Draft Environmental Assessment for the SpaceX Starship and Super Heavy Launch Vehicle at Kennedy Space Center (KSC)

August 2019

EXECUTIVE SUMMARY

Space Exploration Technologies Corporation (SpaceX) has prepared this Environmental Assessment (EA), with National Aeronautics and Space Administration (NASA) as Lead Agency, to evaluate the potential environmental impacts resulting from construction and operations associated with the proposed SpaceX Starship/Super Heavy launch vehicle at Kennedy Space Center (KSC). This EA analyzes effects on resources due to the Proposed Action 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). Because SpaceX plans to apply to the Federal Aviation Administration (FAA) Office of Commercial Space Transportation for launch and reentry licenses for Starship/Super Heavy, this EA considers the FAA's NEPA-implementing policy-FAA Order 1050.1F, *Environmental Impacts: Policies and Procedures*, regarding potential launch-related and reentry-related impacts.

SpaceX has successfully demonstrated their ability to service the launch industry with the Falcon family of launch vehicles now developing a multi-mission, fully reusable, super heavy-lift launch vehicle. The Starship/Super Heavy launch vehicle would reduce the cost of access to space, exceeding the capabilities of the Falcon 9 and Falcon Heavy launch vehicles, enabling cost-effective delivery of cargo and people to the Moon and Mars.

Purpose and Need

NASA's purpose and need for the Proposed Action is to develop and implement formal agreements with SpaceX for use of NASA assets and to provide services and commodities to enable Starship/Super Heavy launches. Commercial use of KSC real property supports NASA's mandate to encourage the fullest commercial use of space, supports the goals of the National Aeronautics and Space Act, and advances the National Space Policy that federal agencies shall ensure that U.S. Government space technology and infrastructure is made available for commercial use on a reimbursable, noninterference, and equitable basis. The need for the Proposed Action also aligns with NASA's Space Act Agreement and the FAA Office of Commercial Space Transportation's mission, which is to support the U.S. goal of encouraging activities by the private sector to strengthen and expand U.S. space transportation infrastructure.

Additionally, the Proposed Action will support NASA in its continued mission to expand commercial uses of space and the space industry by facilitating SpaceX efforts to strengthen United States (U.S.) space transportation and launch infrastructure. It would also provide greater mission capability to NASA and SpaceX by continuing the development of ever evolving next generation launch vehicles and spacecraft. Additionally, the Proposed Action may support NASA in meeting the U.S. goal of near-term lunar exploration.

Proposed Action

Pursuant to the Commercial Space Launch Act (CSLA), SpaceX currently operates its Falcon family of launch vehicles on KSC at Launch Complex 39A (LC-39A). SpaceX proposes to expand operations to include launch of Starship/Super Heavy vehicle from this complex. The fully reusable rocket system is being developed by SpaceX to take humans and cargo to Earth orbit and beyond, including to the Moon and Mars.

The launch vehicle is comprised of two stages; the Super Heavy booster is the first stage, and the Starship is the second stage. The booster would be powered by 31 Raptor engines and Starship spacecraft would be powered by seven Raptor engines. The propellant is composed of liquid oxygen (LOX) and liquid methane (LCH_4). SpaceX intends to eventually launch the Starship/Super Heavy approximately 24 times per year. The Starship/Super Heavy would include Lunar and Mars missions, satellite payload missions, and human spaceflight.

SpaceX would construct an additional launch mount for Starship/Super Heavy at LC-39A, adjacent to the existing mount used for the Falcon 9 and Falcon Heavy. A LCH_4 farm would be built near the existing Falcon Rocket Propellant-1 (RP-1) farm similar in structure to the existing LOX farm. Site improvements would also include an interior transport road leading from the pad entrance gate up to the launch mount as well as several new high pressure gaseous commodity lines. A deluge water system and water cooled flame diverter would be installed and comprised of new water tanks capable of delivering the necessary water pressure. The Landing Zone 1 (LZ-1) facility, at Cape Canaveral Air Force Station (CCAFS), would be used as a landing location for Starship, similar to its current use for Falcon booster landings. The Starship spacecraft is the second stage of the vehicle. Super Heavy is the first stage booster and would be landed downrange on a droneship (converted barge), similar to the downrange landings of Falcon boosters. SpaceX's proposed action includes the construction of a landing pad for Starship land landings within the LC-39A boundary. The potential for land landings of Starship at LC-39A will require additional analysis to fully assess the potential impacts to NASA programs, facilities, personnel and operations.

Alternatives Considered but Removed from Further Analysis

Alternative locations for the operation, launch, and landing of the Starship/Super Heavy considered included, SLC-40 within CCAFS and Space Launch Complex 4 (SLC-4) within Vandenberg Air Force Base (VAFB), where SpaceX also operates the Falcon. SpaceX would need to undertake significant modifications to either site to support the Proposed Action. Further, SLC-4's location does not support launch trajectories that will compromise the vast majority of Starship/Super Heavy. LC-39A was ultimately chosen for the Proposed Action since it presented the least environmental impact. LC-39A provides the best combination of available real estate, existing developments, distance from population centers, and available clear launch azimuths to maximize public safety for operational launches. LC-39A also provides enough space to accommodate both the Falcon and Starship/Super Heavy. SLC-40 was also considered for landing operations but the infrastructure and size do not support landing a space vehicle. SLC-4 was considered as a landing location; however the distance needed to transport the vehicle from SLC-4 back to the LC-39A launch site would not support the operations of the Starship/Super Heavy launch vehicle. LZ-1 is the preferred landing location because of the existing infrastructure needed for safing a landed vehicle and the minimal distance needed to transport from landing to re-launching. For those reasons, SLC-40 and SLC-4 were not considered as alternatives for this EA, therefore they were not further analyzed. SpaceX is a Starship prototype "hopper" at SpaceX's site in Cameron County, TX. In the future, SpaceX may develop and launch the Starship/Super Heavy from its facility in Cameron County, TX. This action would analyzed in a separate NEPA document.

No Action Alternative

Under the No Action Alternative, NASA would not allow SpaceX to implement Starship/Super Heavy at LC-39A. There would be no construction of the new launch pad or construction of the additional infrastructure and commodities. The NASA mission to assist the National Space Transportation Policy of 1994 stated goal of "assuring reliable and affordable access to space through U.S. space transportation capabilities" would be limited.

Summary of Potential Environmental Effects

This EA considered the following 15 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) properties.

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. Table E-1 presents a summary of the resources considered and the potential impacts on those resources. The descriptions include both construction and operation related tasks associated with Starship/Super Heavy.

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

Resource Area	Potential Environmental Impact from Proposed Action
Land Use/Visual Resources	The land use designation for LC-39A is Vertical Launch and would need to be amended to include landing activities of the Starship. Any proposed land use changes for LC-39A would be initiated and managed by the KSC Center Planning and Development office. LC-39A is surrounded by Operational Buffer/Conservation areas managed by Merritt Island National Wildlife Refuge (MINWR). NASA KSC management would assist the (Unites States Fish and Wildlife Service (USFWS) in resolving any operational barriers in order to accomplish prescribed burns. The Proposed Action is not anticipated to change current fire management program activities. 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. Implementing the Starship/Super Heavy would require some construction and modifications at LC-39A, however these additions would be consistent with existing infrastructure. The Proposed Action would have no significant impact to Land Use or Visual Resources.
Noise	The day-night average sound level (DNL) 65 decibel (dB) contour for Starship/Super Heavy launch is located within the CCAFS and KSC properties and would not reach residences in neighboring communities. The 65 dB contour does overlap MINWR and Canaveral National Seashore (CNS), but these areas would be impacted intermittently, for short periods. The Max A-Weighted Level (L_{Amax}) would be less than 90 dB and Sound Exposure Level (SEL) would be less than 110 dB on CNS during a Starship/Super Heavy launch from LC-39A. Impacts would be moderate with no significant impacts. The estimated DNL 65 dB contour for Starship landing operations at LZ-1 is contained within CCAFS and KSC properties. The Max A-Weighted Level (L_{Amax}) would be less than 90 dB and Sound Exposure Level (SEL) would be close to 90 dB on CNS during a Starship land landing from LZ-1. The Super Heavy booster droneship landings are planned to occur no closer than 20 nautical miles (nm) offshore and would not be heard by coastal residents. The estimated DNL contours over land for Starship and Super Heavy booster static fire tests at LC-39A are all contained within the KSC boundary. The Max A-Weighted Level (L_{Amax}) would be less than 90 dB and Sound Exposure Level (SEL) would be less than 100 dB on CNS during a Starship static fire at LC-39A. The Max A-Weighted Level (L_{Amax}) would be 90 dB and Sound Exposure Level (SEL) would be less than 110 dB on CNS during a Super Heavy booster static fire at LC-39A. Under the Proposed Action, the highest levels of noise from launches, launch support, and industrial-type activities taking place at the site would have no significant impacts on the immediate environment and areas beyond KSC.

Resource Area	Potential Environmental Impact from Proposed Action
Biological Resources	Construction and operations at LC-39A and operations at LZ-1 would require lighting at night, which has a potential to disorient nesting and hatching marine turtles. The proper management of exterior lighting would assist in reducing this impact such that it would not result in jeopardy to any sea turtle species. All facilities would operate under KSC and CCAFS exterior lighting requirements. This would result in a less than significant impact. Adherence to the reasonable and prudent measures and conditions identified in the USFWS Biological Opinions (BOs) would help reduce lighting impacts and incidental take of sea turtles. Measures are similar for both KSC and CCAFS and require Lighting Operations Manual (LOM) and Light Management Plan (LMP) compliance, inspection, enforcement, and monitoring of sea turtle orientation. Any new concerns would be determined through additional Section 7 Consultation between NASA and the United States Air Force (USAF), and the United States Fish and Wildlife Service (USFWS) Endangered Species Office. The routine launch and landing support vessels traveling within the nearshore waters would not constitute a significant increase in water traffic of concern to whales, manatees, or marine turtles. Possible terrestrial effects from launch, include the exhaust heat plume and noise. Repeated heat plumes may cause a less than significant impact to a small mangrove fringe located southeast of LC-39A during launch. Heat damage to near-field vegetation was common during the Shuttle Program with an eventual succession of plants to heat tolerant grasses. The noise associated with Starship/Super Heavy would cause the same startle responses for nearby birds as observed for other launch and aircraft operations. Birds tend to startle, lift-off, and return shortly after the noise subsides. This startle response would effectively direct birds away and reduce risk of being affected by heat. Impacts from launches to birds are expected to be insignificant. No significant impacts to biological resources are expected from sonic booms since the greatest overpressures occur many miles offshore.
Cultural Resources	There are no known archaeological resources within the LC-39A boundary. The use of LC-39A and the Crawlerway by SpaceX for Starship/Super Heavy would not have an impact to the LC-39A Historic District or the historic Crawlerway. There are no historic or archaeologic resources at LZ-1, therefore landing of Starship at the site would have no impact to cultural resources.

