of measures to address future and existing light pollution at the facilities to minimize direct and indirect take of the species. The EMB has developed a NEPA checklist process for all new small scale lighting projects to ensure compliance (CM1). KSC is transitioning to amber LED lamps which are energy efficient and more turtle friendly when feasible and to streamline retrofitting, KSC is stocking true amber LED lamps to replace street, parking, and general safety area lighting as they become non-functional (CM 5).

Research shows that various types of lights affect sea turtles to varying degrees and there is uncertainty over how to measure the acceptable amount of light pollution for nesting sea turtles. Therefore, it is most productive to minimize light pollution and use the best available technology. To reduce the impacts to nesting and emerging sea turtles, light sources near the beach that are necessary for human safety for operations of the facility should be retrofitted (Witherington *et al.* 2014). KSC has performed annual routine night time lighting surveys throughout the sea turtle nesting season since 2010 (CM 3) and a priority list of lighting issues shall be outlined in the annual Activity report to guide retrofitting activities (CM 4,5).

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 BO. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Act. The Service is not aware of any cumulative effects in the project area.

CONCLUSION

After reviewing the current status of the loggerhead, green, leatherback, hawksbill and Kemp's ridley sea turtles, the environmental baseline for the action area, the effects of the proposed plan, and the cumulative effects, it is the Service's biological opinion that the project, as proposed, is not likely to jeopardize the continued existence of these species and is not likely to destroy or adversely modify designated critical habitat.

It is our opinion that considering NASA has implemented since the issuance of the 2009 Biological Opinion and will be implementing to minimize direct lighting of the nesting beaches and background lighting glow at KSC, the proposed update for the Master Plan is not likely to jeopardize the continued existence of listed sea turtles. We do, however, believe that adverse impacts to sea turtles will continue from lighting sources essential for human safety and national security at KSC. We believe the reasonable and prudent measures provided with the incidental take statement below will effectively reduce the take of sea turtles.

INCIDENTAL TAKE STATEMENT

Section 9 of the Act and Federal regulation pursuant to section 4(d) of the Act prohibit the take of endangered or threatened 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. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, carrying out an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited under the Act provided that such taking is in compliance with the terms and conditions of this incidental take statement.

The measures described below are non-discretionary, and must be implemented by NASA so that they become binding conditions of any grant or permit issued to the applicant, as appropriate, for the exemption in section 7(o)(2) to apply. NASA has a continuing duty to regulate the activity covered by this incidental take statement. If NASA (1) fails to implement the conservation measures or fails to require the applicants to adhere to KSC's conservation measures in the project description (2) fails to assume and implement reasonable and prudent measures and associated terms and conditions or (3) fails to require the applicant to adhere to the reasonable and prudent measures and associated 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. In order to monitor the impact of incidental take, NASA must report the progress of the action and its impacts on the species to the Service as specified in the incidental take statement. [50 CFR §402.14(i) (3)].

AMOUNT OR EXTENT OF TAKE

The Service has determined that incidental take of hatchlings will be calculated as the number of surveyed nests where hatchlings that disoriented/misoriented divided by the number of observed emergences. Surveys will be conducted 3 times a week during the hatchling emergence period to determine the incidental take.

The Service anticipates that up to a total of 3 % of all hatchlings disoriented/misoriented events from a representative sample of surveyed nests may occur. The incidental take is expected to be in the form of hatchling and nesting female disorientations and misorientations. The hatchling disorientation rate will be based on the total number of nests where disoriented hatchlings were observed, divided by the total number of nests with observed emergences. A nest is considered "disoriented" when more than four hatchlings exhibit disorientation or misorientation behavior.

The disorientation rate for adult female turtles is anticipated to be up to a total of 3%. Adult disorientations will be calculated separately and based on the number of adult females that disorient/misorient and the total number of nests laid. While the tracks of all marine turtle species that have historically nested on the KSC/MINWR beach loggerhead, green, or leather back sea turtles will be identified, disorientation rate will be based on their combined numbers. NASA will be held responsible for disorientation or misorientation incidents caused by KSC lighting only. It will not be held responsible for disorientation and misorientation incidents that might occur as a result of CCAFS lighting (i.e., lighting at the CCAFS LC 40 and 41 located on KSC property or any of the LC on CCAFS property).

EFFECT OF THE TAKE

In the accompanying BO, the Service has determined that this level of anticipated take (3% hatchlings and 3 % adult nesting females) is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

REASONABLE AND PRUDENT MEASURES

The Service considered all conservation measures when analyzing the effects of the action. The conservation measures on page 5-9 are binding measures for the protective coverage of section 7(o)(2). The shelter that section 7(o)2 provides from section 9 liabilities applies to both the applicants and the action agency provided all conservation measures and the following reasonable and prudent measures and associated terms and conditions. The Service believes the following reasonable and prudent measures are necessary and appropriate to further minimize take of sea turtles.

1. Facility compliance monitoring shall be conducted randomly during the sea turtle nesting and hatching season to ensure the operational constraints of approved LOM and facilities using the ELR are met.

2. Lighting policies shall apply for all existing and future facilities and KSC will be responsible for compliance.

3. During the sea turtle nesting and hatching season, the use of short-arc xenon lights at LC 39A and 39B will occur 24 hours prior to a launch and 24 hours post launch.

4. Lighting surveys will be conducted annually per CM #3 and reporting shall be submitted to the Service.

5. Nighttime surveys shall be conducted to record sea turtle nesting activities and hatchling disorientation and misorientation events. Surveys will continue annually to monitor the potential of lighting to harm or harass sea turtles.

6. Operational constraints will preclude use of exterior lights between 9 p.m. and dawn from May 1 through October 31 except where essential to support launch-related activities at active launch complexes for the safety/security of night operations.

7. Exterior lighting to be replaced at KSC will follow the approved ELM or the site specific LOMs that has been reviewed and approved by the Service.

8. The site specific LOMs for new large scale construction projects and launch pad plans developed per CM# 1 shall be reviewed and approved by the NASA EMB and the Service.

9. To monitor take, calculations of disorientation/misorientation events must be reported to the Service.

TERMS AND CONDITIONS

In order to be exempt from the prohibitions of section 9 of the Act, NASA must comply with the following terms and conditions, which implement reasonable and prudent measures described above and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary.

1. The EMB will inspect and record noncompliance of approved site specific LOM, EML compliant facilities, and LOMs for all existing facilities during the sea turtle nesting and hatching season. In addition to contacting non-compliant facilities and

initiating compliance actions per CM #4, KSC will provide a summary of the compliance inspections, corrective actions, and success of the action in the annual activity report provided per CM #4. The annual activity report shall also include annual retrofitting actions or corrective actions taken to eliminate existing light sources. The annual activity report shall also include data from compliance inspections that shall inform adaptive light management.

2. To ensure compliance and that CM #2 lighting outreach and education is effective, KSC shall include engineers, facility managers, and any other representatives that design and/or enforce lighting at KSC to attend the lighting workshop that is conducted at CCAFS every two years. Facility managers of non-compliant facilities are required to attend.

3. During the sea turtle nesting and hatching season, use of short-arc xenon lights will occur 24 hours before launch and 24 hours post launch. Any light source which is not directly related to the launch operation and needed for safety and security must be shut off.

4. Five lighting surveys will be completed and submitted to the Service for each nesting season. Additional lighting surveys will be conducted, as needed, to ensure observed lighting violations are brought into compliance and to confirm light sources of hatchling disorientations that cannot be identified during hatchling disorientation surveys. The nighttime lighting survey data shall also be included in the annual activity report (CM#4). The annual activity report include information on the evaluation of the effectiveness of artificial light management at existing facilities, compliance with the ELR, approved site specific LOMs, and the new operational policies, prioritize retrofitting actions, and identify any needs for modifications for site specific LOM and ELRs.

5. Nighttime surveys to record sea turtle nesting activities and hatchling disorientation and misorientation events will continue annually on the following schedule: prior to nesting season by March 1st, during early nesting season May 1st, peak nesting season July 1st and late nesting season and early hatching season September 1st, peak and late hatching season by November 1st. These reports must be sent to the Service via email to JaxRegs@fws.gov to on March 15th, May 15th, July 15th, September 15th, and November 15th. After the first five years of reporting with satisfactory implementation of surveys and reporting, reporting shall be annually thereafter.

6. Operational constraints for all facilities at KSC include use of amber LED or exterior lights off between 9 p.m. and dawn from May 1 through October 31, except

where essential to support launch-related activities at active launch complexes for the safety/security of night operations. If incubating nests are still present on the beach after October 31 that could be impacted by particular noncompliant light sources, the lighting must be corrected to prevent potential disorientation/misorientation events in those particular cases.

7. KSC will generate a priority list of lighting projects and identify retrofitting or fixture replacement actions for each calendar year (CM # 5). KSC shall implement up to two retrofitting or fixture replacement projects per year, selecting the highest priority projects as determined by the lighting surveys. If this can't be achieved due then KSC should contact the Service to reinitiate consultation. The recommendations in the Florida Marine Research Institute Technical Report titled "Understanding, Assessing, and Resolving Light- Pollution Problems on Sea Turtle Nesting Beaches, updated in 2014" should be used as a guide when replacing fixtures. This report can be downloaded on the following website: http://myfwc.com/research/wildlife/sea-turtles/threats/artificial-lighting/

8. Coordination and review for new large scale site specific LOMs shall be submitted during the design phase and approved prior to construction of the project.

9a. Per CM #4, the EMB shall review monthly disorientation reports and shall provide monthly reports as outlined below and an annual summary of disorientation/misorientation. If an event is not included in the annual summary per EMB review, the event must be reported to the Service and shall include a rational of why the EMB did not qualify the event as a lighting disorientation/misorientation event.

All disorientation/misorientation will be provided in the annual activity report using the following methods:

i. $\dfrac{\text{Number of marked nests where more than 5 hatchlings disoriented}}{\text{Total number of all marked nests with signs of emergence tracks}}$

ii. $\dfrac{\text{Number of disoriented or misoriented adult nesting female turtles}}{\text{Total number of nests}}$

9b. In the event disoriented or misoriented hatchlings are discovered, the following procedures shall be followed:

1. Live hatchlings shall be maintained in covered, rigid walled containers on moist

sand in a building protected from extremes of heat or cold. Hatchlings shall be released after dark on the first night subsequent to the disorientation/misorientation event if their health permits.

2. A Florida Fish and Wildlife Conservation Commission "Marine Turtle Hatchling Disorientation Incident Report Form" shall be completed for each disorientation/misorientation incident. These forms shall be submitted to the Service's Jacksonville Field Office on a monthly basis on May 15th, June 15th, July 15th, August 15th, September 15th, October 15th, and November 15th. Reports shall be sent to Jaxregs@fws.gov. If there are no disorientations to reports, please send a brief email documenting that there were no disorientations. After the first five years of reporting, reporting shall be on an annual basis.

The Service has determined that up to a total of 3% of all disoriented/misoriented surveyed nests and 3% of all females nesting at KSC for each nesting season will be incidentally taken as a result of the proposed action. The reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize the impact of incidental take that might otherwise result from the proposed action. If, during the course of the action, this level of incidental take is exceeded, such incidental take represents new information requiring reinitiation of consultation and review of the reasonable and prudent measures provided. The Federal agency must immediately provide an explanation of the causes of the taking and review with the Service the need for possible modification of the reasonable and prudent measures.

CONSERVATION RECOMMENDATIONS

Section 7(a) (1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations 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.

1. Educational information should be provided to personnel where appropriate at beach access points explaining the importance of the area to sea turtles and/or the life history of sea turtle species that nest in the area.

In order for the Service to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, the Service requests notification of the implementation of any conservation recommendations.

REINITIATION NOTICE

This concludes formal consultation on the action outlined in the request for reinitiation. 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, any operations causing such take must cease pending reinitiation. The Service appreciates the cooperation of the NASA during this consultation. We would like to continue working with you and your staff regarding the lighting at KSC. For further coordination please contact Tera Baird at (904) 791-3196.

Sincerely,

Jay B. Herrington
Field Supervisor

cc: Jean Higgins, Florida Fish and Wildlife Conservation Commission, Tequesta, FL
Mike LeGare, Merritt Island National Wildlife Refuge, Titusville, FL
John Shaffer, Kennedy Space Center

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Appendix C. Blue Ridge Research Noise Study

Blue Ridge Research and Consulting, LLC

Technical Report

Launch Noise Study for the LC-48 Environmental Assessment

May 2017 (Final)

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Acronyms and Abbreviations

The following acronyms and abbreviations are used in the report:

AEE	Office of Environment and Energy
AST	Office of Commercial Space Transportation
BRRC	Blue Ridge Research and Consulting, LLC
dB	decibel
dBA	A-weighted decibel level
DI	directivity indices
DNL	Day-Night Average Sound Level
DOD	Department of Defense
DSM-1	Distributed Source Method 1
EA	Environmental Assessment
ft	foot/feet
IMSS	Integrated Mission Support Services, LLC
KSC	Kennedy Space Center
lbf	pound force
lbm	pound mass
$L_{A,max}$	maximum A-weighted OASPL in decibels
L_{max}	maximum unweighted OASPL in decibels
L_{pk}	peak sound pressure level in decibels
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
NIHL	noise-induced hearing loss
NIOSH	National Institute for Occupational Safety and Health
NPS	National Park Service
OASPL	overall sound pressure level in decibels
OSHA	Occupational Safety and Health Administration
P_k	peak pressure
psf	pounds per square foot
RUMBLE	The Launch Vehicle Acoustic Simulation Model
sec	second
SEL	Sound Exposure Level in decibels
SCLV	Small class launch vehicle
μPa	micropascal

1 Introduction

This report documents the noise study performed as part of Integrated Mission Support Services (IMSS) efforts on the Environmental Assessment (EA) for the proposed Multi-Use Launch Complex (LC) 48 at National Aeronautics and Space Administration (NASA) Kennedy Space Center (KSC). LC-48 is located within the KSC secured perimeter between LC-39A and LC-41. Although a number of small class launch vehicles (SCLV) could operate from the proposed LC-48, this noise study examines a single nominal launch vehicle representing the largest SCLV (in terms of thrust) projected to be launched from LC-48. Noise contours are presented for the modeled SCLV annual operations which include launches, pre-launch hot fire tests, and engine tests. Note, while engine testing does not currently occur at KSC, pre-launch hot fire tests and engine tests are included in this analysis to assess noise levels associated with the maximum potential level of future development and operations. The potential for propulsion noise and sonic boom impacts is evaluated on a single-event and cumulative basis in relation to human annoyance, hearing conservation and structural damage criteria.

This noise study describes the environmental noise associated with the proposed SCLV events. Section 2 summarizes the noise metrics discussed throughout this report; Section 3 describes the general methodology of the propulsion noise and sonic boom modeling; Section 4 describes the acoustical modeling input parameters for LC-48 operations; and Section 5 presents the propulsion noise and sonic boom modeling results. A summary is provided in Section 6 to document the notable findings of this noise study.