Resource Area	Potential Environmental Impact from Proposed Action
Air Quality	Impacts to local and regional air quality due to activities associated with the construction activities, ground and launch operations, landing operations, engine test firing, the occasional operation of generators, and ground vehicle emissions are expected to be insignificant. For the maximum launch frequency of 24 launches per year, Starship/Super Heavy launch vehicle would emit up to 0.29 tons per year of nitrogen oxides (NOx) and carbon monoxide (CO). During the Starship landing, up to 0.016 tons per year of NOx and CO would be emitted. During the Super Heavy booster landing, up to 0.036 tons per year of NOx and CO would be emitted. Static fire tests conducted prior to launch for the Super Heavy booster and Starship would emit 0.13 and 0.03 tons per year, of NOx and CO, respectively. The total potential emissions of any criteria pollutants under the Proposed Action would not be expected to cause exceedances of the National Ambient Air Quality Standards (NAAQS).
Climate and Climate Change/Sea Level Rise	Greenhouse gas (GHG) emissions from construction activities related to the Proposed Action would be minimal and insignificant. The source of emissions would be temporary, occurring only during the construction period. The estimated carbon dioxide (CO_2) emissions from launch, static fire test, and landing events are significantly less than the total GHG emissions generated by the United States in 2018 and the total CO_2 emissions generated worldwide. CO_2 emissions from landing of the Starship or Super Heavy booster, whether on a droneship, at LZ-1, or at LC-39A, would be appreciably less than emissions from launches because fewer engines would be relit. In addition, planned reuse of first stage boosters would reduce potential emissions compared to manufacturing and shipping a new booster to the launch site. Therefore, the emissions of GHGs from Starship/Super Heavy launch, static fire test, and landing events would be insignificant and would not cause any appreciable addition of GHGs into the atmosphere; and the impact to regional or global climate change, including sea level rise, is anticipated to be insignificant. The Crawlerway, roadways and underground utilities are more vulnerable to sea level rise, storm surge and elevated water table than LC-39A, which is elevated.
Hazardous Materials/ Hazardous Waste	All generated wastes would be properly containerized, stored, labeled, manifested, shipped, and disposed of in full regulatory compliance. Best management practices (BMPs) in place for the handling of hazardous materials and hazardous waste would result in minimal impacts from the Proposed Action. All accidental releases of pollutants would be responded to quickly and appropriate clean up measures would be implemented in accordance with applicable laws to minimize impacts to the environment. Therefore, the impact of this project on the environment from hazardous materials and waste would be insignificant.
Water Resources	Impacts to surface water and groundwater would occur from stormwater runoff associated with newly created impervious surface. Treatment of runoff would be required by and involve percolation to groundwater. In each of these cases, the effect would not be significant and easily absorbed by the environment.

Resource Area	Potential Environmental Impact from Proposed Action
	Employing BMPs such as silt fences, turbidity barriers, and stormwater management systems would reduce impacts to surface waters receiving storm runoff from LC-39A and LZ-1. There are no wetland resources located within LC-39A, and no direct impacts to wetlands are expected from Starship/Super Heavy construction actions. Launch deluge and pad washdown water generated from the new Starship/Super Heavy launch pad at LC-39A would be isolated from the existing Falcon deluge system and flow into a new containment and disposal system designed to satisfy industrial wastewater permitting requirements. The Proposed Action is not expected to have significant impacts on water resources.
Geology and Soils	Construction for the Proposed Action would directly impact previously disturbed soils. However, these soils are common on KSC and in east central Florida, therefore impacts would not be significant. The underlying geology of the proposed action area would not be impacted by either construction of facilities or Starship/Super Heavy launch operations at LC-39A.
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. Short- and long-term insignificant 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 changes in traffic patterns near more centralized activities at KSC and the launch complexes. Transportation impacts are classified as minimal due to increased traffic on roadways in support of the launches predicted to take place each year.
Utilities	Construction, ground support activities, and launches are anticipated to have minimal and insignificant impacts on the current wastewater treatment (domestic and industrial), potable water resources, electricity and natural gas, communications, and solid waste resources on KSC. Industrial wastewater such as deluge water or similar discharges not listed as an approved discharge in the Kennedy Industrial Wastewater Inventory (KIWI) would have the potential for insignificant impacts. However, these impacts would be mitigated by an authorized Industrial Wastewater Permit under the Florida Department of Environmental Protection (FDEP). Water supply impacts during construction would be insignificant since potable and non-potable water resources are available near the proposed site. All of the utilities and services are expected to be able to absorb the additional demands. Existing substations and wastewater treatment plants would have sufficient capacities for anticipated needs. Construction of new impervious surfaces would require stormwater management systems and permits and would; therefore, result in moderate but no significant impacts. A stormwater treatment system would be built on site for and any

Resource Area	Potential Environmental Impact from Proposed Action
	modifications within launch pad perimeters or compensatory stormwater treatment would be provided elsewhere for any modifications within the launch pad perimeter. Operations at LC-39A and LZ-1 would have minimal and insignificant impacts on the surface water quality. Stormwater runoff at LC-39A drains to various manmade grassed swales that radiate from the pad and discharge via culverts to a swale that runs parallel to the perimeter access road before discharging to receiving waters on the periphery of the site. Stormwater runoff at LZ-1 drains to pervious surfaces around the pad and infiltrates. In compliance with the Clean Water Act (CWA), operators of stormwater discharges associated with certain industrial activities are authorized to discharge to waters of the United States in accordance with the eligibility and NOI requirements, effluent limitation, inspection requirements, and other conditions set forth by National Pollutant Discharge Elimination System (NPDES) Multi Sector General Permit. SpaceX operates in accordance with an NPDES Multi-Sector General Permit. Implementing procedures already in place and adhering to permit conditions would mitigate effects from stormwater runoff resulting in no significant impacts.
Health and Safety	Potential adverse effects to human health and safety could occur during construction and facility modifications, and industrial operations attributed to the Proposed Action. SpaceX would comply with all applicable federal, state, and local and company safety regulations for storage, use, and transfer of toxic and hazardous materials. Coordination between LC-39A and LZ-1 users and the KSC or CCAFS Explosive Safety Managers would 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. Any potential releases of hazardous materials would be managed according to all applicable regulations, and implementation of BMPs would ensure this increased risk is minimal. With the 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 and insignificant.
Socioeconomics	Overall, the direct, economic impacts resulting from the Proposed Action would be positive. The improved capabilities and longevity of SpaceX operations at KSC and CCAFS would continue to provide beneficial impacts and labor income over the next two decades.
Environmental Justice and Children's Environmental Health and Safety	Currently, the population inhabiting 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. Within the region of influence (ROI), 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.

Resource Area	Potential Environmental Impact from Proposed Action
Department of Transportation Act, Section 4(f) Properties	Launch operations would not result in a physical use (direct taking) or temporary occupancy of any Section 4(f) property. At this time, the FAA does not have enough information about SpaceX's proposal to conduct a sufficient 4(f) analysis with respect to potential impacts and constructive use. Specifically, the details regarding potential closures or restricted access of Section 4(f) properties is unknown. Therefore, the FAA cannot reach a 4(f) determination for potential launch-related impacts. Once the FAA receives a license application from SpaceX for Starship/Super Heavy launch operations at LC-39A, the FAA will conduct a 4(f) analysis prior to issuing a decisional document for the FAA's environmental review or any launch or reentry license. As part of the FAA's 4(f) analysis, the FAA will coordinate with the officials that have jurisdiction over the Section 4(f) properties (e.g., USFWS and NPS) in determining potential for use under Section 4(f). Due to the proximity of Section 4(f) properties to LC-39A, the Section 4(f) properties might experience increased light emissions or sky glow generated during nighttime operations. All nighttime lighting would comply with the KSC Lighting Operations Plan (KSC-PLN-1210, Rev A), thereby avoiding or minimizing any potential lighting impacts to the Section 4(f) properties. The Section 4(f) properties would experience temporary noise from Starship/Super Heavy launches, landings, and engine tests. The increased noise level would only last a few minutes during a launch (i.e. takeoff), less than a minute during a landing, and a few seconds during a static engine test. Additionally, a sonic boom would be audible (less than a second) within the Section 4(f) properties during a Starship landing. There is a possibility of temporary restricted access on portions of KSC property managed by USFWS (MINWR) and NPS (CNS), as have occurred for recent and past launch operations. Closures due to safety hazards are dependent upon the risk assessment performed by the USAF Range Safety office and the FAA (for commercially licensed launches) using the specific launch trajectory and fuel loads on the rocket prior to launch. The risk assessments for launch and landings are still being developed as the trajectories and rocket develops. Any required CNS or MINWR closures would be coordinated between SpaceX and the respective agency, NPS and/or USFWS.

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, 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 regional resources.