2 Noise Metrics and Criteria

2.1 Noise Metrics

Any unwanted sound that interferes with normal activities or the natural environment can be defined as noise. Noise sources can be continuous (constant) or transient (short-duration) and contain a wide range of frequency (pitch) content. Determining the character and level of sound aids in predicting the way it is perceived. Both propulsion noise and sonic booms are classified as transient noise events.

A decibel (dB) is a ratio that compares the sound pressure of a sound source of interest (e.g., the rocket launch) to a reference pressure (the quietest sound humans can hear, 20 μPa [micropascal]). A change in sound level of about 10 dB is usually perceived by the average person as a doubling (or halving) of the sound's loudness. In the community, "it is unlikely that the average listener would be able to correctly identify at a better than chance level the louder of two other-wise similar… events which differed in maximum sound level by < 3 dB" [1]. Standard weighting filters help to shape the levels in reference to how they are perceived. An "A-weighting" filter approximates the frequency response of human hearing, adjusting low and high frequencies to match the sensitivity of human hearing. For this reason, the A-weighted decibel level (dBA) is commonly used to assess community noise. However, if the structural response of a building is of concern in the analysis, a "flat-weighted" (unweighted) level is more appropriate. Sonic boom noise levels are described in units of peak overpressure in pounds per square foot (psf).

Noise metrics are used to describe noise events and to identify any potential impacts to receptors within the environment. These metrics are based on the nature of the event and who or what is affected by the sound. Individual time-varying noise events have two main characteristics: a sound level that changes throughout the event and a period of time the event is heard. The overall sound pressure level (OASPL) provides a measure of the sound level at any given time and the maximum OASPL (L_{max}) indicates the highest level achieved over the duration of the event. Sound Exposure Level (SEL) represents the cumulative noise exposure of a transient noise event and includes both its magnitude and its duration. However, SEL does not directly represent the sound level heard at any given time. Mathematically, it represents the sound level of a constant sound that would generate the same acoustical energy in one second as the actual time-varying noise event. For sound generated by rocket launches, which last more than one second, the SEL is greater than the L_{max} because an individual launch can last for minutes and the L_{max} occurs over a short duration.

The Day-Night Average Sound Level (DNL) is a cumulative noise metric that accounts for the SEL of all noise events in a 24-hour period. Typically, DNL values are expressed as the level over a 24-hour annual average day. To account for increased human sensitivity to noise at night, a 10 dB adjustment is applied to nighttime events (occurring between the hours of 10:00 p.m. and 7:00 a.m.). Therefore, the DNL is dependent on the number of annual daytime and nighttime events. Noise contour maps of these metrics are comprised of lines of equal noise level or exposure, and they serve as visual aids for assessing the impact of noise on the community.

2.2 Noise Criteria

Noise criteria have been developed to protect the public health and welfare of the surrounding communities. The impacts of propulsion noise and sonic booms are evaluated on a cumulative basis in terms of human annoyance. In addition, the propulsion noise and sonic boom impacts are evaluated on a single-event basis in relation to hearing conservation and structural damage criteria. Although FAA Order 1050.1F does not have guidance on hearing conservation or structural damage criteria, it recognizes the use of supplemental noise analysis to describe the noise impact and assist the public's understanding of the potential noise impact.

2.2.1 Human Annoyance

A significant noise impact would occur if the "action would increase noise by DNL 1.5 dB[A] or more for a noise sensitive area that is exposed to noise at or above the DNL 65 dB[A] noise exposure level, or that will be exposed at or above this level due to the increase, when compared to the No Action Alternative for the same timeframe" [2]. DNL is based on long-term cumulative noise exposure and has been found to correlate well with long-term community annoyance for regularly occurring events including aircraft, rail, and road noise [3, 4]. Noise studies used in the development of the DNL metric did not include rocket noise, which are historically irregularly occurring events. Thus, it is acknowledged that the suitability of DNL for infrequent rocket noise and sonic boom events is uncertain. Additionally, it has been noted that the "DNL 65 dB threshold does not adequately address the effects of noise on visitors to areas within a national park or national wildlife refuge where other noise is very low and a quiet setting is a generally recognized purpose and attribute" [2]. DNL contours are provided as the most widely accepted metric to estimate the potential long-term community annoyance.

2.2.2 Hearing Conservation

Rocket Noise

U.S. government agencies have provided guidelines on permissible noise exposure limits. These documented guidelines are in place to protect human hearing from long-term continuous daily exposures to high noise levels and aid in the prevention of noise-induced hearing loss (NIHL). A number of federal agencies have set exposure limits on non-impulsive noise levels including the Occupational Safety and Health Administration (OSHA) [5], National Institute for Occupational Safety and Health (NIOSH) [6], and the Department of Defense (DOD) Occupational Hearing Conservation Program [7]. The most conservative of these upper noise level limits has been set by OSHA at 115 dBA. At 115 dBA the allowable exposure duration is 15 minutes for OSHA and 28 sec for NIOSH and DOD. In addition, the OSHA standard specifies exposure to continuous steady-state noise is limited to a maximum of 115 dBA. In addition to implementing Federal OSHA regulations, KSC's Hearing Loss Prevention Program states that unprotected exposures above 103 dBA are not allowed for any duration [8]. $L_{A,max}$ contours are used to identify potential locations where hearing protection should be considered for rocket operations.

Sonic Boom

A sonic boom is the sound associated with the shock waves created by a vehicle traveling through the air faster than the speed of sound. Multiple federal government agencies have provided guidelines on permissible noise exposure limits on impulsive noise such as a sonic boom. These documented guidelines are in place to protect one's hearing from exposures to high noise levels and aid in the prevention of NIHL. In terms of upper limits on impulsive or impact noise levels, NIOSH [6] and OSHA [5] have stated that levels should not exceed 140 dB peak sound pressure level, which equates to a sonic boom level of approximately 4 psf. However, KSC's Hearing Loss Prevention Program states that impact or impulse noise exposure levels should not exceed 130 dB peak sound pressure level, which equates to a sonic boom level of approximately 1.3 psf.

2.2.3 Structural Damage

Rocket Noise

Typically, the most sensitive components of a structure to propulsion noise are windows, and infrequently, the plastered walls and ceilings. The potential for damage to a structure is unique interaction among the incident sound, the condition of the structure, and the material of each element and its respective boundary conditions. A report from the National Research Council on the "Guidelines for Preparing Environmental Impact Statements on Noise" [9] states that one may conservatively consider all sound lasting more than one second with levels exceeding 130 dB (unweighted) as potentially damaging to structures.

A NASA technical memo found a relationship between structural damage claims and overall sound pressure level, where "the probability of structural damage [was] proportional to the intensity of the low frequency sound" [10]. This relationship estimated that one damage claim in 100 households exposed is expected at an average continuous sound level of 120 dB, and one in 1,000 households at 111 dB. The study was based on community responses to the 45 ground tests of the first and second stages of the Saturn V rocket system conducted in Southern Mississippi over a period of five years. The sound levels used to develop the criteria were mean modeled sound levels.

It is important to highlight the difference between the static ground tests in which the rate of structural damage claims is based on and the dynamic events modeled in this noise study. During ground tests, the engine/motor remains in one position, which results in longer exposure duration to continuous levels as opposed to the transient noise occurring from the moving vehicle during a launch event. Regardless of this difference, Guest and Slone's (1972) damage claim criteria represents the best available dataset regarding structural damage resulting from rocket noise. Thus, L_{max} values of 120 dB and 111 dB are used in this report as conservative thresholds for potential risk of structural damage claims.

Sonic Boom

Sonic booms are also commonly associated with structural damage. Most damage claims are for brittle objects, such as glass and plaster. Table 1 summarizes the threshold of damage that may be expected at various overpressures [11]. A large degree of variability exists in damage experience, and much of the damage depends on the pre-existing condition of a structure. Breakage data for glass, for example, spans a range of two to three orders of magnitude at a given overpressure. The probability of a window breaking at 1 psf ranges from one in a billion [12] to one in a million [13]. These damage rates are associated with a combination of boom load and glass condition. At 10 psf, the probability of breakage is between one in 100 and one in 1,000. Laboratory tests involving glass [14] have shown that properly installed window glass will not break at overpressures below 10 psf, even when subjected to repeated booms. However, in the real world, glass is not always in pristine condition.

Damage to plaster occurs at similar ranges to glass damage. Plaster has a compounding issue in that it will often crack due to shrinkage while curing or from stresses as a structure settles, even in the absence of outside loads. Sonic boom damage to plaster often occurs when internal stresses are high as a result of these factors. In general, for well-maintained structures, the threshold for damage from sonic booms is 2 psf [11], below which damage is unlikely.

Table 1. Possible damage to structures from sonic booms [11]

Sonic Boom Overpressure Nominal (psf)	Type of Damage	Item Affected
0.5 - 2	Plaster	Fine cracks; extension of existing cracks; more in ceilings; over doorframes; between some plasterboards.
	Glass	Rarely shattered; either partial or extension of existing.
	Roof	Slippage of existing loose tiles/slates; sometimes new cracking of old slates at nail hole.
	Damage to outside walls	Existing cracks in stucco extended.
	Bric-a-brac	Those carefully balanced or on edges can fall; fine glass, such as large goblets, can fall and break.
	Other	Dust falls in chimneys.
2 - 4	Glass, plaster, roofs, ceilings	Failures show that would have been difficult to forecast in terms of their existing localized condition. Nominally in good condition.
4 - 10	Glass	Regular failures within a population of well-installed glass; industrial as well as domestic greenhouses.
	Plaster	Partial ceiling collapse of good plaster; complete collapse of very new, incompletely cured, or very old plaster.
	Roofs	High probability rate of failure in nominally good state, slurry-wash; some chance of failures in tiles on modern roofs; light roofs (bungalow) or large area can move bodily.
	Walls (out)	Old, free standing, in fairly good condition can collapse.
	Walls (in)	Inside ("party") walls known to move at 10 psf.
Greater than 10	Glass	Some good glass will fail regularly to sonic booms from the same direction. Glass with existing faults could shatter and fly. Large window frames move.
	Plaster	Most plaster affected.
	Ceilings	Plasterboards displaced by nail popping.
	Roofs	Most slate/slurry roofs affected, some badly; large roofs having good tile can be affected; some roofs bodily displaced causing gale-end and will-plate cracks; domestic chimneys dislodged if not in good condition.
	Walls	Internal party walls can move even if carrying fittings such as hand basins or taps; secondary damage due to water leakage.
	Bric-a-brac	Some nominally secure items can fall; e.g., large pictures, especially if fixed to party walls.

3 Acoustic Modeling Methodology

Launch vehicle propulsion systems, such as solid rocket motors and liquid-propellant rocket engines, generate high amplitude, broadband noise. The majority of the noise is created by the rocket plume interacting with the atmosphere, and the combustion noise of the propellants. Although rocket noise radiates in all directions, it is highly directive, meaning that a significant portion of the source's acoustic power is concentrated in specific directions.

In addition to the rocket noise, a launch vehicle creates sonic booms during supersonic flight. The potential for the boom to intercept the ground depends on the trajectory and speed of the vehicle as well as the atmospheric profile. The sonic boom is shaped by the physical characteristics of the vehicle and the atmospheric conditions through which it propagates. These factors affect the perception of a sonic boom. The noise is perceived as a deep double boom, with most of its energy concentrated in the low frequency range. Although sonic booms generally last less than one second, their potential for impact may be considerable.

3.1 Propulsion Noise Modeling

The Launch Vehicle Acoustic Simulation Model (RUMBLE), developed by Blue Ridge Research and Consulting, LLC (BRRC), is the noise model used to predict the SCLV noise associated with the proposed operations at LC-48. The core components of the model are visualized in Figure 1 and are described in the following sub sections.

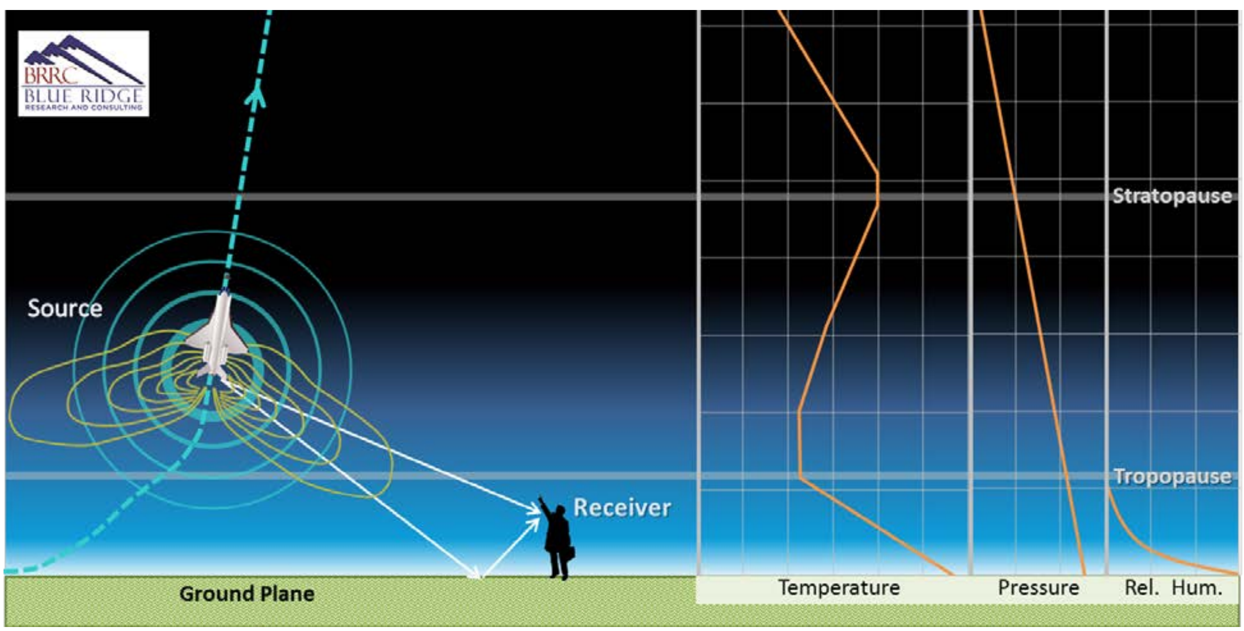

Figure 1. Conceptual overview of rocket noise prediction model methodology.

3.1.1 Source

The rocket noise source definition considers the acoustic power of the rocket, forward flight effects, directivity, and the Doppler effect.

Acoustic Power

Eldred's Distributed Source Method 1 (DSM-1) [15] is utilized for the source characterization. The DSM-1 model determines the launch vehicle's total sound power based on its total thrust, exhaust-velocity and the engine/motor's acoustic efficiency. BRRC's recent validation of the DSM-1 model showed very good agreement between full-scale rocket noise measurements and the empirical source curves [16]. The acoustic efficiency of the rocket engine/motor specifies the percentage of the mechanical power converted into acoustic power. The acoustic efficiency of the rocket engine/motor was modeled using Guest's variable acoustic efficiency [17]. Typical acoustic efficiency values range from 0.2% to 1.0% [15]. In the far-field, distributed sound sources are modeled as a single compact source located at the nozzle exit with an equivalent total sound power. Therefore, launch vehicle propulsion systems with multiple tightly clustered equivalent engines can be modeled as a single engine with an effective exit diameter and total thrust [15]. Additional boosters or cores (that are not considered to be tightly clustered) are handled by summing the noise contribution from each booster/core.