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ACRONYMS AND ABBREVIATIONS

45 SW	45th Space Wing
ACI	Archaeological Consultants, Inc.
AFSPC	Air Force Space Command
BCOS	Brevard County Sherriff's Office
BLS	Below Sea Level
BMAP	Basin Management Action Plan
BMP	Best Management Practice
BO	Biological Opinion
BOSS	Base Operations and Spaceport Services
BRRC	Blue Ridge Research Company
C	Celsius
CA	California
CCAFS	Cape Canaveral Air Force Station
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CH_4	Methane
cm	Centimeters
CNS	Canaveral National Seashore
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
CO	Carbon Monoxide
COC	Contaminant of Concern
CSLA	Commercial Space Launch Act
CUP	Consumptive Use Permit
CWA	Clean Water Act
CX	Construction
CZMA	Coastal Zone Management Act
DARM	Division of Air Resource Management
dB	Decibels
dBA	A Weighted Sound Pressure Level
DNL	Day-Night Average Noise Level
DOD	Department of Defense
DOT	Department of Transportation
EA	Environmental Assessment
EAIP	Environmental Impact Analysis Process
EFH	Essential Fish Habitat
EGS	Exploration Ground Systems
EIA	Energy Information Administration
EIS	Environmental Impact Statement
EO	Executive Order
EPA	Environmental Protection Agency
ERD	Environmental Resources Document
ERP	Environmental Resource Permit
ESA	Endangered Species Act
FAA	Federal Aviation Administration
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FDOS	Florida Department of State
FEMA	Federal Emergency Management Agency
FL	Florida
FL SHPO	Florida State Historic Preservation Officer
FMU	Fire Management Unit

FONSI	Finding of No Significant Impact
FPL	Florida Power and Light
FR	Final Rule
FY	Fiscal Year
GCTL	Groundwater Cleanup Target Level
GHe	Gaseous Helium
GHG	Greenhouse Gas
GIS	Geographic Information System
GN_2	Gaseous Nitrogen
GPS	Global Positioning System
GSDO	Ground Systems Development and Operations
GWP	Global Warming Potential
H_2	Hydrogen Gas
H_2O	Water
ha	Hectares
HAER	Historic American Engineering Record
HAP	Hazardous Air Pollutant
HQ	Headquarters
ICRMP	Integrated Cultural Resource Management Plan
IM	Interim Measure
IPCC	International Panel on Climate Change
IRL	Indian River Lagoon
IRLNEP	Indian River Lagoon National Estuary Program
ISS	International Space Station
KARS	Kennedy Athletic, Recreation and Social
KEMCON	Kennedy Space Center Environmental and Medical Contract
kg	Kilogram
KIWI	Kennedy Industrial Wastewater Inventory
km	Kilometer
KNPR	Kennedy NASA Procedural Requirement
KSC	John F. Kennedy Space Center
kV	Kilovolt
l	Liters
L_{Amax}	Maximum A-Weighted Level
LATRA	Launch Area Toxic Risk Assessment Model
LC	Launch Complex
LCH_4	Liquid Methane
LED	Light-Emitting Diodes
LEO	Low Earth Orbit
LLC	Limited Liability Company
LMP	Light Management Plan
LN_2	Liquid Nitrogen
LOM	Lighting Operations Manual
LOS	Line of Sight
LOX	Liquid Oxygen
LZ	Landing Zone
m	Meters
m^2	Square Meters
mi	Miles
MARPOL	International Convention for the Prevention of Pollution from Ships
MHW	Mean High Water line
MINWR	Merritt Island National Wildlife Refuge
MMPA	Marine Mammal Protection Act
MN	Meganewtons
mph	Miles per Hour
MSL	Mean Sea Level

MSS	Mobile Service Station
MT	Metric Tons
N	Nitrogen
N/A	Not Applicable
NAAQS	National Ambient Air Quality Standards
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
NJ	New Jersey
NLAA	Not Likely to Adversely Affect
nm	Nautical Miles
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NO_2	Nitrogen Dioxide
NOx	Nitrogen Oxide
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NPR	NASA Procedural Requirement
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
O_2	Oxygen
OASPL	Overall Sound Pressure Level
OB/DG	Ocean Breeze/Dry Gulch
ODS	Ozone Depleting Substances
OFW	Outstanding Florida Waters
OSHA	Occupational Safety and Health Administration
OSTDS	On Site Treatment and Disposal System
PA	Programmatic Agreement
PAFB	Patrick Air Force Base
PAH	Polycyclic Aromatic Hydrocarbons
Pb	Lead
PCB	Polychlorinated Biphenyl
PEIS	Programmatic Environmental Impact Statement
pH	A Measure of Acidity/Alkalinity of a Solution
PM	Particulate Matter
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
PPF	Payload Processing Facility
ppm	parts per million
PRL	Potential Release Location
psf	Pounds per Square Foot
PWQ	Process Waste Questionnaire
RCRA	Resource Conservation Recovery Act
REEDM	Rocket Exhaust Effluent Dispersion Model
RFI	Resource Conservation Recovery Act Facility Investigation
ROI	Region of Influence
RP-1	Rocket Propellant 1 (kerosene)
RWWTF	Regional Waste Water Treatment Facility
S/A	Similarity of Appearance
SCTL	Soil Cleanup Target Levels
SEL	Sound Exposure Level

SIC	Standard Industrial Classification
SJRWMD	St. Johns River Water Management District
SLF	Shuttle Landing Facility
SLS	Space Launch System
SO_2	Sulfur Dioxide
SpaceX	Space Exploration Technologies Corporation
SPCC	Spill Prevention, Control, and Countermeasures
SR	State Road
SWMU	Solid Waste Management Unit
TMDL	Total Maximum Daily Load
TRP	Technical Response Package
TRPH	Total Recoverable Petroleum Hydrocarbons
TV	Television
TX	Texas
$\mu g/m^3$	Micrograms per Liter
UES	Universal Engineering Services,
ULA	United Launch Alliance
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
VAFB	Vandenberg Air Force Base
VOC	Volatile Organic Compound
WMO	World Meteorological Organization
ZAP	Zones of Archaeological Potential

1.0 PURPOSE AND NEED FOR THE PROPOSED ACTION

1.1 Introduction

Founded in 2002, Space Exploration Technologies Corp (SpaceX) is a space transportation and technology company headquartered in Hawthorne, CA. SpaceX currently operates the Falcon family of launch vehicles, which includes the Falcon 9 and the Falcon Heavy, from launch complexes at Kennedy Space Center (KSC), Cape Canaveral Air Force Station (CCAFS), and Vandenberg Air Force Base (VAFB). All Falcon 9 and Falcon Heavy launch vehicles can carry payloads that include satellites, experimental payloads, and SpaceX's Dragon spacecraft (Dragon). Dragon-1 is currently used for cargo missions to the International Space Station (ISS) and Dragon-2 is being developed with the intent to carry astronauts (crew) and future cargo missions. Launches are conducted for commercial and government customers. SpaceX has launched more than 60 times from CCAFS, KSC, and VAFB. More than 30 of SpaceX's Falcon 9 launch missions have included boost-back and landing of the first stage booster with the landing occurring either on SpaceX's droneship (a converted barge) in the Atlantic Ocean or Pacific Ocean or on land at CCAFS Landing Zones 1 and 2 (LZ-1 and LZ-2) and Landing Zone 4 (LZ-4) at VAFB.

SpaceX is proposing to launch the Starship and Super Heavy booster in addition to the current Falcon vehicle from KSC at LC-39A. Originally constructed in 1965-1966, LC-39A supported the Apollo Program and was later modified for the Shuttle Program, which ended in 2011. The National Aeronautics and Space Administration (NASA) prepared an Environmental Assessment (EA) with the Federal Aviation Administration (FAA) as a cooperating agency, to increase KSC spaceport capabilities and allow both commercial and governmental entities to use LC-39A and LC-39B for launch purposes involving a variety of vertical launch vehicles, including SpaceX Falcon launch vehicles (NASA 2013). In 2014, pursuant to the Commercial Space Launch Act (CSLA), NASA granted a lease to SpaceX to operate at LC-39A. Additional components of SpaceX activities at LC-39A are reviewed by NASA via the KSC Environmental Checklist process. SpaceX successfully launched the first of several Falcon 9 v1.1 at LC-39A on February 19, 2017, and as of January 2019 there have been 16 Falcon launches from LC-39A. The Falcon Heavy launched for the first time on February 6, 2018. On March 2, 2019, SpaceX successfully launched the first test flight of the Crew Dragon spacecraft on top of a Falcon 9 rocket.

The Starship/Super Heavy would exceed the capabilities of the Falcon 9 and Falcon Heavy launch vehicles, reducing the cost of access to space, enabling cost effective delivery of cargo, and eventually transporting people to the Moon and Mars. A Starship/Super Heavy launch mount is proposed to be constructed adjacent to the existing Falcon launch mount within the LC-39A boundary.

All of SpaceX's past construction and launch activities at KSC and CCAFS were analyzed by the U.S. Air Force (USAF), NASA, and the FAA. This was in accordance with the National Environmental Policy Act (NEPA) (42 United States Code [U.S.C.] §4321 et seq.), Council on Environmental Quality (CEQ) NEPA-implementing regulations (40 Code of Federal Regulations [CFR] Parts 1500–1508), and agency-specific NEPA regulations or policies.

Federal agencies are required to consider environmental consequences resulting from their actions. This EA was prepared by SpaceX and NASA to evaluate the proposed development and operation of the Starship/Super Heavy at LC-39A. In addition to the above mandates, this document is prepared in accordance with 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).

SpaceX would continue to use LZ-1 landing facility at CCAFS and the USAF is a cooperating agency in preparation of this EA. This EA has been prepared in accordance with the Air Force Environmental Impact Analysis Process (EIAP) (32 CFR Part 989), Department of Defense (DoD) Directive 6050.

Furthermore, because commercial launch operations require licensing by the FAA Office of Commercial Space Transportation, SpaceX would need to obtain a license from the FAA prior to conducting Starship/Super Heavy commercial space launch operations at LC-39A. SpaceX plans to apply to the FAA for a launch license once the launch site is built. Therefore, this EA considers the FAA's NEPA-implementing policy—FAA Order 1050.1F, Environmental Impacts: Policies and Procedures—regarding potential launch-related impacts. The FAA plans to adopt this EA, in part, to support its environmental review of a SpaceX license application(s) for Starship/Super Heavy launch operations at LC-39A.

1.2 Location and Background

NASA was created in 1958 to lead the nation's civilian space exploration and aeronautical technology development activities and began acquiring property to be used as a base for launch operations in support of the Manned Lunar Landing Program in 1962. A Launch Operations Center, later known as KSC, was established in Merritt Island, FL. KSC, located in Florida within Brevard and Volusia counties, is comprised of approximately 57,400 hectares (ha) and is situated along the Atlantic east coast approximately 242 kilometers (km) south of Jacksonville, 322 km north of Miami, and 64 km east of Orlando (Figure 1-1). KSC is the nation's primary federal spaceport for government and commercial access to space. From 1981 to 2011, KSC was responsible for ground processing, launch, and landing activities for the Space Shuttle Program.