Forward Flight Effect

A rocket in forward flight radiates less noise than the same rocket in a static environment. A standard method to quantify this effect reduces overall sound levels as a function of the relative velocity between the jet plume and the outside airflow [18, 19, 20, 21]. This outside airflow travels in the same direction as the rocket exhaust. At the onset of a launch, the rocket exhaust travels at far greater speeds than the ambient airflow. As the differential between the forward flight velocity and exhaust velocity decreases, jet plume mixing is reduced, which reduces the corresponding noise emission. Notably, the maximum OASPLs are normally generated before the vehicle reaches the speed of sound. Thus, the modeled noise reduction is capped at a forward flight velocity of Mach 1.

Directivity

Rocket noise is highly directive, meaning the acoustic power is concentrated in specific directions and the sound pressure observed will depend on the angle from the source to the receiver. NASA's Constellation Program has made significant improvements in determining launch vehicle directivity of the reusable solid rocket motor (RSRM) [22]. The RSRM directivity indices (DI) incorporate a larger range of frequencies and angles then previously available data. Subsequently, improvements were made to the formulation of the RSRM DI [23] accounting for the spatial extent and downstream origin of the rocket noise source. These updated DI are used for this analysis.

Doppler Effect

The Doppler effect is the change in frequency of an emitted wave from a source moving relative to a receiver. The frequency at the receiver is related to the frequency generated by the moving sound source and by the speed of the source relative to the receiver. The received frequency is higher (compared to the emitted frequency) if the source is moving towards the receiver, it is identical at the instant of passing by, and it is lower if the source is moving away from the receiver. During a rocket launch, an observer on the ground will hear a downward shift in the frequency of the sound as the distance from the source to receiver increases. The relative changes in frequency can be explained as follows: when the source of the waves is moving toward the observer, each successive wave crest is emitted from a position closer to the observer than the previous wave. Therefore, each wave takes slightly less time to reach the observer than the previous wave, and the time between the arrivals of successive wave crests at the observer is reduced, causing an increase in the frequency. While they are travelling, the distance between successive wave fronts is reduced such that the waves "bunch together". Conversely, if the source of waves is moving away from the observer, then each wave is emitted from a position farther from the observer than the previous wave; the arrival time between successive waves is increased, reducing the frequency. Likewise, the distance between successive wave fronts increases, so the waves "spread out." Figure 2 illustrates this spreading effect for an observer in a series of images, where a) the source is stationary, b) the source is moving less than the speed of sound, c) the source is moving at the speed of sound, and d) the source is moving faster than the speed of sound. As the frequency is shifted lower, the A-Weighting filtering on the spectrum results in a decreased A-weighted sound level. For unweighted overall sound levels, the Doppler effect does not change the levels since all frequencies are accounted for equally.

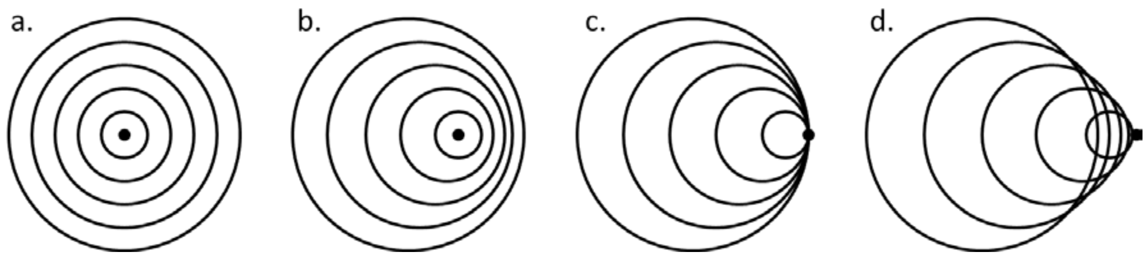

Figure 2. Effect of expanding wavefronts (decrease in frequency) that an observer would notice for higher relative speeds of the rocket relative to the observer for: a) stationary source b) source velocity < speed of sound c) source velocity = speed of sound d) source velocity > speed of sound

3.1.2 Propagation

The sound propagation from the source to receiver considers the ray path, atmospheric absorption, and ground interference.

Ray Path

The model assumes straight line propagation between the source and receiver to determine propagation effects. For straight rays, sound levels decrease as the sound wave propagates away from a source uniformly in all directions. The propulsion noise model components are calculated based on the specific geometry between source (launch vehicle trajectory point) to receiver (grid point). The position of the launch vehicle, described by the trajectory, is provided in latitude and longitude, defined relative to a reference system (e.g., World Geodetic System 1984 [WGS84]) that approximates the Earth’s surface by an ellipsoid. The receiver grid is also described in geodetic latitude and longitude, referenced to the same reference system as the trajectory data, ensuring greater accuracy than traditional flat earth models.

Atmospheric Absorption

Atmospheric absorption is a measure of the sound attenuation from the excitation of vibration modes of air molecules. Atmospheric absorption is a function of temperature, pressure and relative humidity of the air. Figure 1 shows an example atmospheric profile. The atmospheric absorption is calculated using formulas found in ANSI standard S1.26-1995 (R2004). The result is a sound-attenuation coefficient, which is a function of frequency, atmospheric conditions, and distance from the source. The amount of absorption depends on the parameters of the atmospheric layer and the distance that the sound travels through the layer. The total sound attenuation is the sum of the absorption experienced from each atmospheric layer.

Nonlinear propagation effects can result in distortions of high-amplitude sound waves [24] as they travel through the medium. These nonlinear effects are counter to the effect of atmospheric absorption [25, 26]. However, recent research shows that nonlinear propagation effects change the perception of the received sound [27, 28] , but the standard acoustical metrics are not strongly influenced by nonlinear effects [29, 30]. The overall effects of nonlinear propagation on high-amplitude sound signatures and their perception is an on-going area of research, and it is not currently included in the propagation model.

Ground Interference

The calculated results of the sound propagation using DSM-1 provide a free-field sound level (i.e., no reflecting surface) at the receiver. However, sound propagation near the ground is most accurately modeled as the combination of a direct wave (source to receiver) and a reflected wave (source to ground to receiver) as shown in Figure 1. The ground will reflect sound energy back toward the receiver and interfere both constructively and destructively with the direct wave. Additionally, the ground may attenuate the sound energy causing the reflected wave to propagate a smaller portion of energy to the receiver. RUMBLE accounts for the attenuation of sound by the ground [31, 32] when estimating the received noise. The model assumes a five-foot receiver height and a homogeneous grass ground surface. However, it should be noted that noise levels may be 3 dB louder over water surfaces compared to the predicted levels over the homogeneous grass ground surfaces assumed in the modeling. To account for the random fluctuations of wind and temperature on the direct and reflected wave, the effect of atmospheric turbulence is also included [31, 33].

3.1.3 Receiver

The received noise is estimated by combining the source and propagation components. The basic received noise is modeled as overall and spectral level time histories. This approach enables a range of noise metrics relevant to environmental noise analysis to be calculated and prepared as output.

3.2 Sonic Boom Modeling

When a vehicle moves through the air, it pushes the air out of its way. At subsonic speeds, the displaced air forms a pressure wave that disperses rapidly. At supersonic speeds, the vehicle is moving too quickly for the wave to disperse, so it remains as a coherent wave. This wave is a sonic boom. When heard at ground level, a sonic boom consists of two shock waves (one associated with the forward part of the vehicle, the other with the rear part) of approximately equal strength and (for fighter aircraft) separated by 100 to 200 milliseconds. For launch vehicles, the separation can be extended because of the volume of the plume. Thus, their waveform durations can be as large as one second. When plotted, this pair of shock waves and the expanding flow between them has the appearance of a capital letter "N," so a sonic boom pressure wave is usually called an "N-wave." An N-wave has a characteristic "bang-bang" sound that can be startling. Figure 3 shows the generation and evolution of a sonic boom N-wave under the vehicle. Figure 4 shows the sonic boom pattern for a vehicle in steady, level supersonic flight. The boom forms a cone that is said to sweep out a "carpet" under the flight track. The boom levels vary along the lateral extent of the "carpet" with the highest levels directly underneath the flight track and decreasing as the lateral distance increases to the cut-off edge of the "carpet." When the vehicle is maneuvering, the sonic boom energy can be focused in highly localized areas on the ground.

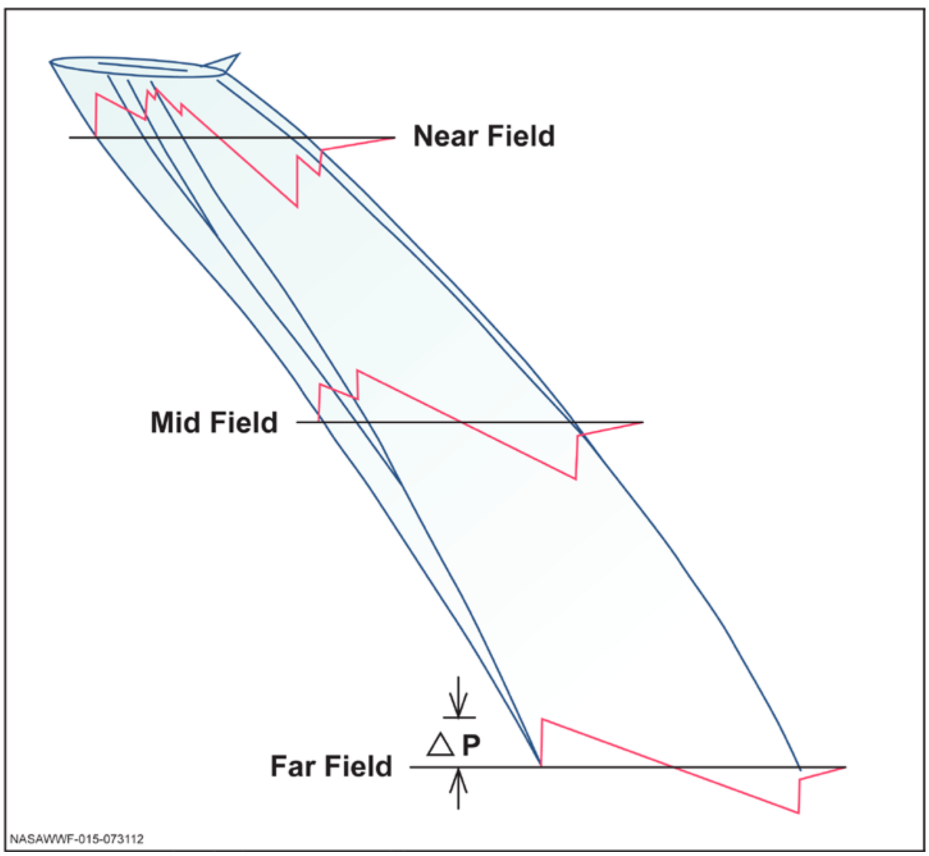

Figure 3. Sonic boom generation and evolution to N-wave [34]

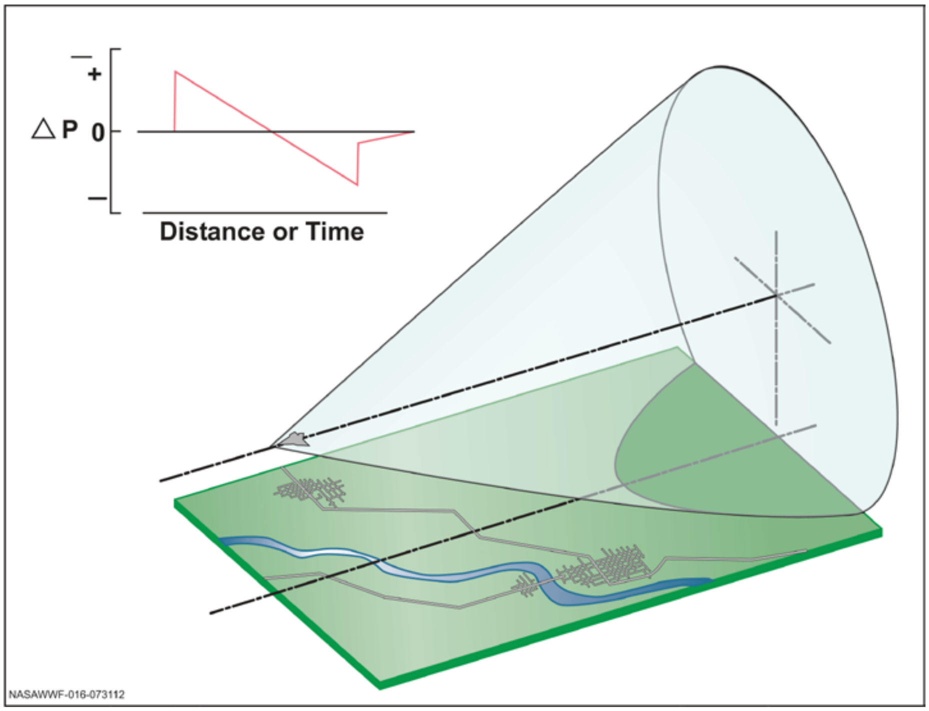

Figure 4. Sonic boom carpet for a vehicle in steady flight [35]

The complete ground pattern of a sonic boom depends on the size, weight, shape, speed, and trajectory of the vehicle. Since aircraft fly supersonically with relatively low horizontal angles, the boom is directed toward the ground. However, for rocket trajectories, the boom is directed laterally until the rocket rotates significantly away from vertical, as shown in Figure 5. This difference causes a sonic boom from a rocket to propagate much further downrange compared to aircraft sonic booms. This extended propagation usually results in relatively lower sonic boom levels from rocket launches. For aircraft, the front and rear shock are generally the same magnitude. However, for a rocket the plume provides a smooth decrease in the vehicle volume, which diminishes the strength of the rear shock.