NASA is leasing multiple KSC facilities for a variety of space programs that support the agency and advance the commercial space industry, secondary support industries, and universities. Current property agreements at KSC include the aforementioned CSLA agreement with SpaceX for processing and launch of Falcon vehicles at LC-39A, Space Florida's operation of the Shuttle Landing Facility (SLF), the Florida Power and Light (FPL) photovoltaic facilities, Boeing's use of the former Orbiter Processing Facility 3 for the CST-100 Starliner, and the Blue Origin Manufacturing Facility in Exploration Park.

The Proposed Action at LC-39A would continue the NASA goal of supporting KSC site use by the private sector, including SpaceX as it strengthens U.S. space transportation and infrastructure. It would provide greater mission capability to NASA and SpaceX by continuing the development of ever evolving next generation launch vehicles and spacecraft. SpaceX would also continue to use LZ-1 and other SpaceX leased facilities on CCAFS to support the Proposed Action (Figure 1-2).

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 (NASA 2016). 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. The EA for Multi-Use of LC-39A and LC-39B evaluated the utilization of these launch complexes by both commercial and governmental entities for launch purposes (NASA 2013). Programmatic NEPA documents such as the KSC PEIS and Multi-Use EA 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 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 Environmental Impact Statement (EIS) or EA. Instead, they would incorporate by reference a summary of those discussions and analyses and focus on the project-specific issues. NASA has prepared this EA with SpaceX as a tiered document focusing on implementation of the SpaceX Starship/Super Heavy, including the enhancement of LC-39A.

This EA was prepared by NASA as the lead federal agency with SpaceX as the proponent of the Proposed Action, in cooperation with the FAA (Office of Commercial Space Transportation), National Park Service (NPS), and the USAF. As the landowner, NASA is responsible for managing areas on KSC for space-related development and operations and provides oversight for non-NASA space and technology development use of KSC property. KSC is responsible for establishing and coordinating appropriate use agreements and operating procedures for those activities outlined in the Proposed Action.

The FAA is a cooperating agency for this EA due to its role in licensing commercial launch operations. The FAA Office of Commercial Space Transportation's 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 expects to receive a launch license application(s) from SpaceX for Starship/Super Heavy operations at LC-39A. The FAA plans to adopt this EA, in part, to support its environmental review of a SpaceX license application(s) for Starship/Super Heavy launch operations at LC 39A.

The Canaveral National Seashore (CNS) was created by Public Law 93-326 and an agreement with the Department of the Interior was formed in 1975 due to a portion of CNS being located within KSC boundaries. CNS provides approximately 38.6 km of undeveloped seashore used by the public for recreation and viewing rocket launches. The 54,723 ha outside of NASA operational control are managed by the NPS and the USFWS. The NPS administers a 2,693 ha area of the CNS, while the USFWS administers the remaining 52,030 ha of the CNS and the MINWR.

USAF 45th Space Wing (45 SW) is currently the host wing under Air Force Space Command (AFSPC) and conducts east coast military, civilian, and commercial launch operations. The 45 SW is responsible for overseeing the preparation and launch of U.S. Government, civil, and commercial satellites from CCAFS and operates the Eastern Range for the AFSPC. The 45 SW at CCAFS also provides facilities and services to support NASA and commercial space operations and the Naval Ordnance Test Unit program for missile tests and submarine operations.

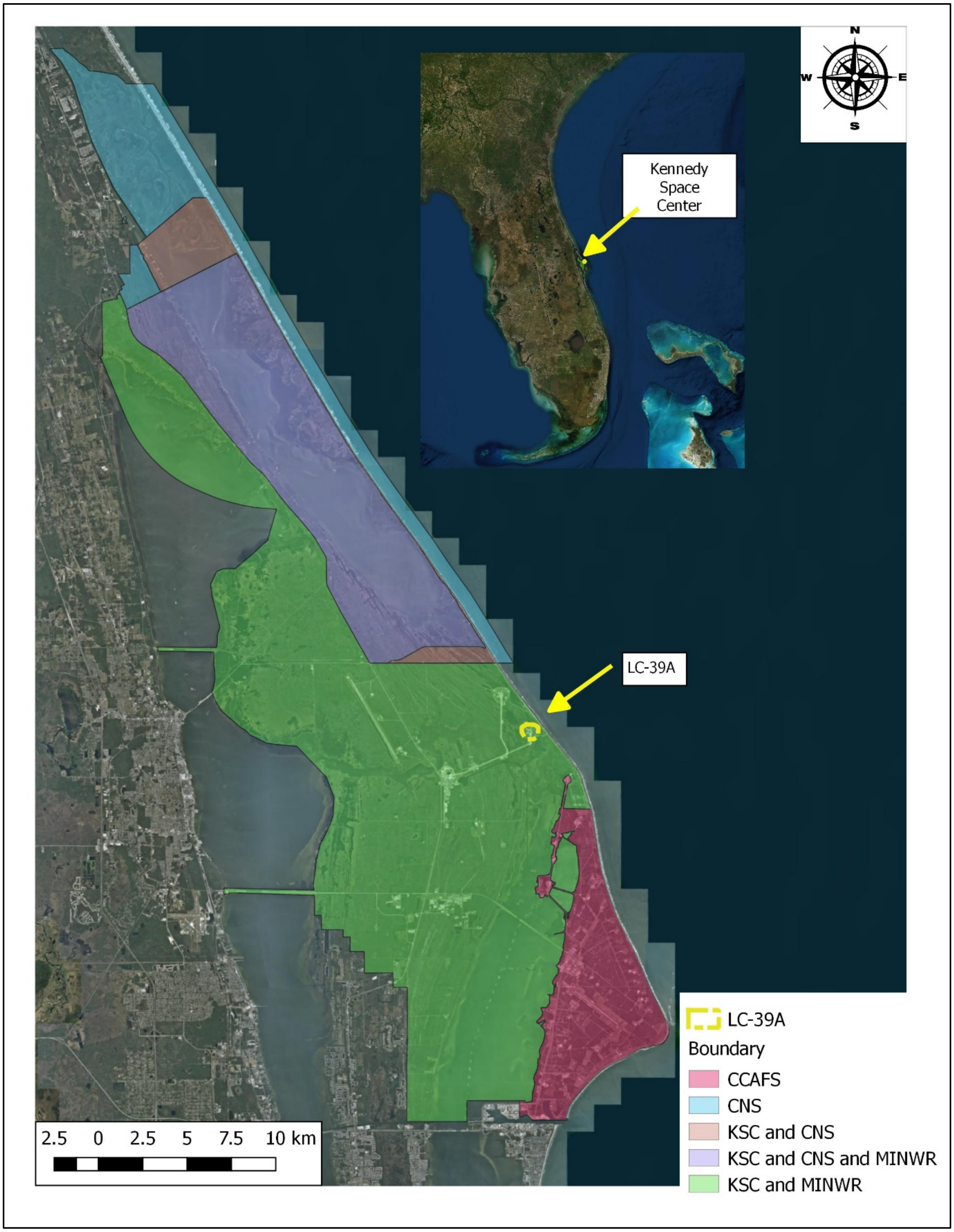

Figure 1-1. KSC and Neighboring Boundaries

Figure 2-2. Location of the Launch Site and Support Facilities for the Proposed Action

1.3 Purpose and Need for Action

Currently operating the Falcon at LC-39A, SpaceX proposes to also launch the Starship/Super Heavy vehicle from LC-39A. SpaceX would construct an additional launch mount for Starship/Super Heavy, adjacent to the existing mount used for Falcon.

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. 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]).

This directive is detailed in the NASA Authorization Act of 2010 and the Space Act of 1958, as amended. This action would 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) continue to 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 furthers the goals of KSC long-term planning initiatives, NASA programmatic objectives, and ultimately increases American competitiveness in the commercial space market. NASA's purpose and need for the Proposed Action is to develop and implement formal agreements with SpaceX for use of NASA assets and to provide services and commodities to enable Starship/Super Heavy launches. Commercial use of KSC real property supports NASA's mandate to encourage the fullest commercial use of space, supports the goals of the National Aeronautics and Space Act, and advances the National Space Policy that federal agencies shall ensure that U.S. Government space technology and infrastructure is made available for commercial use on a reimbursable, noninterference, and equitable basis. The need for the Proposed Action also aligns with NASA's Space Act Agreement and the FAA Office of Commercial Space Transportation's mission, which is to support the U.S. goal of encouraging activities by the private sector to strengthen and expand U.S. space transportation infrastructure.

Additionally, the Proposed Action will support NASA in its continued mission to expand commercial uses of space and the space industry by facilitating SpaceX efforts to strengthen United States (U.S.) space transportation and launch infrastructure. It would also provide greater mission capability to NASA and SpaceX by continuing the development of ever evolving next generation launch vehicles and spacecraft. Additionally, the Proposed Action may support NASA in meeting the U.S. goal of near-term lunar exploration.

SpaceX has successfully demonstrated their ability to service the launch industry with the Falcon and is now developing a multi-mission, fully reusable, super heavy-lift launch vehicle. The Starship/Super Heavy would reduce the cost of access to space, exceeding the capabilities of the Falcon 9 and Falcon Heavy launch vehicles, enabling cost-effective delivery of cargo and people to the Moon and Mars. The Proposed Action would satisfy requirements for more efficient and effective space transportation methods and continue the U.S. goal of encouraging activities by the private sector to strengthen and expand U.S. space transportation infrastructure.

The proposed enhancement and use of LC-39A would also be a direct fulfillment of the KSC Master Plan (KSC, 2013) to "foster and support the fullest commercial use of space." This Proposed Action continues fulfillment of the U.S. expectation that space transportation costs are reduced in order to make the continued exploration, development, and use of space more affordable.

The FAA's action of issuing licenses to SpaceX for commercial space launches of the Starship/Super Heavy at LC-39A is considered part of the Proposed Action analyzed in this EA. The FAA's purpose of issuing licenses to SpaceX 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 and the No Action Alternative. Section 3 describes the affected environmental resources, the potential impacts of the Proposed Action on those resources, and the No Action consequences. 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
- Department of Transportation (DOT), Section 4(f)

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 this EA.

1.5 Regulatory Requirements

In accordance with the applicable requirements, NASA is initiating a public review and comment period for the Draft EA. The 30-day public comment period for the NEPA process begins with the issuance of the Notice of Availability on August 2, 2019 and will end on September 3, 2019.