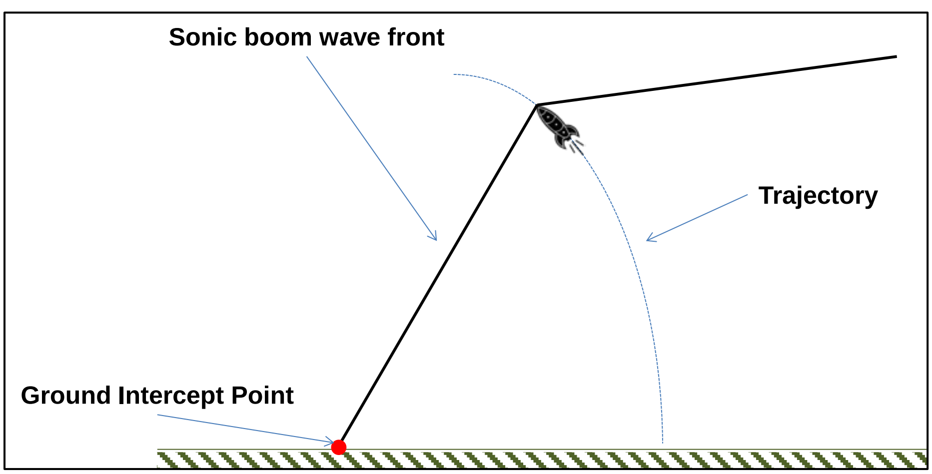

Figure 5. Sonic boom propagation for rocket launch

4 LC- 48 Modeling Input

4.1 Launch Site Description

LC-48 is located within the KSC secured perimeter between LC-39A and LC-41. The locations of the proposed LC-48 launch pad and engine test stand are shown in Figure 6. Table 2 includes the latitude and longitude coordinates of two notional sites identified within LC-48 based on preliminary planning research. The launch pad's flame trench is modeled to be in line with the initial heading of the SCLV trajectory. The models utilize an atmospheric profile, which describes the variation of temperature, pressure and relative humidity with respect to the altitude. Standard atmospheric data sources [36, 37, 38] were used to create a composite atmospheric profile for altitudes up to 62 miles.

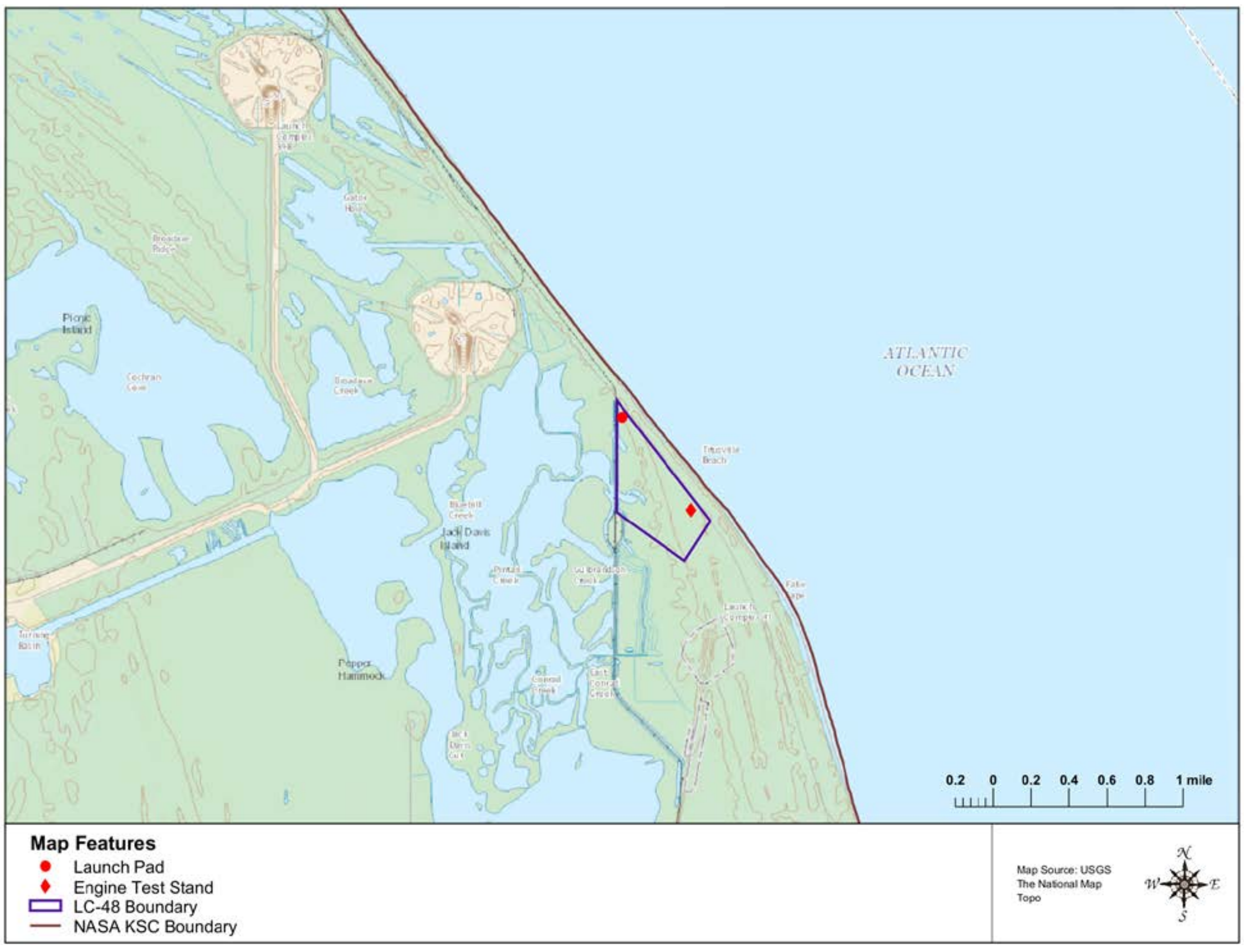

Figure 6. LC-48 launch pad and engine test stand locations

Table 2. LC-48 launch pad and engine test stand locations

Pad	Latitude	Longitude
Launch Pad	28.601462°	-80.590312°
Engine Test Stand	28.594395°	-80.584352°

4.2 Vehicle and Engine Modeling Parameters

The proposed action involves operations of a liquid-fueled SCLV at LC-48. The RUMBLE model requires specific vehicle/engine input parameters to determine the noise exposure resulting from the proposed operations of the SCLV. The representative parameters of the SCLV and its engine are presented in Table 3. The thrust of the SCLV's engine is modeled using the time varying thrust profile provided in the SCLV nominal trajectory, with a maximum thrust of 414,090 lbf.

Table 3. Vehicle and engine parameters used in acoustic modeling

Parameters	Values
Vehicle Description	Small Class Launch Vehicle
Vehicle Length	99.5 feet
Gross Vehicle Weight	266,000 lbs
Number of Engines	1
Maximum Net Thrust Per Engine	414,090 lbf
Nozzle Exit Diameter	91.2 inches
Propellant Description	LOX/RP-1

4.3 Flight Trajectory Data

Launch trajectories departing from LC-48 will be unique to each mission and the environmental conditions. However, for the purpose of assessing potential noise impacts from SCLV launches, a nominal trajectory has been designed by NASA's Launch Services Program to represent the trajectory for a generic SCLV with a liquid first stage engine. The provided trajectory has a flight path heading that ranges from approximately 86° to 89° relative to true north.

4.4 Operational Data

The proposed SCLV annual operations, summarized in Table 4, consist of 13 launches, 13 pre-launch hot fire tests, and 13 engine tests. Of the 39 total annual operations, zero occur during acoustic nighttime hours (0200 – 0700). The duration of each hot fire and engine test was modeled to be 20 seconds.

Table 4. Proposed annual SCLV operations at LC-48

			Annual Operations		
Operation	Location	Duration Seconds	Acoustic Day 0700 to 2200	Acoustic Night 2200 to 0700	Total
Launch	Launch Pad	-	13	0	13
Pre-Launch Hot Fire Test	Launch Pad	20	13	0	13
Engine Test	Engine Test Stand	20	13	0	13
		Total	39	0	39

5 Results

The following sections present the study results of the environmental noise and sonic boom impacts associated with the proposed SCLV operations at LC-48. Single event propulsion noise and sonic boom results are presented in Section 5.1 and cumulative noise results are presented in Section 5.2. It should be noted that noise levels may be 3 dB louder over water because of the acoustical hardness of the water surface.

5.1 Single Event Results

Propulsion noise and sonic boom impacts are evaluated on a single-event basis in relation to hearing conservation and structural damage criteria. Noise and sonic boom modeling was conducted for the proposed SCLV launch and engine test operations.

5.1.1 Propulsion Noise

Maximum A-weighted OASPL ($L_{A,max}$)

KSC's Hearing Loss Prevention Program has set an upper limit of 103 dBA for unprotected exposures as a guideline to protect human hearing from long-term continuous daily exposures to high noise levels and to aid in the prevention of noise-induced hearing loss [8]. To assess the potential risk in relation to hearing conservation, the 103 dBA $L_{A,max}$ contours generated by each SCLV event are presented in Figure 7 through Figure 9. $L_{A,max}$ in excess of 103 dBA would be limited to a radius of 1.4 miles from the launch pad for launch events. The engine test $L_{A,max}$ contours are more directive than the launch SCLV events as a result of redirecting the plume in-line with the flame trench heading over the entire duration of the event. During an engine test, a receptor located along the peak directivity angle may experience an $L_{A,max}$ of 103 dBA at approximately 1.0 miles from the launch pad or engine test stand. Note, levels produced by engine tests would remain constant over the duration of the event whereas the levels produced by launch events would change as the vehicle sound source moves away from the receiver. The 103 dBA contours are contained within KSC boundaries and encompass LC-39A for launch events and part of LC-41 for launches and engine tests. Note, predicted noise levels in the community are less than OSHA's 115 dBA upper noise limit guideline.

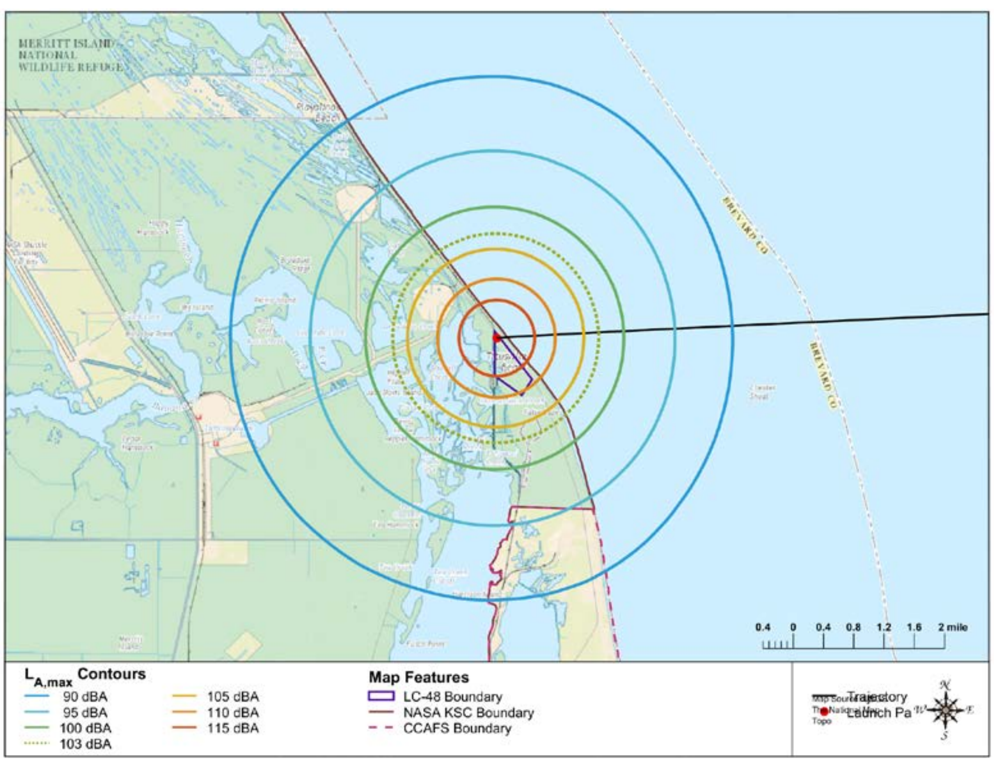

Figure 7. $L_{A,max}$ contours for a SCLV launch

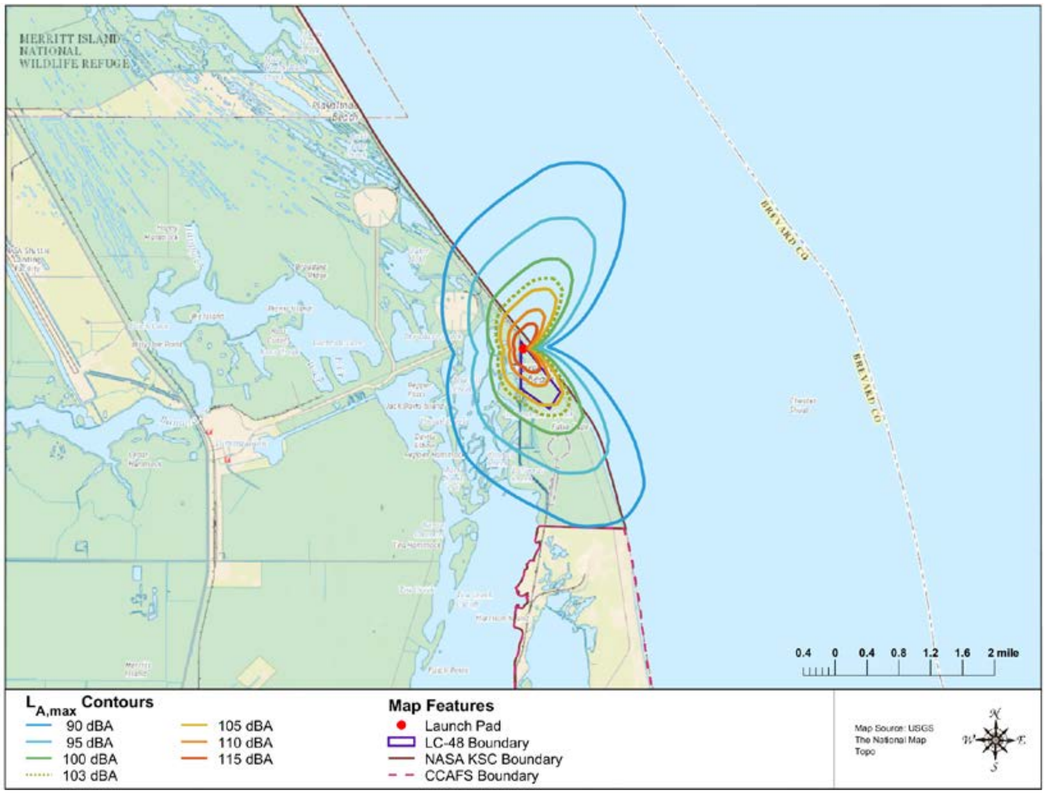

Figure 8. $L_{A,max}$ contours for a SCLV pre-launch hot fire test

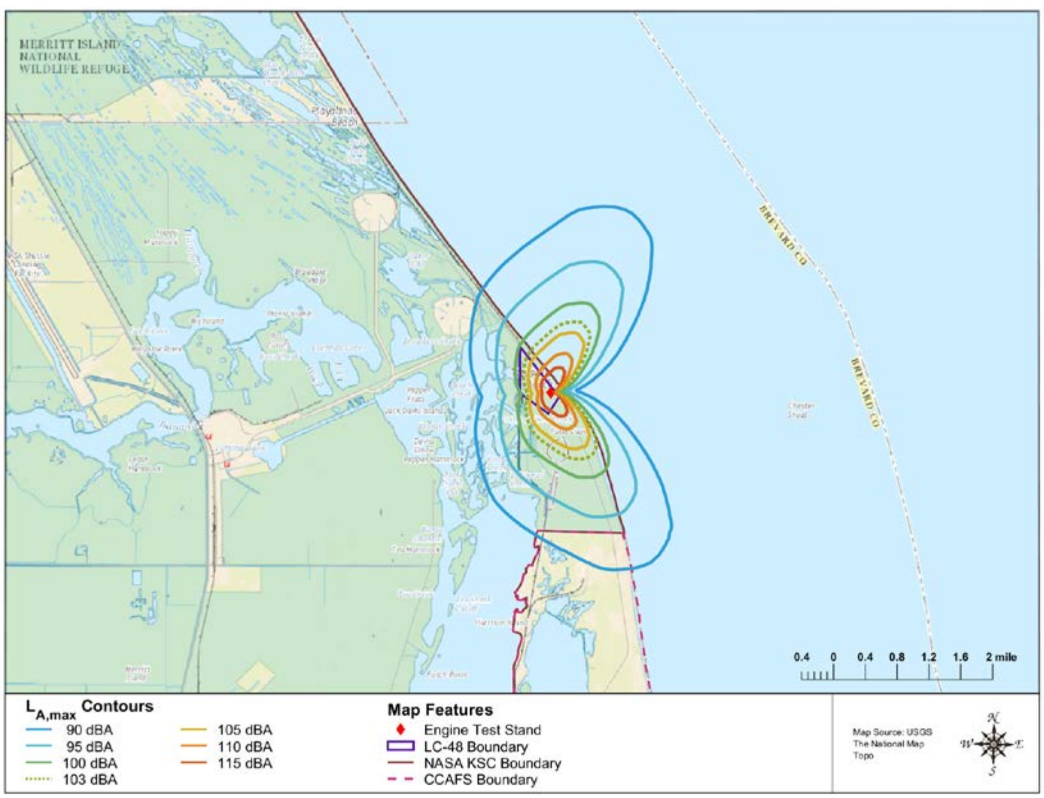

Figure 9. $L_{A,max}$ contours for a SCLV engine test at the designated engine test stand

Maximum Unweighted OASPL ($L_{,max}$)

To assess the potential risk to structural damage claims, the 111 dB and 120 dB L_{max} contours generated by each SCLV event are presented in Figure 10 through Figure 12. The potential for structural damage claims is approximately one damage claim per 100 households exposed at 120 dB and one in 1,000 households at 111 dB [10]. For launch events, L_{max} in excess of 120 dB and 111 dB would be limited to a radius of 1.4 miles and 3.8 miles from the launch pad, respectively. The SCLV engine test L_{max} contours are more directive than the launch SCLV events. A receptor located along the peak directivity angle may experience an L_{max} of 120 dB at 1.4 miles and 111 dB at 3.4 miles from the launch pad or engine test stand. Note, predicted noise levels in the community are less than the 111 dB guideline.

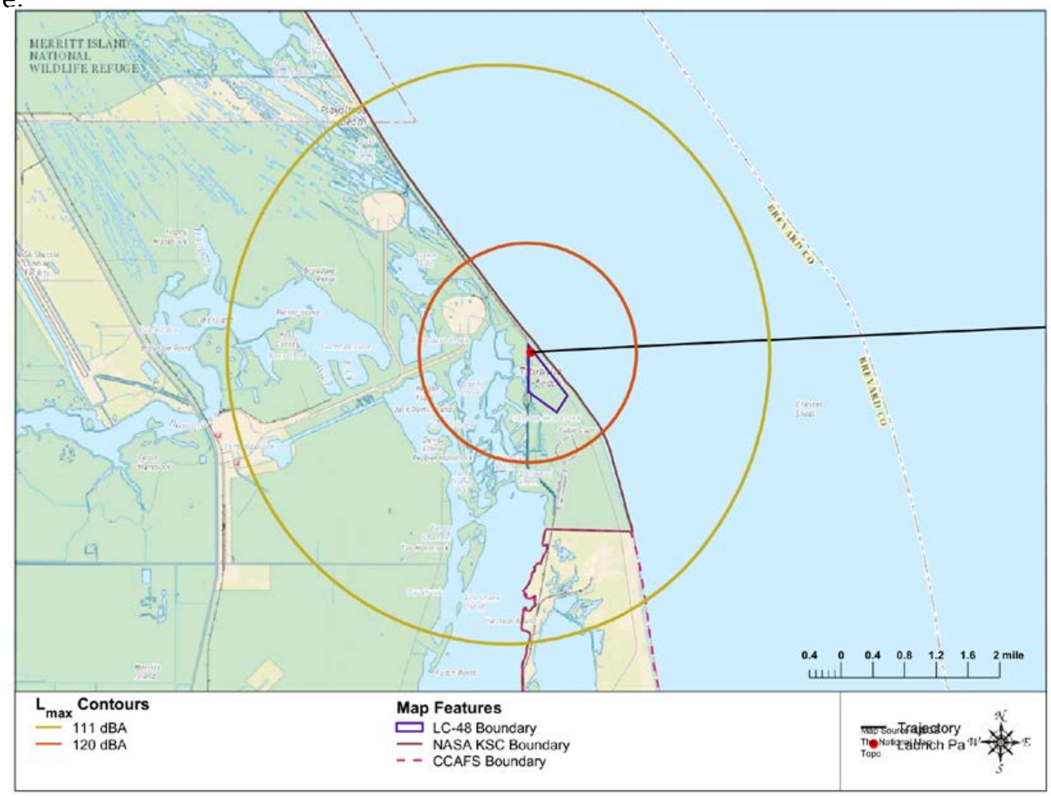

Figure 10. L_{max} contours for a SCLV launch

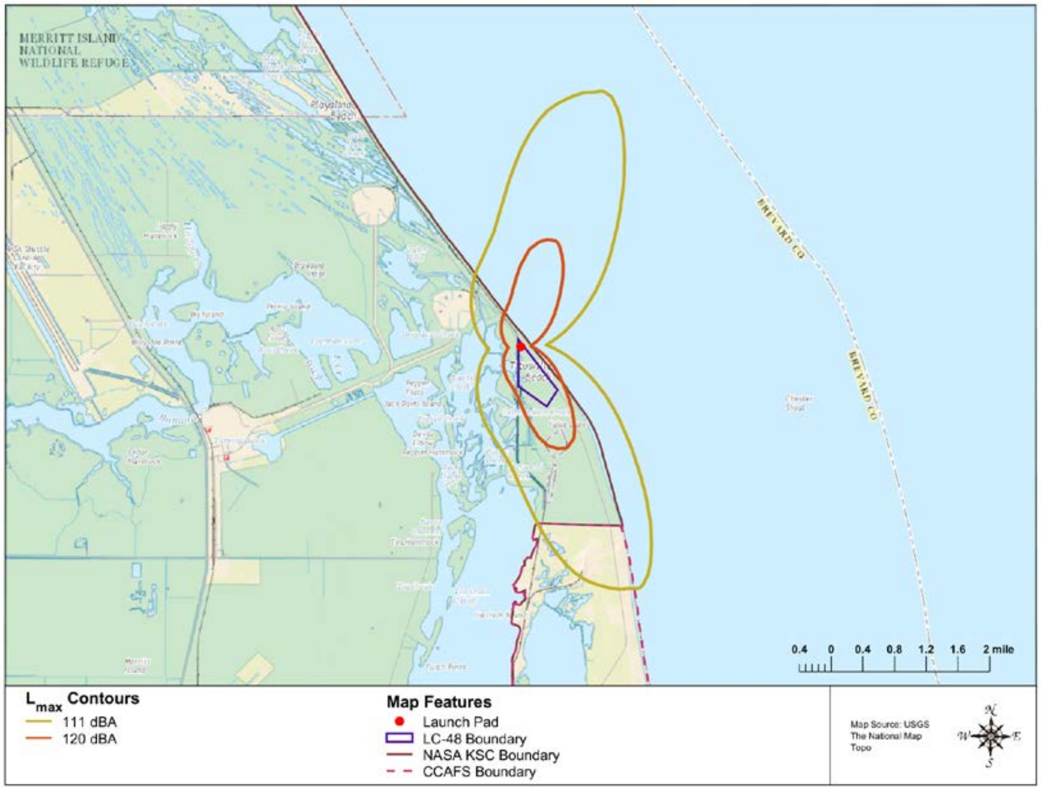

Figure 11. L_{max} contours for a SCLV pre-launch hot fire test

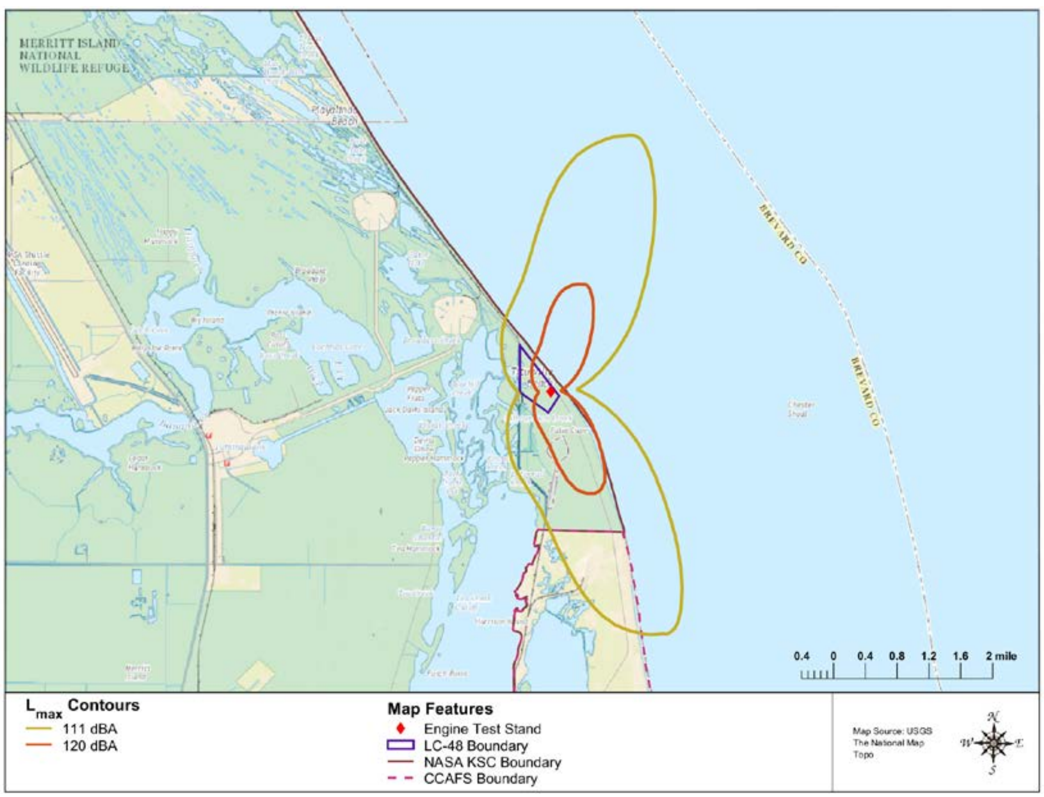

Figure 12. L_{max} contours for a SCLV engine test at the designated engine test stand

5.1.2 Sonic Boom

A sonic boom is the sound associated with the shock waves created by a vehicle traveling through the air faster than the speed of sound. The presence and/or location of sonic boom regions is highly dependent on the actual trajectory and atmospheric conditions at the time of flight. The sonic boom contours generated by each SCLV event, represented by peak overpressure in psf, are shown in Figure 13. In addition to the contours, the figure show the portion of supersonic flight during each event that generate sonic boom footprints that intercept the ground.

For the nominal SCLV launch event, sonic booms intercept the ground during the supersonic portion of the ascent because the flight path angle deviates from vertical with increasing altitude. The modeled overpressure contour values between 0.25 and 4 psf are shown in Figure 13 for the nominal SCLV launch event. The maximum overpressure is 6.3 psf, is located over water, and covers an area too small to be seen in the figures. The boom footprint falls in the Atlantic Ocean, approximately 30 miles from the launch pad along the launch azimuth. The nominal sonic boom from a SCLV launch operation is not predicted to intercept the mainland of Florida, and as such, will not exceed the hearing conservation and structural damage criteria.