Additionally, the Florida State Clearinghouse reviews EAs for projects planned at KSC pursuant to Gubernatorial Executive Order 95-359; the Coastal Zone Management Act; 16 U.S.C. § 1451-1464 as amended; and the National Environment Policy Act, 42 U.S.C. § 4321, 4331-4335, and 4341-4347. The State of Florida Clearinghouse sends copies of the draft EAs to applicable regulatory agencies for review and submits any comments so that they may be addressed in the final EA.

2.0 DESCRIPTION OF THE PROPOSED ACTION AND ALTERNATIVES

2.1 Proposed Action

A fully reusable rocket system consisting of two parts, Starship and Super Heavy booster, is being developed by SpaceX for crewed and uncrewed missions to take humans and cargo to Earth orbit and beyond, including to the Moon and Mars. SpaceX plans to launch the Starship/Super Heavy up to 24 times per year from LC-39A. A static fire test would be conducted on each stage prior to each launch.

The launch vehicle is comprised of two stages: Super Heavy and Starship. Super Heavy is the first stage (booster), and Starship (ship) is the second stage. The integrated vehicle would be 118 m in height with the ship being 55 m in length and 9 m in diameter. The top of the fully integrated rocket once installed on the launch mount would stand approximately 150 m above ground level (Figure 2-1). As mentioned, both stages would be reusable with any potential processing actions taking place at SpaceX facilities. The booster is expected to have minimal post flight refurbishment requirements; however, it may require periodic maintenance and upgrades. Unlike Falcon, there would be no separable fairings or parachutes in this reusable system.

The booster would be powered by 31 Raptor engines and Starship would be powered by seven Raptor engines. The Raptor engine was recently developed and is currently in Texas undergoing tests. Starship/Super Heavy maximum lift-off mass is approximately 5,000 metric tons (MT), with a lift-off thrust of up to 62 meganewtons (MN) (13.9 million lbs). The booster would hold up to 3,500 MT of propellant and Starship would hold up to 1,500 MT of propellant. The propellant is composed of liquid oxygen (LOX) and liquid methane in a 3.6:1 mass ratio. Each Raptor engine would produce 1.7 to 2.0 MN (0.3 to 0.4 million lbs) of thrust. The 31 booster engines would cut off at an altitude of approximately 70 km and the two stages would separate. Shortly thereafter, at an altitude of approximately 80 km, the Starship engines would start up and burn to the desired orbit location. Additional operational details are provided below. All vehicle specifications, propellant, and mission data would be provided to NASA to ensure the Proposed Action meets NASA safety requirements.

Construction

New construction activity would primarily consist of a launch mount positioned approximately 100 to 200 m to the southeast of the current Falcon pad and a liquid methane farm located on the east side of LC-39A. The methane farm would be approximately 50 m x 70 m in size and structured similar to the existing LOX farm. SpaceX is still considering the exact location of the methane farm and is also considering using the hydrogen sphere used during the Shuttle program as a potential storage area for methane. Minor upgrades inside the sphere and additional tanks would be constructed if the sphere is used. The existing flare system used during the Shuttle program would be refurbished and used as a methane flare. If this is not feasible, a new flare stack would be installed near the methane farm.

Site improvements would also include an interior transport road leading from the pad entrance gate up to the launch mount as well as several new high pressure gaseous commodity lines and demolition of legacy infrastructure and facilities to accommodate the proposed Starship infrastructure. A new deluge water system and water-cooled diverter would be installed and comprised of new water tanks capable of delivering the necessary water pressure. SpaceX would comply with all local and federal stormwater and industrial wastewater regulations. If treatment or retention is required, an approximately 3,000 kiloliter (kl) impervious water retention pond and a pervious percolation pond would be constructed. Water would be routed to the retention pond at the edge of the flame diverter for treatment via trenches and graded concrete. After treatment, a pumping system would route the water to the adjoining pervious surface percolation pond (Figure 2-2).

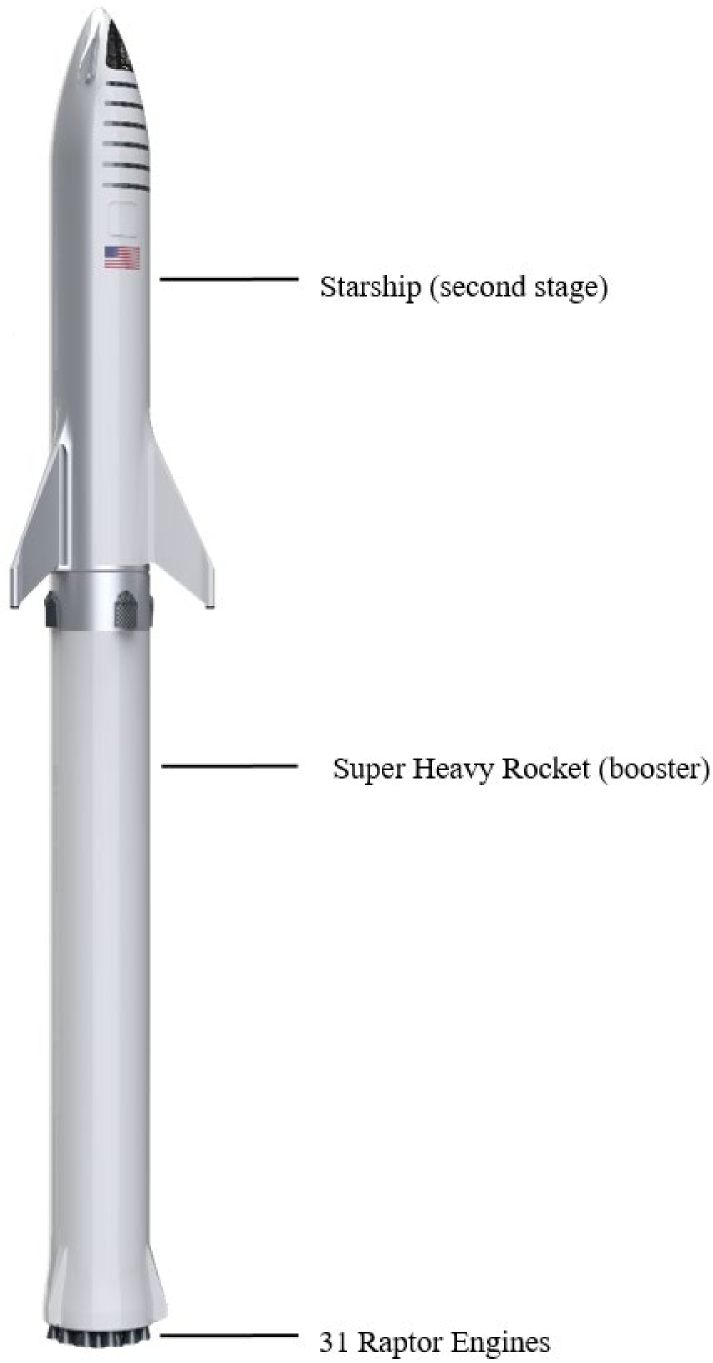

Figure 3-1. Starship Design Overview

The Proposed Action would include earthwork, construction of foundations, steel structures, and large fluid storage and delivery systems. Lightning protection would consist of tying the launch vehicle into the adjacent LC-39A grounding system. Existing infrastructure such as the LOX farm, helium and nitrogen systems, high-power electrical, and command and control systems would be modified and extended to support the Starship/Super Heavy launch capability.

Substantial earthwork would occur in the area of the new launch mount and at the site of the new methane farm. The launch mount would be elevated up to approximately 30 m to reduce excess recirculation and erosion from rocket exhaust. A flame diverter would be constructed instead of a flame trench as is currently used at the Falcon launch mount. The flame diverter would be composed of metal piping similar in construction to the SLC-40 water-cooled diverter. It would measure approximately 20 m wide by 20 m tall and be positioned directly under the rocket. It would divert the heat and rocket exhaust plume away from the launch pad and commodities.

SpaceX would also construct a landing pad for potential future launch vehicle returns within the LC-39A boundary. The landing pad location would be inside the LC-39A fence line. SpaceX is still determining the exact location of the landing pad, but it is tentatively planned for the area southeast of the new launch mount. The landing pad would be approximately 85 m in diameter and similar to the existing LZ-1 landing pads on CCAFS.

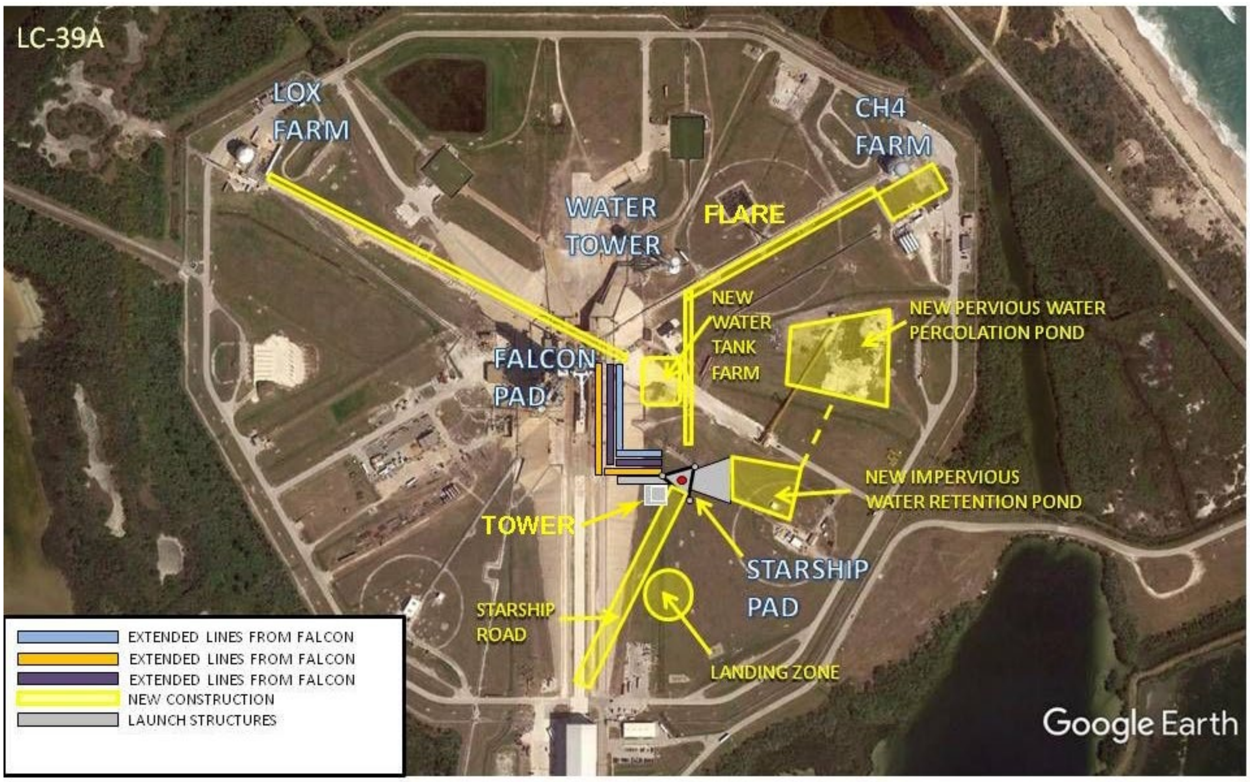

Figure 2-2. Proposed LC-39A Configuration with Starship/Super Heavy Launch Pad and Associated Operational Structures Shared or Separate from Falcon