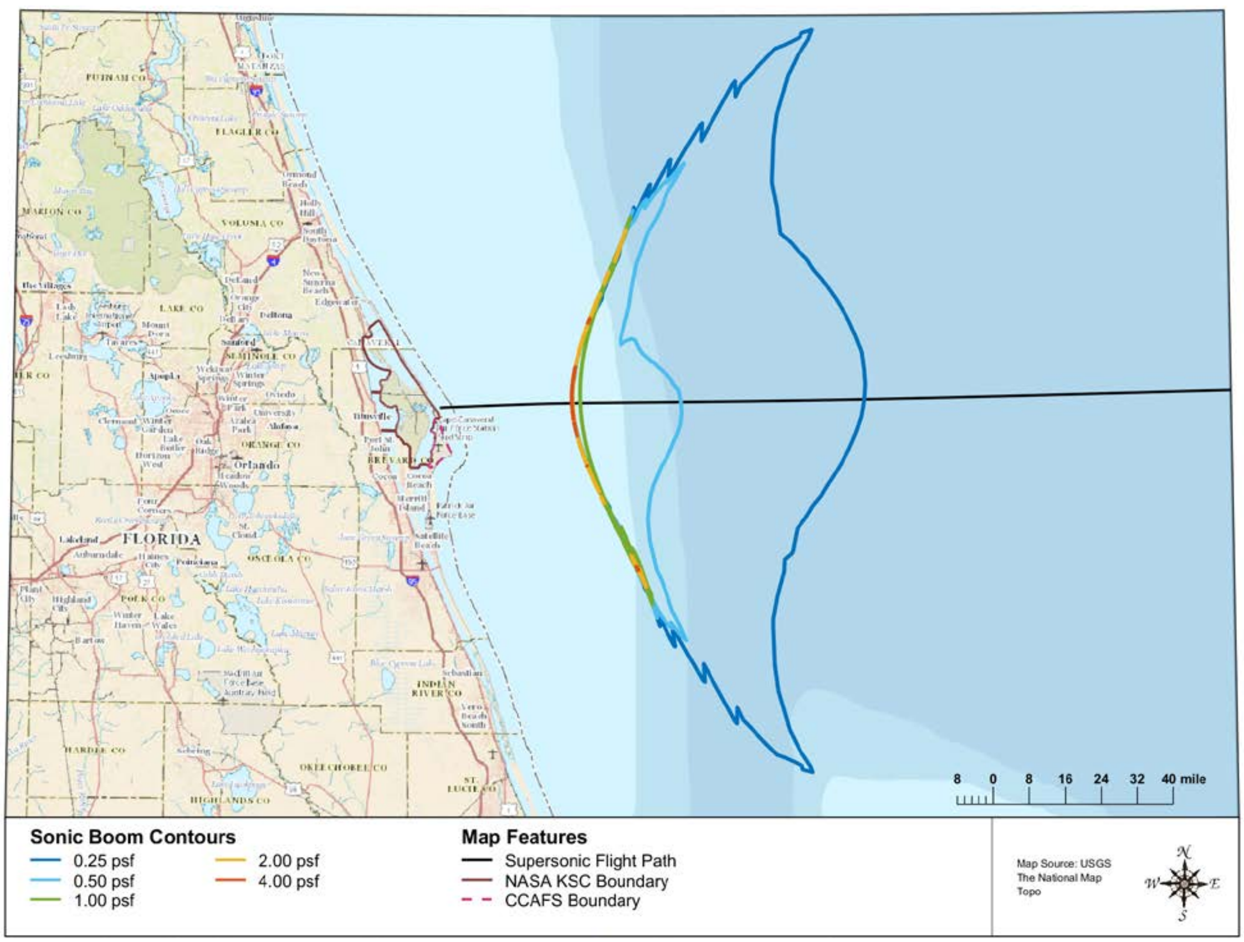

Figure 13. Sonic boom peak overpressure contours for a SCLV launch

5.2 Cumulative Noise Results

DNL is based on long-term cumulative noise exposure and has been found to correlate well with long-term community annoyance. A significant noise impact is one in which the "action would increase noise by DNL 1.5 dB[A] or more for a noise sensitive area that is exposed to noise at or above the DNL 65 dB[A] noise exposure level, or that will be exposed at or above this level due to the increase, when compared to the no action alternative for the same timeframe" [2]. As DNL contours representing the no action alternative at KSC are unavailable, an alternative technique was used to identify potential areas where significant noise impacts may occur as a result of the proposed operations. For any potential impacts to occur as a result of the SCLV operations, the SCLV launch and engine test noise would have to combine with existing noise to increase the 65 dBA DNL by 1.5 dBA or more. Existing noise at LC-48 would include the noise from neighboring launch complexes LC-39 (operated by SpaceX) and LC-41 (operated by ULA), which currently support operations of medium-heavy launch vehicles (i.e. Falcon 9 and Atlas V). Existing noise exposure at or below 63.5 dBA would require the SCLV launch and engine tests to generate levels at or above DNL 60 dBA to produce an increase of 1.5 dBA in the DNL to levels above 65 dBA. Therefore, DNL 60 dBA is used to conservatively identify potential areas where noise impacts may occur as a result of the proposed operations. The DNL contours from 60 dBA to 75 dBA are presented in Figure 14. The DNL 65 and 60 dBA contours extend approximately 0.4-1.0 and 0.7-1.2 miles from the launch pad, respectively. This area does not encompass land outside of the KSC boundaries and thus no residences are impacted. The sonic boom footprint for nominal launch azimuths does not intercept land and thus would not contribute to the DNL contours.

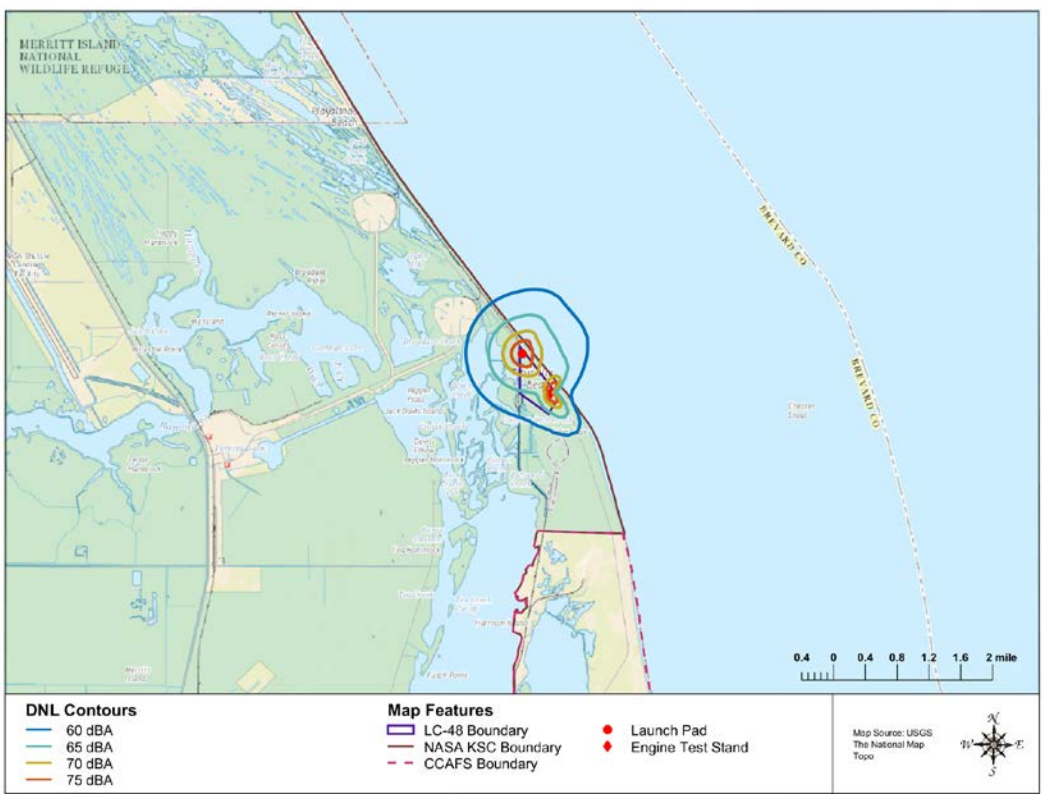

Figure 14. DNL contours for SCLV operations at LC-48

6 Summary

This report documents the noise study performed as part of IMSS efforts on the EA for the proposed Multi-Use LC-48 at KSC. Noise analysis was performed for the launch and engine test operations of a representative SCLV. Note, while engine testing does not currently occur at KSC, pre-launch hot fire tests and engine tests are included in this analysis to assess noise levels associated with the maximum potential level of future development and operations. The potential for propulsion noise and sonic boom impacts is evaluated on a single-event and cumulative basis in relation to human annoyance, hearing conservation and structural damage criteria.

The single event propulsion noise and sonic boom results are discussed in relation to hearing conservation and structural damage claims. The propulsion noise analysis uses KSC's upper noise level limit of 103 dBA, set as a guideline to protect human hearing from long-term continuous daily exposures. $L_{A,max}$ in excess of 103 dBA would be limited to a radius of 1.4 miles from the launch pad, within KSC and Cape Canaveral Air Force Station boundaries. Predicted noise levels in the community are less than OSHA's 115 dBA upper noise limit guideline. The potential for structural damage claims from propulsion noise is approximately one damage claim per 100 households exposed at 120 dB and one in 1,000 households at 111 dB [10]. L_{max} in excess of 120 dB would be limited to a radius of 1.4 miles from the launch pad or engine test stand, and L_{max} in excess of 111 dB would be limited to a radius of 3.8 miles from the launch pad and 3.4 miles from the engine test stand. Predicted noise levels in the community are less than the 111 dB guideline. The nominal sonic boom from a SCLV launch operation is not predicted to intercept the mainland of Florida, and as such, will not exceed the hearing conservation and structural damage criteria.

A significant noise impact is one in which the "action would increase noise by DNL 1.5 dB[A] or more for a noise sensitive area that is exposed to noise at or above the DNL 65 dB[A] noise exposure level, or that will be exposed at or above this level due to the increase, when compared to the No Action Alternative for the same timeframe" [2]. As DNL contours representing the no action alternative at KSC are unavailable, an alternative technique was used to identify potential areas where significant noise impacts may occur as a result of the proposed operations. Existing noise exposure at or below 63.5 dBA would require the SCLV launch and engine tests to generate levels at or above DNL 60 dBA to produce an increase of 1.5 dBA in the DNL to levels above 65 dBA. Therefore, the DNL 60 dBA contour, which extends approximately 0.7-1.2 miles from the launch pad, is used to conservatively identify potential areas where noise impacts may occur as a result of the proposed operations.

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Appendix D. National Marine Fisheries Service 2016 Consultation Letter

UNITED STATES DEPARTMENT OF COMMERCE
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NATIONAL MARINE FISHERIES SERVICE
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St. Petersburg, Florida 33701-5505
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F/SER31: NMB

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Environmental Management Branch
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AUG 08 2016

Daniel Czelusniak
Environmental Specialist
Federal Aviation Administration
800 Independence Avenue Southwest
Suite 325
Washington, DC 20591

Dear Mr. Dankert and Mr. Czelusniak:

This letter responds to your request for consultation with us, the National Marine Fisheries Service (NMFS), pursuant to Section 7 of the Endangered Species Act (ESA) for the following action.

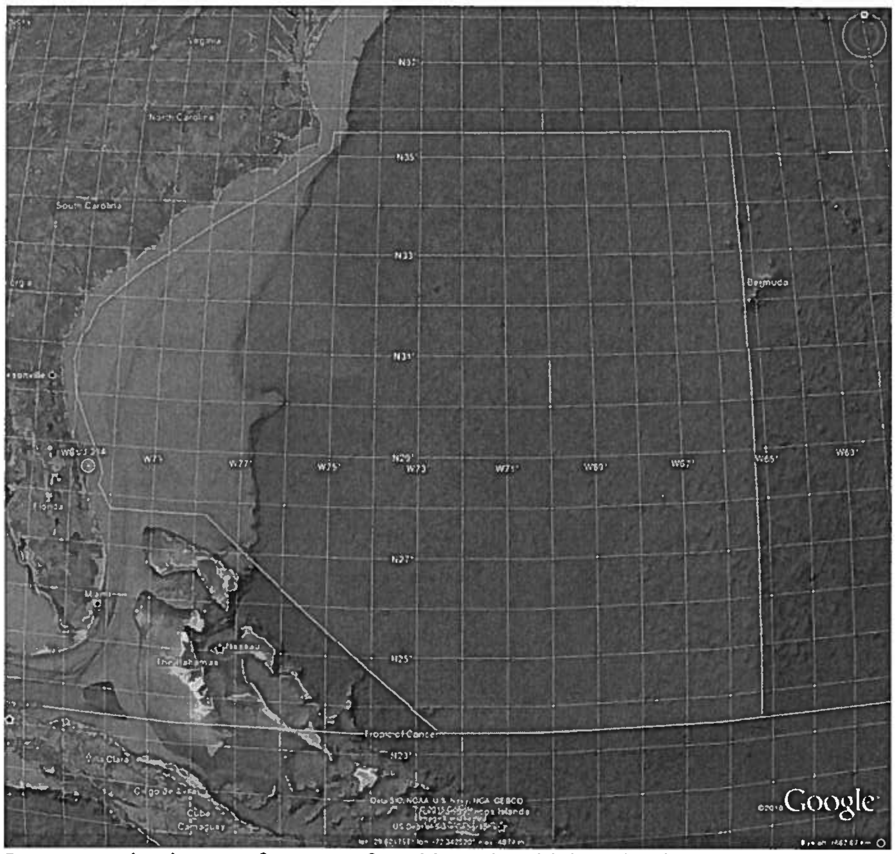
Applicant(s)	**SER Number**	**Project Type(s)**
National Aeronautics and Space Administration (NASA) and Federal Aviation Administration	SER-2016-17894	Waterborne landings of spacecraft

Consultation History

We received your letter requesting consultation on April 11, 2016. We discussed the project with the applicant on May 3, 2016, and requested additional information. During this call, we determined that the project would be expanded from the request to analyze 2 launches with NASA as the lead federal agency to now analyzing all launches occurring from the Kennedy Space Center (KSC), Cape Canaveral Air Force Station (CCAFS), and SpaceX Texas Launch Complex, with the lead federal agency being assigned as NASA, Federal Aviation Administration, or the U.S. Air Force. After exchanging 3 drafts of the project description, we received a final response on July 14, 2016, and initiated consultation that day.

Project Location

Address	Latitude/Longitude	Water body
Kennedy Space Center and Canaveral Air Force Station, Brevard County, Florida	28.608402°N, 80.604201°W (North American Datum 1983) Coordinates provided are for launch pad 39A. Other launch pads at the KSC and CCAFS may be used.	Atlantic Ocean off of Cape Canaveral and Gulf of Mexico
Texas SpaceX Launch Site, 2 miles east of Boca Chica Village, Cameron County, Texas	25.99684°N, 97.15523°W (World Geodetic System 1984)	Gulf of Mexico



Representative image of spacecraft and launch vehicle Atlantic Ocean landing site (Image provided by NASA)


Representative image of spacecraft and launch vehicle Gulf of Mexico landing site (Image provided by NASA)

Existing Site Conditions
The KSC and CCAFS are located on Merritt Island on the northeast coast of Florida. The Texas SpaceX launch site is located on a private site along the east coast of Texas away from the nearby beach. All launch areas are located in upland areas and landing areas are located in open-water within the Atlantic Ocean or Gulf of Mexico, as shown in the images above. The open-water areas for planned landings start a minimum of 5 nautical miles offshore and exclude North Atlantic right whale critical habitat in the Atlantic Ocean.

Project Description
For the purposes of this consultation, the term “spacecraft” will be used to describe modules sent into orbit on the launch vehicle carrying payloads, supplies, or crew. The term “launch vehicle” will be used to describe the rocket and all of its components.

The launch complexes on KSC and CCAFS provide the capability for a variety of vertical and horizontal launch vehicles including, but not limited to, Atlas V, Delta IV, Delta IV Heavy, Liberty, Falcon 9 and 9 v1.1, Falcon Heavy, Antares, RSLV-S, Athena IIc, Xaero, and the Space Launch System to be processed and launched. These launch vehicles and their commercial or government operators are responsible for transporting various spacecraft and payloads into orbit, including reusable manned and unmanned spacecraft such as Orion, Dream Chaser, Boeing CST-100, Liberty Composite Crew Module, and the SpaceX Crew and Cargo Dragon.

The SpaceX Texas launch site provides the capability for operating the Falcon 9 and Falcon Heavy launch vehicles. All Falcon 9 and Falcon Heavy launches would be expected to have payloads including satellites or experimental payloads. Additionally, the Falcon 9 and Falcon Heavy may also carry the SpaceX Dragon spacecraft. Most payloads would be commercial; however, some could be government sponsored launches.

Commercial and government spacecraft launched from KSC, CCAFS and the SpaceX Texas launch complex may result in portions of the spacecraft and/or launch vehicle returning to earth and landing in the Atlantic Ocean or Gulf of Mexico. The launch trajectories are specific to each particular launch vehicle’s mission. However, all launches are conducted to the east over the

Atlantic Ocean, similar to past and current launches from KSC and CCAFS. All launch trajectories from the SpaceX Texas launch facility would be to the east over the Gulf of Mexico.