The new methane farm would accommodate a total capacity of approximately 2 million kg. Approximately 1.5 million kg of liquid nitrogen would also be stored in the methane farm. The liquid nitrogen is a cryogenic and would be used to cool the methane. The methane and nitrogen farm would require lighting similar to the existing RP-1 farm located at LC-39A. If a new methane flare stack is needed, the flare would be approximately 30 m tall. The flare stack and any required anchors would be contained inside the construction project area. There are no planned modifications to the existing LOX farm capacity; however, as the program develops, an additional tank and piping may need to be installed to support the Proposed Action.

Exterior lighting would be used as needed during the construction phase and when hazardous operations occur. The additional lighting required would be similar to that used on the current launch mount for the Falcon launch vehicles. All lighting would comply with the KSC Lighting Operations Plan (KSC-PLN-1210, Rev A).

Operation

The SpaceX goal is to eventually launch Starship/Super Heavy approximately 24 times per year. As Starship/Super Heavy launches gradually increase to 24 launches per year, the number of launches of the Falcon would decrease. The Starship and Super Heavy would exceed the lift capabilities of the Falcon Heavy. Due to the higher lift capability, Starship/Super Heavy could launch more payloads and reduce the overall launch cadence when compared to Falcon 9 and Falcon Heavy. This would increase the cost effectiveness of the space industry. Starship/Super Heavy missions would include Lunar and Mars destinations, currently not supported by any other space vehicle, increased satellite payload missions, and human spaceflight. Missions could range from tests of the launch vehicle and ship, to cargo delivery. The manifest is incomplete at this time but would evolve as the rocket develops. There could be multiple launches in close succession required to support a single mission (i.e., Lunar Program sending multiple payloads to resupply). Prior to launch, during initial phases of Starship/Super Heavy development, SpaceX would perform rehearsals without propellants on the vehicle (dry) and rehearsals with propellants on the vehicle (wet) to verify full launch readiness. Dry and wet rehearsals were conducted during the development of the Falcon 9. A static fire test of the Super Heavy booster and the Starship would be performed prior to each launch. The static tests would be similar to that currently done for Falcon, with the booster held in place while engines are ignited to simulate the initial stage of launch. The test would be used to assess the performance of the Raptor engines prior to launch.

Fabrication and assembly of launch vehicle components would occur at existing SpaceX facilities located on KSC and CCAFS. These facilities could include Area 59 and the Payload Processing Facility (PPF) on CCAFS, the Falcon Hangar at LC-39A, and the soon to be constructed KSC SpaceX Operations Area on Roberts Road. SpaceX would also perform fabrication, assembly, and integration operations at the Mobile Service Station (MSS) Park Site Property and on the Crawlerway area. No modifications to the Crawlerway are expected from transport or operational use of Starship and Super Heavy. Staging and temporary fabrication tents could be used on the Crawlerway to support operations. SpaceX would coordinate through EIAP with USAF and the KSC Environmental Checklist with NASA if any new facilities were needed to support Starship/Super Heavy.

Starship or Super Heavy components would be delivered over roadways on a mobile transporter similar to the transports performed for Falcon. Most manufacturing of vehicle components would occur at the SpaceX facility in Hawthorne, CA. Additional facilities being considered for manufacturing and assembly include Boca Chica, TX, and a facility in the Cidco Industrial Park, Cocoa, FL. Large vehicle components would be transported by barge utilizing the KSC Turn Basin, then transported to LC-39 area as the final delivery point. The area of the Turn Basin SpaceX intends to use to offload vehicle components would be the wharf just southeast of the Vehicle Assembly Building (VAB). This area was used for arrival and offloading of vehicle components during the Shuttle Program.

The rocket would be integrated vertically on the pad at LC-39A using a mobile crane. This would involve the booster being mated to the launch mount followed by Starship being mated to the booster. Initial flights would use a temporary or mobile crane, with a permanent crane tower constructed later. The height of the permanent crane tower would be approximately 120 to 180 m.

After launch, SpaceX plans to land the Starship at LZ-1 at CCAFS. The Starship would land vertically on the pad (Figure 2-3) and would go into an automatic safing sequence that would vent any remaining liquid oxygen or methane. After the vehicle is in a safe state, a mobile hydraulic lift would raise Starship onto a transporter, similar to the current transporter used for Falcon. The Starship would be transported from the landing pad back to LC-39A or to one of the locations described above for refurbishment. SpaceX's proposed action includes the construction of a landing pad for Starship land landings within the LC-39A boundary. Proposed land use changes to the KSC Master Plan may be accomplished through KSC's land use amendment process or evaluated as part of the current KSC Master Plan update. Any proposed amendments to KSC land use to support the land landings of Starship at LC-39A may require additional evaluation and analysis to fully assess the potential impacts to KSC programs, operations and resources. These additional evaluations will occur as the Starship vehicle matures. Starship would use the droneship (located no closer than 5 nautical miles (nm) off the coast) as contingency landing location.

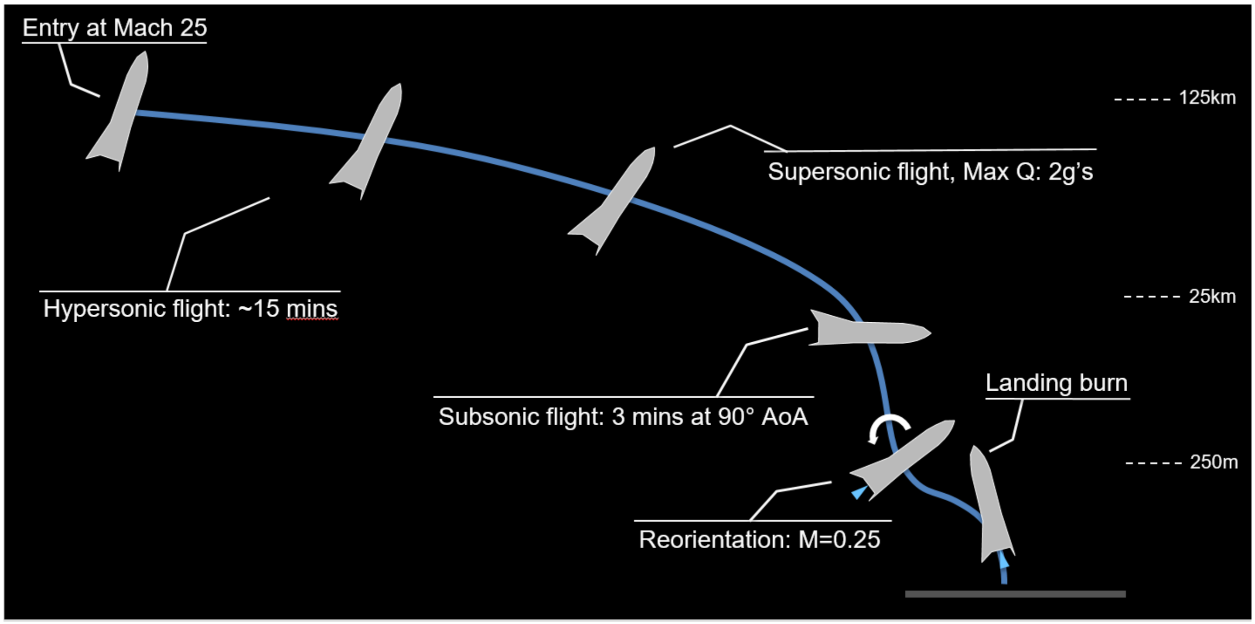

Figure 2-3. Proposed Starship Reentry and Landing

The Super Heavy booster would land downrange on a droneship in the Atlantic Ocean no closer than 20 nm off the coast. Recovery support vehicles would be similar to those used for Falcon booster landings on the droneship. In the event there is an anomaly during the descent, the booster would land in the open ocean. SpaceX is developing the technology and capability of Super Heavy booster. If SpaceX develops the ability to land Super Heavy booster on land, a supplemental EA will be developed.

After launch and landing at a downrange location, Super Heavy booster would be delivered by barge from the landing site utilizing the KSC Turn Basin wharf as a delivery point and transported the remaining distance to the launch complex over the Crawlerway. A downrange landing would be a contingency landing location for Starship and transport would be similar to the Super Heavy booster.

2.2 Alternatives Considered but Removed From Further Analysis

Alternative locations for the operation, launch, and landing of the Starship/Super Heavy considered included, SLC-40 within CCAFS and Space Launch Complex 4 (SLC-4) within Vandenberg Air Force Base (VAFB), where SpaceX also operates the Falcon. SpaceX would need to undertake significant modifications to either site to support the Proposed Action. Further, SLC-4's location does not support launch trajectories that will compromise the vast majority of Starship/Super Heavy. LC-39A was ultimately chosen for the Proposed Action since it presented the least environmental impact. LC-39A provides the best combination of available real estate, existing developments, distance from population centers, and available clear launch azimuths to maximize public safety for operational launches. LC-39A also provides enough space to accommodate both the Falcon and Starship/Super Heavy. SLC-40 was considered for landing operations but the infrastructure and size do not support landing a space vehicle. SLC-4 was considered as a landing location; however the transport distance from SLC-4 back to the LC-39A launch site would not support the operations of the Starship/Super Heavy launch vehicle. LZ-1 is the preferred landing location because of the existing infrastructure needed for safing a landed vehicle and the minimal distance needed to transport from landing to re-launching. For those reasons, SLC-40 and SLC-4 were not considered as alternatives for this EA, therefore they were not further analyzed. SpaceX is testing a Starship prototype “hopper” at SpaceX’s site in Cameron County, TX. In the future, SpaceX may develop and launch the Starship/Super Heavy from its facility in Cameron County, TX. This action would analyzed in a separate NEPA document.

2.3 Description of the No Action Alternative

Under the No Action Alternative, SpaceX would not implement the Starship/Super Heavy at KSC. Thus, the SpaceX mission to assist the National Space Transportation Policy of 1994 stated goal of “assuring reliable and affordable access to space through U.S. space transportation capabilities” would be limited.

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 considers the FAA's NEPA-implementing policy, FAA Order 1050.1F. FAA Order 1050.1F, Paragraph 4-1, lists environmental impact categories (i.e., resource areas) the FAA considers in its NEPA documents. This EA analyzes all of the FAA's environmental impact categories except farmlands. As assessed 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, in part, to support its environmental review of a future license application(s), the FAA's significance thresholds are considered in this assessment of potential environmental consequences.

The analysis in this EA considers the current conditions of the affected environment and compares those to conditions that might occur should NASA and SpaceX implement the action. The affected environment for this EA includes the geographic extent of the land encompassed by LC-39A and adjacent areas, LZ-1 on CCAFS, Port Canaveral, and the Atlantic Ocean region of influence (ROI) for droneship landings. A broader regional area was evaluated for some environmental resources such as noise and transportation. 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. 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 significant, 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 or significant 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 (including 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 DOT Act, Section 4(f) properties.

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 2015). 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, NASA 2015). A summary is provided in the following paragraphs.

Land Use

Land and open water resources of KSC comprise 57,400 ha 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 (IRL) system, including portions of the Indian River, Banana River, Mosquito Lagoon, and all of Banana Creek (NASA 2015).

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 of KSC (NASA 2015). 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 MINWR and the NPS at CNS. The 54,723 ha outside of NASA operational control are managed by the NPS and the USFWS. The NPS administers a 2,693 ha area of the CNS, while the USFWS administers the remaining 52,030 ha 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. Congress established CNS in 1975. It is located in both Brevard and Volusia Counties and includes 23,472 ha of barrier islands, open lagoons, coastal hammocks, and pine flat woods and 39 km of undeveloped beaches. KSC has an agreement with the U.S. Department of the Interior for management of a portion of the CNS by the NPS and a portion by the USFWS.

Under the Interagency Agreement between NASA and USFWS for Use and Management of Property at KSC known as MINWR (KCA-1649 Rev. B) the USFWS conducts habitat management activities, including prescribed burning. The USFWS coordinates 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," (KSC 2019).

For more than 35 years, MINWR has conducted prescribed fire and wildfire control operations in smoke sensitive areas of KSC and CCAFS. KSC facilities are intermixed with fire-dependent wildland habitats including oak-palmetto scrub, pine flat woods, 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 and 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 prefire exclusion conditions, to promote and benefit wildlife species that are dependent on fire adapted ecosystems, to aid the control of exotic plants and vegetation or "hazardous fuel loads" to reduce wildfire threat and protect critical spaceflight infrastructure on CCAFS and KSC.

LC-39A and the MSS Park Station are adjacent to Fire Management Unit (FMU) 5.3 to the north and west, and approximately 0.3 km from FMU 7.4 to the southeast. Approximately 47 ha of the 407 ha contained in FMU 5.3 burned in May 2011. FMU 7.4 encompasses 754 ha, of which 321 ha 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 (Figure 3-1). FMU 5.2 encompasses roughly 3,732 acres of primarily marsh wetland. This entire unit was burned during a wildfire in 2017. This unit is difficult to prescribe burn due to its location, operational restrictions and fuel type. It could possibly receive prescribed fire in 2020/2021 timeframe. This FMU is north of FMU 5.3. FMU 5.4 and 7.1 are near the Turn Basin and MSS Park Site. FMU 5.4 (also referred to C-21/36) encompasses roughly 930 acres. A total of 930 acres received prescribed fire in 2006. This unit is classified as low to moderate on the refuge burn rotation. When fuel loading occurs, it does pose a fire hazard and does contain wildlife habitat value. This will receive a higher burn classification in the future as the time increases between burns. FMU 7.1 encompasses 2,586 acres divided into several burn blocks in support of prescribe fire operations. This unit last received fire back in 2011, for a total of 1,714 acres burned. Several smoke sensitive areas are located adjacent to this burn unit. This block does not receive fire according to the prescribe fire schedule. As described above, the USFWS attempts to manage wildfire threats through planned prescribed burn ignitions. Although some FMUs do not receive fire according to the fire schedule due to restrictions, all FMUs are scheduled to receive fire on a 3 to 4 year rotation and will receive fire when restrictions allow.

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 18 land use categories to describe regions within which various types of operational or support activities are conducted (NASA 2016).

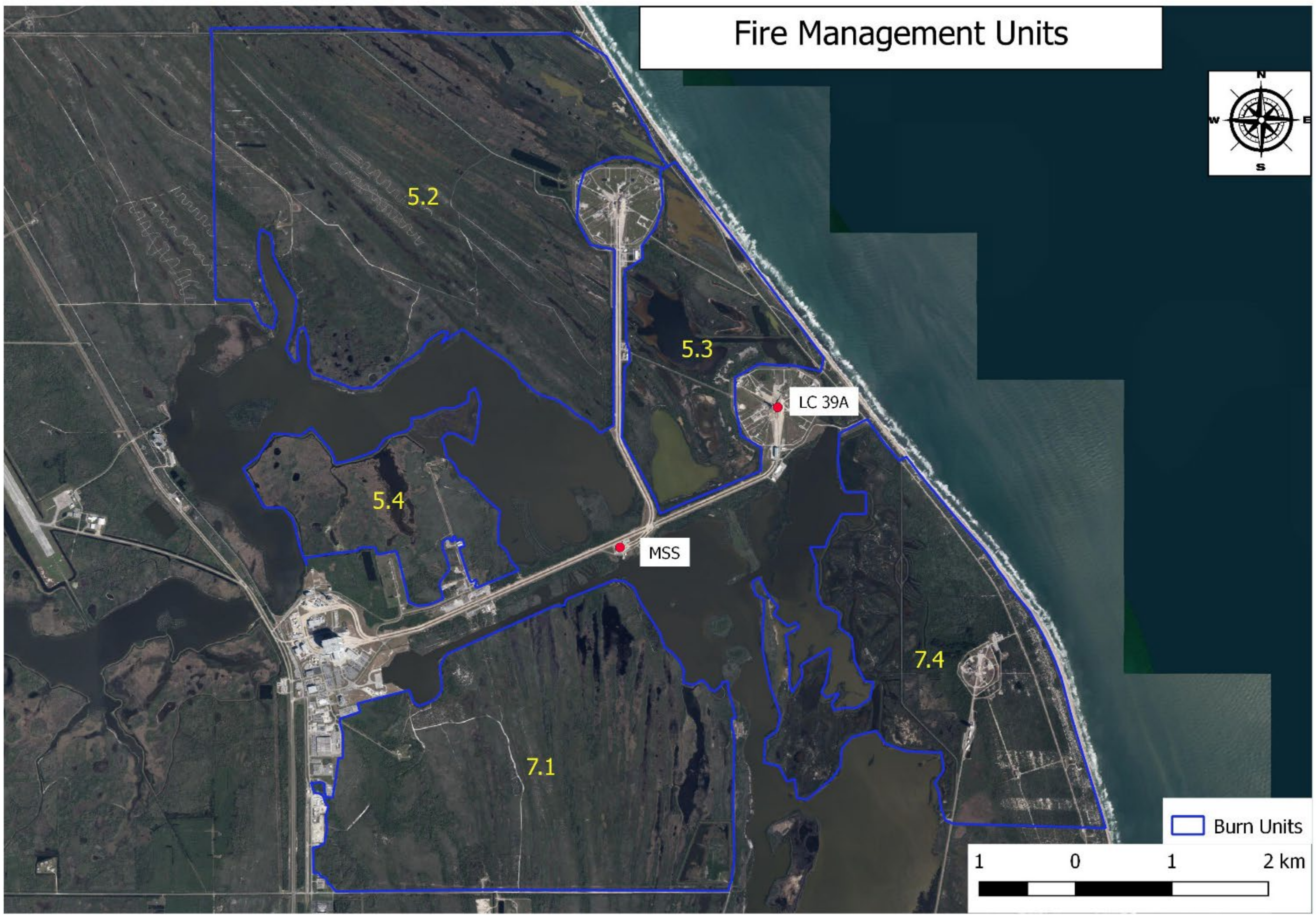

Figure 3-1. Fire Management Units near the Proposed Action

Visual Resources

The area of consideration for visual resources includes the viewshed around the Proposed Action site, such as adjacent lands at KSC and 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-39A, LC-39B, LC-41, and those launch pads further south of the proposed site. Due to the flat topography and the height of the lightning protection towers, approximately 181 m, the towers can be seen several kilometers away. Other highly visible structures include the 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 LC-39A, 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.

CNS, located north of KSC, consists of naturally dark conditions. Lighting impacts can disrupt this and degrade the views of the night sky in the park. The existing conditions on KSC, including LC-39A, require lighting that may cause skyglow, light that escapes into the sky and illuminates particulates and degrade the views of the night sky in the park.

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 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 (LOM) 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 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.

Federal activities at KSC that 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 phases of the Proposed Action, the discussion of the effects of these two stages have 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 unique location and purpose of the CNS and MINWR, overlaid on KSC lands creates a threshold that is also unique as compared to other more remote park lands. The land use designation for LC-39A is Vertical Launch and would need to be amended to include landing activities of the Starship. Any proposed land use changes for LC-39A will be initiated and managed by the KSC Center Planning and Development office. The land is surrounded by Operational Buffer/Conservation areas managed by MINWR. These conservation lands are currently designated as non-operational areas by NASA and are managed by MINWR. These areas are subject to controlled burning operations, one of the Refuge’s primary management tools. NASA KSC, working with MINWR, would continue to include SpaceX in their prescribed fire planning and coordination activities to ensure that controlled burning of adjacent land and related issues are well-communicated with the ultimate goal of limited, if any, impact to operations at the launch complex. The burn planning and operations of this operational area, as well as, the entire KSC land area adhere to a Prescribed Burn MOU, KCA-4205 Rev B (NASA 2019). This document lays out conditions and constraints for conducting prescribed burns, both on KSC and CCAFS.