The following is a representative example of a nominal launch, waterborne landing and recovery based on the SpaceX Falcon 9 launch vehicle and the Crew Dragon spacecraft launched from KSC. This scenario is also generally applicable to other launch vehicles and spacecraft launch and recovery operations. It should be noted that currently not all of the above mentioned launch vehicles have a recoverable first or second stage. For example, launch vehicles in the Atlas and Delta family are classified as evolved expendable launch vehicles. These types of launch vehicles destruct upon reentry into the atmosphere and are not recovered. In the unlikely event of a launch failure, pad abort, or assent abort, efforts would be made to attempt to recover any remaining portions of the launch vehicle or spacecraft. Any debris that could not be recovered from the surface would sink to the ocean bottom.

There are several scenarios that could occur due to a launch failure:

- The entire launch vehicle and spacecraft, with onboard propellants, fails on the launch pad and an explosion occurs. The spacecraft may be jettisoned into the nearshore waters.
- The entire launch vehicle and spacecraft, with onboard propellants, is consumed in a destruction action during assent. The launch vehicle is largely consumed in the destruction action and the spacecraft is jettisoned, but residual propellant escapes and vaporizes into an airborne cloud.
- The launch vehicle and spacecraft survive to strike the water intact or partially intact potentially releasing propellants into the surface waters.

The probability of any of these launch failure scenarios is unknown and highly unlikely but could potentially have a short term localized adverse effect on marine life and habitat. To date, NASA has had a 98-99% success rate with launches.

Following the nominal launch of the launch vehicle and following first stage separation the launch vehicle would make a powered decent returning to either a designated landing pad located onshore or a drone ship located approximately 500 miles down range on the Atlantic Ocean east of Cape Canaveral or in the Gulf of Mexico. The manned or unmanned spacecraft, after completion of its mission, would descend into the Atlantic Ocean or Gulf of Mexico either under parachute canopy or propulsive landing. These capsules are relatively small in size, averaging less than 200 square feet (ft^2) in size. The main parachutes may be up to 150 feet (ft) in diameter.

A propulsive landing scenario and parachute landing scenario generally follow the same landing sequence with the main difference being that under a propulsive landing scenario the spacecraft would fire its engines to slow its decent. The spacecraft performs a deorbit burn in orbit and re-enters the atmosphere on a lifting guided trajectory. At high altitudes, the vehicle may perform an "engine burp" in order to test engine health before the propulsive landing. For a propulsive landing, the drogue chutes may be used but the main parachutes will not be deployed. Instead, at an altitude of between approximately 500 and 1,000 meters, the vehicle will light its engines and start to decelerate until ultimately it makes a waterborne landing. In a non-propulsive waterborne landing scenario the main parachutes are deployed at a predesignated altitude and slow the spacecraft to a safe speed prior to entering the water.

Following a successful landing, a contracted vessel will retrieve the parachutes and spacecraft from the water surface. Since the contracted vessel will be in the water to observe the test, recovery of the capsule and parachutes is expected to begin within an hour of the landing. The vessel will either use an overhead crane to load the capsule onto the vessel or tow the capsule back to shore at Port Canaveral or other nearby commercial wharf where it will be offloaded and transported to an inland facility.

A spacecraft reentering the atmosphere for either a propulsive or non-propulsive waterborne landing may contain residual amounts of propellant used to support on-orbit operations, the deorbit burn, entry and attitude control and propulsive landings. Spacecraft are designed to contain residual propellant and it is not expected that there would be a release of any propellants into the water. Once the spacecraft is safely transported back to land the remaining propellants would be offloaded.

In the unlikely event that any propellants are released into the water during a failed launch or a water landing, they would be quickly dispersed and diluted and would not be expected to create any long term effects on habitat or species within proximity to the landing area. According to NASA, spacecraft may carry hypergolic propellants, which are toxic to marine organisms. Specifically, the spacecraft may carry nominal values of monomethylhydrazine fuel and nitrogen tetroxide oxidizer. Propellant storage is designed to retain residual propellant, so any propellant remaining in is not expected to be released into the ocean. Nitrogen tetroxide almost immediately forms nitric and nitrous acid on contact with water, and would be very quickly diluted and buffered by seawater; hence, it would offer negligible potential for harm to marine life. With regard to hydrazine fuels, these highly reactive species quickly oxidize forming amines and amino acids. Prior to oxidation, there is some potential for exposure of marine life to toxic levels, but for a very limited area and time. A half-life of 14 days for hydrazine in water is suggested based on the unacclimated aqueous biodegradation half-life.

Within the overall missions that could potentially have waterborne landings there may be a limited number of pad abort and assent abort testing operations that would involve launching spacecraft on a low altitude non-orbit trajectory resulting in a waterborne landing within 1-20 miles east of the launch site in the coastal waters of the Atlantic Ocean. This type of testing operation would typically involve a non-propulsive landing using both drogue and main parachutes. Recovery operations would be consistent with the description above.

As the space program advances, there is currently a general progression in the development of technology and mission operations to enable both launch vehicles and spacecraft to land on barges at sea and ultimately on land. To that end, the need for open-water landings of routine missions may be phased out in the future. However, it is likely that waterborne landings in the Atlantic Ocean or Gulf of Mexico will be utilized as back-up landing locations to land based landing sites. NASA estimates that approximately 60 open-water landings could occur in the next 10 years including test launches associated with pad abort and ascent abort operations. Open-water landings may occur day or night at any time of year. This consultation address all open-water landings occurring from KSC, CCAFS and the SpaceX Texas Launch Complex result in portions that follow the protective measures defined below.

Construction Conditions
NASA will follow the protective measures listed below:

1) **Education and Observation:** All personnel associated with the project shall be instructed about the presence of species protected under the Endangered Species Act (ESA) and the Marine Mammal Protection Act (MMPA).
   a) A dedicated observer shall be responsible for monitoring for ESA-species during all in-water activities including transiting marine waters to retrieve space launch equipment. Observers shall survey the area where space equipment landed in the water to determine if any ESA-listed species were injured or killed.
   b) All personnel shall be advised that there are civil and criminal penalties for harming, harassing, or killing ESA listed species or marine mammals.
   c) More information about ESA-listed species is available on our website at: http://sero.nmfs.noaa.gov/protected_resources/section_7/threatened_endangered/index.html

2) **Reporting** of interactions with protected species:
   a) Any collision(s) with and/or injury to any sea turtle, sawfish, or whale, shall be reported immediately to NMFS's Protected Resources Division (PRD) at (1-727-824-5312) or by email to takereport.nmfsser@noaa.gov.
   b) Smalltooth sawfish: Report sightings to 1-941-255-7403 or email Sawfish@MyFWC.com
   c) Sea turtles and marine mammals: Report stranded, injured, or dead animals to 1-877-WHALE HELP (1-877-942-5343).
   d) North Atlantic right whale: Report injured, dead, or entangled right whales to the U.S. Coast Guard via VHF Channel 16.

3) **Vessel Traffic and Construction Equipment**: All vessel operators must watch for and avoid collision with ESA-protected species. Vessel Operators must maintain a safe distance by following these protective measures:
   a) Sea turtles: Maintain a minimum distance of 150 ft.
   b) North Atlantic right whale: Maintain a minimum 1,500 ft (500 yard) distance.
   c) Vessels 65-ft long or more must comply with the Right Whale Ship Strike Reduction Rule (50 CFR 224.105) including reducing speeds to 10 knots or less in Seasonal Management Areas (http://www.fisheries.noaa.gov/pr/shipstrike/).
   d) Mariners shall check various communication media for general information regarding avoiding ship strikes and specific information regarding right whale sightings in the area. These include NOAA weather radio, U.S. Coast Guard NAVTEX broadcasts, and Notices to Mariners.
   e) Marine mammals (i.e., dolphins, whales, and porpoises): Maintain a minimum distance of 300 ft.
   f) When these animals are sighted while the vessel is underway (e.g., bow-riding), attempt to remain parallel to the animal's course. Avoid excessive speed or abrupt changes in direction until they have left the area.

g) Reduce speed to 10 knots or less when mother/calf pairs or groups of marine mammals are observed, when safety permits.

4) **Hazardous Materials Emergency Response**: In the unlikely event of a failed launch or landing, SpaceX would follow the emergency response and cleanup procedures outlined in their Hazardous Material Emergency Response Plan. These procedures may include containing the spill using disposable containment materials and cleaning the area with absorbents or other materials to reduce the magnitude and duration of any impacts. In most launch failure scenarios at least a portion of the fuels will be consumed by the launch, and any remaining fuels will be diluted by seawater and biodegrade over time (timeframes are variable based on environmental conditions).

Effects Determination(s) for Species the Action Agency or NMFS Believes May Be Affected by the Proposed Action

Species	ESA Listing Status	Action Agency Effect Determination	NMFS Effect Determination
Sea Turtles			
Green (North Atlantic and South Atlantic distinct population segment [DPS])	T	NLAA	NLAA
Kemp's ridley	E	NLAA	NLAA
Leatherback	E	NLAA	NLAA
Loggerhead (Northwest Atlantic Ocean DPS)	T	NLAA	NLAA
Hawksbill	E	NLAA	NLAA
Fish			
Smalltooth sawfish (U.S. DPS)	E	NLAA	NLAA
Gulf sturgeon (Atlantic sturgeon, Gulf subspecies)	T	NLAA	NLAA
Shortnose sturgeon	E	NLAA	NLAA
Atlantic sturgeon (Carolina DPS)	E	NLAA	NLAA
Atlantic sturgeon (South Atlantic DPS)	E	NLAA	NLAA
Marine Mammals			
North Atlantic right whale	E	NLAA	NLAA
Blue whale	E	ND	NLAA
Fin whale	E	ND	NLAA
Humpback whale	E	ND	NLAA
Sei whale	E	ND	NLAA
Sperm whale	E	ND	NLAA
E = endangered; T = threatened; NLAA = may affect, not likely to adversely affect; ND = no determination			

Critical Habitat

North Atlantic right whale critical habitat

NASA planned landings are proposed to occur outside of North Atlantic right whale critical habitat. In the unlikely event that a launch failure occurred in nearshore waters near Cape Canaveral, it could occur in North Atlantic right whale critical habitat. The following essential features are present in Unit 2:

- Sea surface conditions associated with Force 4 or less on the Beaufort Scale
- Sea surface temperatures of 7°C to 17°C
- Water depths of 6 to 28 m, where these features simultaneously co-occur over contiguous areas of at least 231 square nautical miles of ocean waters during the months of November through April. When these features are available, they are selected by right whale cows and calves in dynamic combinations that are suitable for calving, nursing, and rearing, and which vary, within the ranges specified, depending on factors such as weather and age of the calves.

We do not believe any of the essential features may be affected by the proposed action.

Loggerhead sea turtle critical habitat

The in-water landing sites are located within the boundary of loggerhead sea turtle critical habitat. The following primary constituent elements (PCEs) are present in the Atlantic Ocean and Gulf of Mexico landing areas that include Units Logg-N-1 to Logg-N-19 plus Logg-S-1 and Logg-S-2. Since the open-water landing areas begin 5 nautical miles offshore, nearshore reproductive habitat is not considered within the planned landing areas. In the unlikely event that a launch failure occurred in nearshore waters near Cape Canaveral, it could occur in loggerhead nearshore reproductive critical habitat.

- Nearshore reproductive habitat: The physical or biological features of nearshore reproductive habitat as a portion of the nearshore waters adjacent to nesting beaches that are used by hatchlings to egress to the open-water environment as well as by nesting females to transit between beach and open water during the nesting season. The following primary constituent elements support this habitat: (i) Nearshore waters directly off the highest density nesting beaches and their adjacent beaches, as identified in 50 CFR 17.95(c), to 1.6 kilometers offshore; (ii) Waters sufficiently free of obstructions or artificial lighting to allow transit through the surf zone and outward toward open water; and (iii) Waters with minimal manmade structures that could promote predators (i.e., nearshore predator concentration caused by submerged and emergent offshore structures), disrupt wave patterns necessary for orientation, and/or create excessive longshore currents.
- Breeding areas: the physical or biological features of concentrated breeding habitat as those sites with high densities of both male and female adult individuals during the breeding season. Primary constituent elements that support this habitat are the following: (i) High densities of reproductive male and female loggerheads; (ii) Proximity to primary Florida migratory corridor; and (iii) Proximity to Florida nesting grounds.
- Constricted migratory habitat: the physical or biological features of constricted migratory habitat as high use migratory corridors that are constricted (limited in width) by land on one side and the edge of the continental shelf and Gulf Stream on the other side. Primary

constituent elements that support this habitat are the following: (i) Constricted continental shelf area relative to nearby continental shelf waters that concentrate migratory pathways; and (ii) Passage conditions to allow for migration to and from nesting, breeding, and/or foraging areas.

- Sargassum habitat: the physical or biological features of loggerhead *Sargassum* habitat as developmental and foraging habitat for young loggerheads where surface waters form accumulations of floating material, especially *Sargassum.* Primary constituent elements that support this habitat are the following: (i) Convergence zones, surface-water downwelling areas, the margins of major boundary currents (Gulf Stream), and other locations where there are concentrated components of the *Sargassum* community in water temperatures suitable for the optimal growth of *Sargassum* and inhabitance of loggerheads; (ii) *Sargassum* in concentrations that support adequate prey abundance and cover; (iii) Available prey and other material associated with *Sargassum* habitat including, but not limited to, plants and cyanobacteria and animals native to the *Sargassum* community such as hydroids and copepods; and (iv) Sufficient water depth and proximity to available currents to ensure offshore transport (out of the surf zone), and foraging and cover requirements by *Sargassum* for post-hatchling loggerheads, i.e., >10 m depth.
- Winter habitat: the physical or biological features of loggerhead winter habitat are warm water habitat south of Cape Hatteras near the western edge of the Gulf Stream used by a high concentration of juveniles and adults during the winter months. Primary constituent elements that support this habitat are the following: (i) Water temperatures above 10° C from November through April; (ii) Continental shelf waters in proximity to the western boundary of the Gulf Stream; and (iii) Water depths between 20 and 100 m.

We do not believe any of the PCEs may be affected by the proposed action.

Analysis of Potential Routes of Effects to Species
Sea turtles, smalltooth sawfish, sturgeon, whales may be affected by open-water landings if they were to be struck by falling materials, spacecraft, or controlled burn water landings. Due to the relative small size of capsules (less than 200 ft^2), NMFS believes that is highly unlikely that protected species will be struck and that the effects are discountable. Smalltooth sawfish and sturgeon are bottom dwelling and unlikely to interact with these items at the surface. Sea turtles and whales spend time at the surface to breath and are thus are at a higher risk of interacting with spacecraft. However, turtles and whales spend the majority of their time submerged as opposed to on the surface, thus lowering the risk of interactions. These launches have been occurring for decades with no known interactions with sea turtles or whales. Also, launches occur intermittently (occurring approximately every few months) and the goal is to ultimately reduce and eliminate the need for open-water landings.

Sea turtles and whales could also become entangled in the parachutes that will transport the capsule to the water surface. However, we believe that these species will avoid the area immediately following a landing and that all materials will be retrieved quickly (approximately 1 hour). Therefore, we believe the risk of entanglement is discountable.

Sea turtles, smalltooth sawfish, sturgeon, and whales could be affected by any hazardous materials spilled into the Atlantic Ocean or Gulf of Mexico during the proposed action.

However, such an effect is highly unlikely (98-99% success rate), failed missions do not necessarily occur over marine waters, and most if not all fuel would be consumed or contained. For planned marine landings, all fuel valves will shut automatically prior to landing to retain any residual fuels. Therefore, although a small fuel spill is possible, it is highly unlikely and any risk to protected species is discountable.

Conclusion
Because all potential project effects to listed species and critical habitat were found to be discountable, insignificant, or beneficial, we conclude that the proposed action is not likely to adversely affect listed species and critical habitat under NMFS's purview. This concludes your consultation responsibilities under the ESA for species under NMFS's purview. Consultation must be reinitiated if a take occurs or new information reveals effects of the action not previously considered, or if the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat in a manner or to an extent not previously considered, or if a new species is listed or critical habitat designated that may be affected by the identified action. NMFS's findings on the project's potential effects are based on the project description in this response. Any changes to the proposed action may negate the findings of this consultation and may require reinitiation of consultation with NMFS.

We have enclosed additional relevant information for your review. We look forward to further cooperation with you on other projects to ensure the conservation of our threatened and endangered marine species and designated critical habitat. If you have any questions on this consultation, please contact Nicole Bonine, Consultation Biologist, at (727) 824-5336, or by email at Nicole.Bonine@noaa.gov.

Sincerely,

for Roy E. Crabtree, Ph.D.
Regional Administrator

Enc.: 1. *Sea Turtle and Smalltooth Sawfish Construction Conditions* (Revised March 23, 2006)
2. *PCTS Access and Additional Considerations for ESA Section 7 Consultations* (Revised March 10, 2015)

File: 1514-22.V

Appendix E. State Historic Preservation Officer (SHPO) Letters

FLORIDA DEPARTMENT of STATE

RICK SCOTT
Governor

KEN DETZNER
Secretary of State

Mr. Chris Stahl
Florida Department of Environmental Protection
Florida State Clearinghouse
2600 Blair Stone Road, MS 47
Tallahassee, FL 32399-2400

November 5, 2018

RE: DHR Project File No.: 2018-5306, Received by DHR: October 4, 2018
SAI# FL201810048448C
Project: *National Aeronautics and Space Administration (NASA) – Draft Environmental Assessment for Launch Complex 48 – John F. Kennedy Space Center, Brevard County, Florida*

Ms. Stahl:

Our office reviewed the *Draft Environmental Assessment for Launch Complex 48 – John F. Kennedy Space Center* in accordance with the National Environmental Policy Act of 1969 (NEPA) and implementing regulations. We find the document to be consistent with federal regulation regarding the treatment of historic properties/cultural resources under NEPA.

The proposed development area was surveyed for cultural resources by Archaeological Consultants, Inc. (ACI) in 2008 on behalf of NASA (Florida Master Site File No.: 15932). ACI did not relocated archaeological sites 8BR915 and 8BR916 and recommended that the sites were destroyed during previous activities. At the time our office agreed with ACI's findings and concurred with NASA's determination that the proposed development activities would have no effect to historic properties listed, or eligible for listing, in the National Register of Historic Places (NRHP) (DHR Project File No.: 2008-5830).

Based on the information included in this draft EA, our office still concurs that the proposed undertaking will have no effect to historic properties listed, or eligible for listing, in the NRHP. If you have any questions, please contact me by email at *Jason.Aldridge@dos.myflorida.com*, or by telephone at 850-245-6344.

Sincerely,

Jason Aldridge
Deputy State Historic Preservation Officer
for Compliance and Review

Division of Historical Resources
R.A. Gray Building • 500 South Bronough Street• Tallahassee, Florida 32399
850.245.6300 • 850.245.6436 (Fax) FLHeritage.com

FLORIDA DEPARTMENT OF STATE
Kurt S. Browning
Secretary of State
DIVISION OF HISTORICAL RESOURCES

Ms. Barbara Naylor
National Aeronautics and Space Administration
Kennedy Space Center, Florida 32899

October 17, 2008

Attn: TA-B1C

Re: DHR Project File No.: 2008-05830
Received by DHR: September 8, 2008
Cultural Resource Assessment Survey of the Proposed Commercial Vertical Launch Complex at the John F. Kennedy Space Center, Brevard County, Florida

Dear Ms. Naylor:

Our office received and reviewed the above referenced survey report in accordance with Section 106 of the *National Historic Preservation Act of 1966* (Public Law 89-665), as amended in 1992, and *36 C.F.R., Part 800: Protection of Historic Properties*, and Chapter 267, *Florida Statutes*, for assessment of possible adverse impact to cultural resources (any prehistoric or historic district, site, building, structure, or object) listed, or eligible for listing, in the National Register of Historic Places (NRHP).

In March 2008, Archaeological Consultants, Inc. (ACI) conducted an archaeological and historical Phase I survey of two potential areas for the Commercial Vertical Launch Complex on behalf of The Dynamac Corporation and the National Aeronautics and Space Administration Kennedy Space Center (NASA-KSC). ACI did not relocate two previously recorded archaeological sites (8BR915 and 8BR916) within the project area during the investigation. It is the opinion of ACI that these sites have been destroyed.

ACI determined that the proposed project will have no effect on the railroad or other cultural resources listed, or eligible for listing, on the NRHP or otherwise of archaeological, architectural, or historical significance. ACI recommends no further investigation of the area.

Based on the information provided, our office concurs with the determinations of the NASA-KSC and finds the submitted report complete and sufficient in accordance with Chapter 1A-46, *Florida Administrative Code.*

500 S. Bronough Street • Tallahassee, FL 32399-0250 • http://www.flheritage.com

❑ Director's Office (850) 245-6300 • FAX: 245-6436
❑ Archaeological Research (850) 245-6444 • FAX: 245-6452
☑ Historic Preservation (850) 245-6333 • FAX: 245-6437

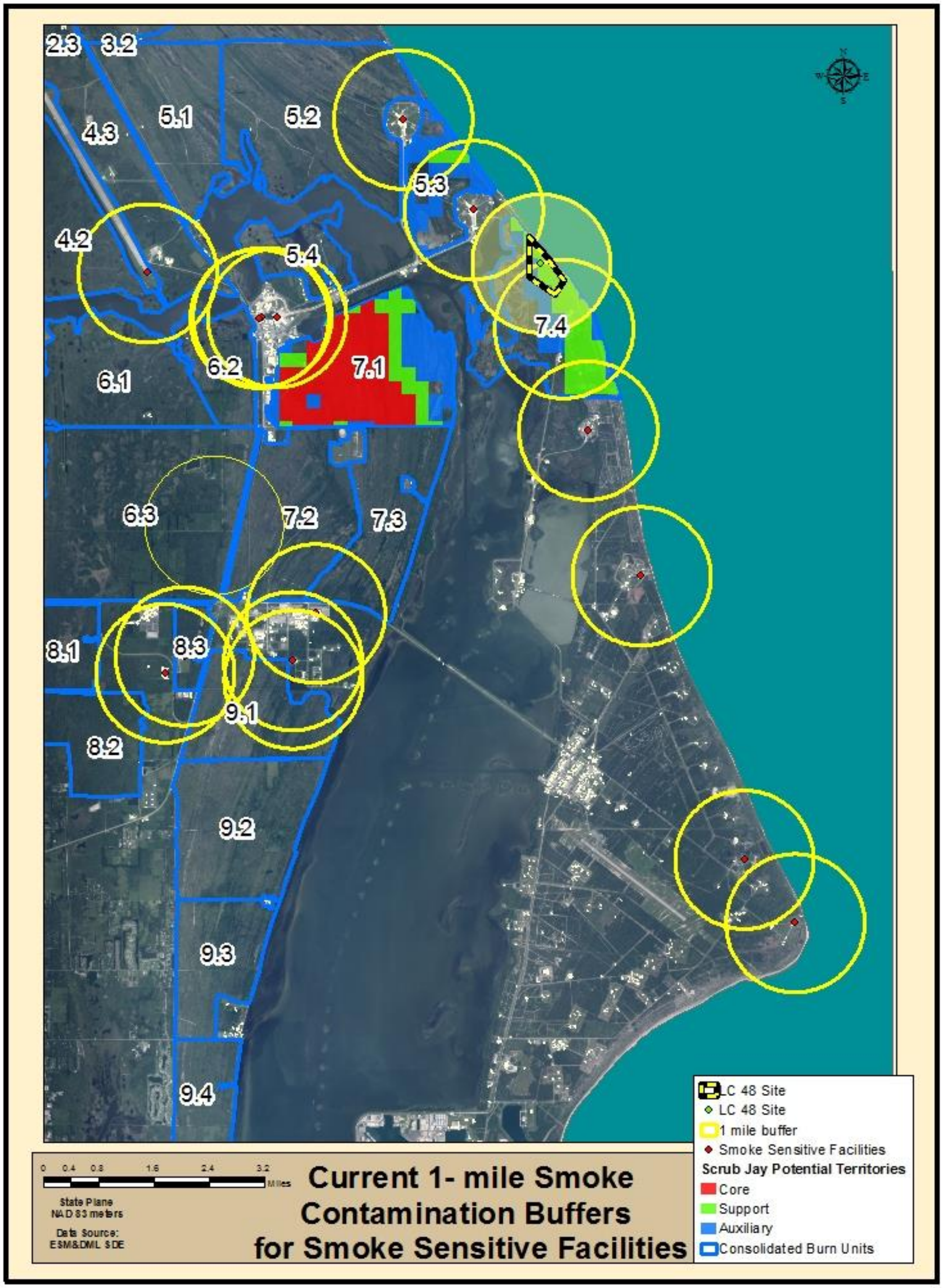
For any questions concerning our comments, please contact April Westerman, Historic Preservationist, by electronic mail at amwesterman@dos.state.fl.us, or by phone at (850) 245-6333. We appreciate your continued interest in protecting Florida's historic properties.

Sincerely,

Frederick P. Gaske, Director, and
State Historic Preservation Officer

Xc: Archaeological Consultants, Inc.

Appendix F. Smoke Contamination Buffers for Smoke Sensitive Facilities



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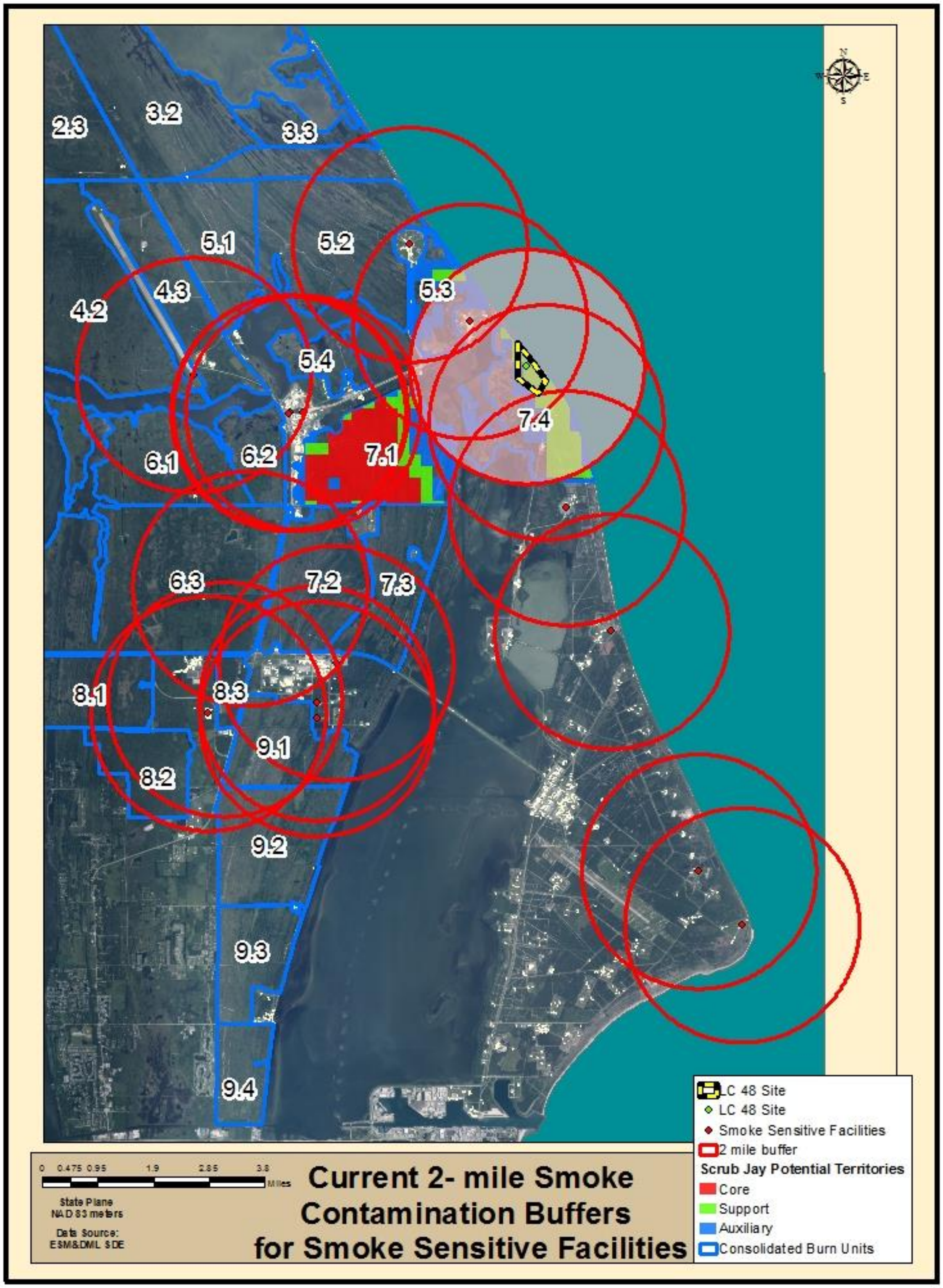
State Plane
NAD 83 meters
Data Source:
ESM&DML SDE
Current 1- mile Smoke
Contamination Buffers
for Smoke Sensitive Facilities
LC 48 Site
LC 48 Site
1 mile buffer
Smoke Sensitive Facilities
Scrub Jay Potential Territories
Core
Support
Auxiliary
Consolidated Burn Units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LC 48 Site
LC 48 Site
Smoke Sensitive Facilities
2 mile buffer
Scrub Jay Potential Territories
Core
Support
Auxiliary
Consolidated Burn Units
0 0.475 0.95 1.9 2.85 3.8 Miles
State Plane
NAD 83 meters
Data Source:
ESM&DML SDE
Current 2- mile Smoke
Contamination Buffers
for Smoke Sensitive Facilities