The fire management program 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-39A, NASA KSC shall notify SpaceX within three days to allow coordination of prescribed burns. NASA KSC management will assist the USFWS in resolving any operational or other barriers in order to accomplish prescribed burns. The Proposed Action would not change the fire management program activities in the area surrounding LC-39A.

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. A crane tower, approximately 120 to 180 m in height would be constructed for vertical integration of rocket on the pad. Lightning protection would consist of one lightning rod at top of launch tower. LC-39A 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 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 new construction at LC-39A to visual resources would be moderate with no significant impact.

No Action Alternative

Under the No Action Alternative there would be no new construction of Starship/Super Heavy facilities on the LC-39A 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 and would have no significant impact on the coastal zone. As part of the CZMA determination process, this EA will be sent to 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-39A area. Therefore, there would be no additional impacts to coastal zone resources. The land use designation for LC-39A site would remain Vertical Launch.

3.2 Noise

Compatible land use means the use of the land is normally consistent with the outdoor noise environment at the location (14 CFR § 150.7). Compatible land use analysis considers the effects of noise on special management areas, such as national parks, national wildlife refuges, and other sensitive noise receptors. The concept of land use compatibility corresponds to the objective of achieving a balance or harmony between the Proposed Action and the surrounding environment. Noise is defined as unwanted or annoying sound that interferes with or disrupts normal human activities; 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. Although exposure to very high noise levels can cause hearing loss, the principal human response to noise is annoyance. The response of different individuals to similar noise events is diverse and influenced by the type of noise, perceived importance of the noise, its appropriateness in the setting, time of day, type of activity during which the noise occurs, and sensitivity of the individual.

FAA Order 1050.1F specifies Day-Night Average Sound Level (DNL) as the standard metric for community noise impact analysis, but also specifies that other supplemental metrics may be used as appropriate for the circumstances. DNL is appropriate for continuous noise sources, such as airport noise and road traffic noise. Additional noise metrics used for rocket noise analysis are Sound Exposure Level (SEL), the maximum A-weighted level (L_{Amax}), the maximum overall sound pressure level (OASPL), and one-third octave spectra at particular sensitive receptors (KBRwyle 2019).

The L_{Amax} and SEL metrics are A-weighted and provide a measure of the impact of individual events. A-weighted represents sound relative to the loudness perceived by humans. Loud individual events can pose a hearing damage hazard to people and can also cause adverse animal reactions. Adverse animal reactions can include flight, nest abandonment, and interference with reproductive activities. The last two metrics, OASPL and spectra, may be needed to assess potential damage to structures and adverse reaction of species whose hearing response is not similar to that of humans.

L_{Amax} is appropriate for community noise assessment of a single event, such as a rocket launch or static fire test. This metric represents the highest A-weighted integrated sound level for the event in which the sound level changes value with time. The L_{Amax} metric indicates the maximum sound level occurring for a fraction of a second. Slowly varying or steady sounds are generally integrated over a period of 1 second. The maximum sound level is important in judging the interference caused by a noise event with conversation, TV or radio listening, sleep, or other common activities. Although it provides some measure of the intrusiveness of the event, it does not completely describe the total event, because it does not include the period of time that the sound is heard.

SEL is a composite metric that represents both the intensity of a sound and its duration. Individual time-varying noise events (e.g., aircraft overflights) have two main characteristics: a sound level that changes throughout the event and a period of time during which the event is heard. SEL provides a measure of the net impact of the entire acoustic event, but it does not directly represent the sound level heard at any given time (KBRwyle 2019).

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 A-weighted sound level (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).

The ROI for noise and noise-compatible land use includes KSC and CCAFS with a center point at LC-39A for Starship/Super Heavy launch operations. This ROI includes those areas where the effects of launch noise and sonic boom noise from reentry and landing may occur at LC-39 or LZ-1, and where recovery offloading activities would occur at CCAFS and Port Canaveral. This ROI does not include the droneship location offshore for landing of the Super Heavy booster.

KSC and CCAFS are relatively isolated, which reduces the potential for noise impacts on adjacent communities. The nearest residential area is Titusville located 20 km to the west, across the Indian River. Open space lies to the north. Land just to the south-southwest of KSC is largely undeveloped with low density housing located approximately 14.5 km from LC-39. The beach cities of Cape Canaveral and Cocoa Beach are also to the south, immediately south of Port Canaveral, approximately 24.1 km from LC-39A. The sound produced by current rocket launches is noticed in all of these areas and the perimeter locations are commonly visited by the public for launch viewing. In the cities of Merritt Island and Cape Canaveral, ambient noise levels are normally low, with higher noise levels occurring in the communities' industrial areas, and lower noise levels (normally about 45 to 55 dBA) in the residential areas and along the beaches. Aircraft fly-overs and rocket launches from CCAFS and KSC increase noise levels for short periods of time; sonic booms from returning rocket vehicles also cause very short noise events.

3.2.1 Affected Environment

Background information on noise in the vicinity of KSC and CCAFS is well described in the KSC PEIS (NASA 2016) and the KSC ERD (NASA 2015). The 24-hour average ambient noise level on KSC is lower than the EPA recommended upper level of 65 dBA. This is on a scale ranging from approximately 10 dBA for the rustling of grass or leaves to 115 dBA, the unprotected hearing upper limit for exposure to a space launch. The areas of KSC and MINWR away from operational areas are exposed to relatively low ambient noise levels, in the range of 35 to 40 dBA. Noise levels measured at the seashore on a nice day with medium waves ranged from 50 to 69 dBA (NASA 2015).

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. Additional onsite sources of noise are the aircraft landing facilities at the CCAFS Skid Strip and the SLF. Other less frequent but more intense sources of noise in the region are launches from CCAFS and KSC, which includes both engine noise and sonic booms produced as launch vehicles reach supersonic speeds. Sonic booms produced during vehicle ascent over the Atlantic Ocean are directed in front of the vehicle and do not impact land areas; however, Falcon first stage vehicles (returning to LZ-1) do produce a double sonic boom that has been heard on land.

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 at a distance of 15 m. 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.

In 2019, KBRwyle performed a study of noise and sonic boom levels (*Starship Noise and Sonic Boom Assessment for Operations at KSC*) associated with the Proposed Action. This study, provided in Appendix A, estimated noise levels from future Starship/Super Heavy launches, Starship landings, booster landings, and static fire tests. Sonic boom levels were also estimated for Starship and booster atmospheric reentry and descent flights for landing. Noise levels were estimated for Starship and Super Heavy booster flight and static test operations conducted at LC-39A and booster landings on a droneship using KBRwyle's RNOISE model. Sonic boom was assessed for reentry operations using KBRwyle's PCBoom model (KBRwyle 2019). 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.

3.2.2 Environmental Consequences

Per FAA Order 1050.1F, impacts are considered significant if the action would increase noise by a 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.

Noise is measured in decibels (dB) and an A-weighted sound pressure level or dBA is commonly applied. The noise metrics (L_{Amax} and SEL) are A-weighted and provide a measure of the impact of individual events.

Under the Proposed Action, short-term 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, engine 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 distance from the source. Noise generated during construction activities of the Proposed Action at LC-39A 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 but insignificant.

Launch Noise

The loudest noise generated at the site would result from launches. Other intermittent raised levels of noise would occur during operation of lifting equipment, diesel-powered generators, and heavy-duty service vehicles.

The model RNOISE was used to compute the L_{Amax}, SEL, and DNL contours, which are shown in the figures provided in the KBRwyle report in Appendix A. The L_{Amax} contours indicate the maximum sound level at each location over the duration of the launch. Maximum L_{Amax} levels of 90 dB through 140 dB are estimated for the Starship/Super Heavy launch at LC-39A. The higher L_{Amax} contours (100 – 140 dB) are located entirely within both the CCAFS and KSC properties, although the 90 dB contour extends into parts of Titusville, west of LC-39A, and Merritt Island, southwest of LC-39A. If a Starship/Super Heavy launch occurs during the day, when background levels are in the 50 dB to 60 dB range, residents of Titusville, Merritt Island, and Cape Canaveral may notice launch noise levels above 70 dB. If the same launch occurs during the night, when background levels are lower than during the day (e.g., below 40 dB to 50 dB range), these residents may notice launch noise levels that exceed 60 dB. A prevailing onshore or offshore breeze may also strongly influence noise levels in these communities (KBRwyle 2019).

As mentioned previously, SEL is an integrated metric and is expected to be greater than the L_{Amax} because the launch event is up to several minutes in duration whereas the maximum sound level (L_{Amax}) occurs instantaneously. The 110 dB and higher level SEL contours are expected to remain entirely within the CCAFS and KSC properties. The 100 dB SEL contour extends past Titusville to the west and beyond Cocoa Beach to the south.

A noise sensitive area is an area where noise interferes with normal activities associated with its use and includes residential, educational, health, and religious structures; parks and recreational areas, and wildlife refuges. The estimated DNL contours for a projected 24 annual Starship/Super Heavy launch operations (80% daytime and 20% nighttime) range from 95 dB at the launch pad to 65 dB. The DNL 65 dB contour is located within the CCAFS and KSC properties (Figure 3-2) and would not reach residences in neighboring communities. The 65 dB contour does overlap MINWR and CNS, partially contained within KSC boundaries. As shown in Figure 3-2, a very small portion of CNS which would potentially be open to the public might experience DNL at the 65 dB level. The Max A-Weighted Level (L_{Amax}) would be less than 90 dBA and Sound Exposure Level (SEL) would be less than 110 dBA on CNS during a Starship/Super Heavy launch from LC-39A. These areas of MINWR and CNS experienced sound levels up to 90 dBA or higher during Shuttle launches (NASA 2008). The perimeters of KSC are commonly visited by the public for launch viewing where rocket launches and accompanying sounds are considered positive and enjoyable experiences. The normally quiet setting of CNS and MINWR would be impacted intermittently for short periods of time and would not adversely impact the value or enjoyment of the land use; therefore, the proposed action would be moderate with no significant impact.

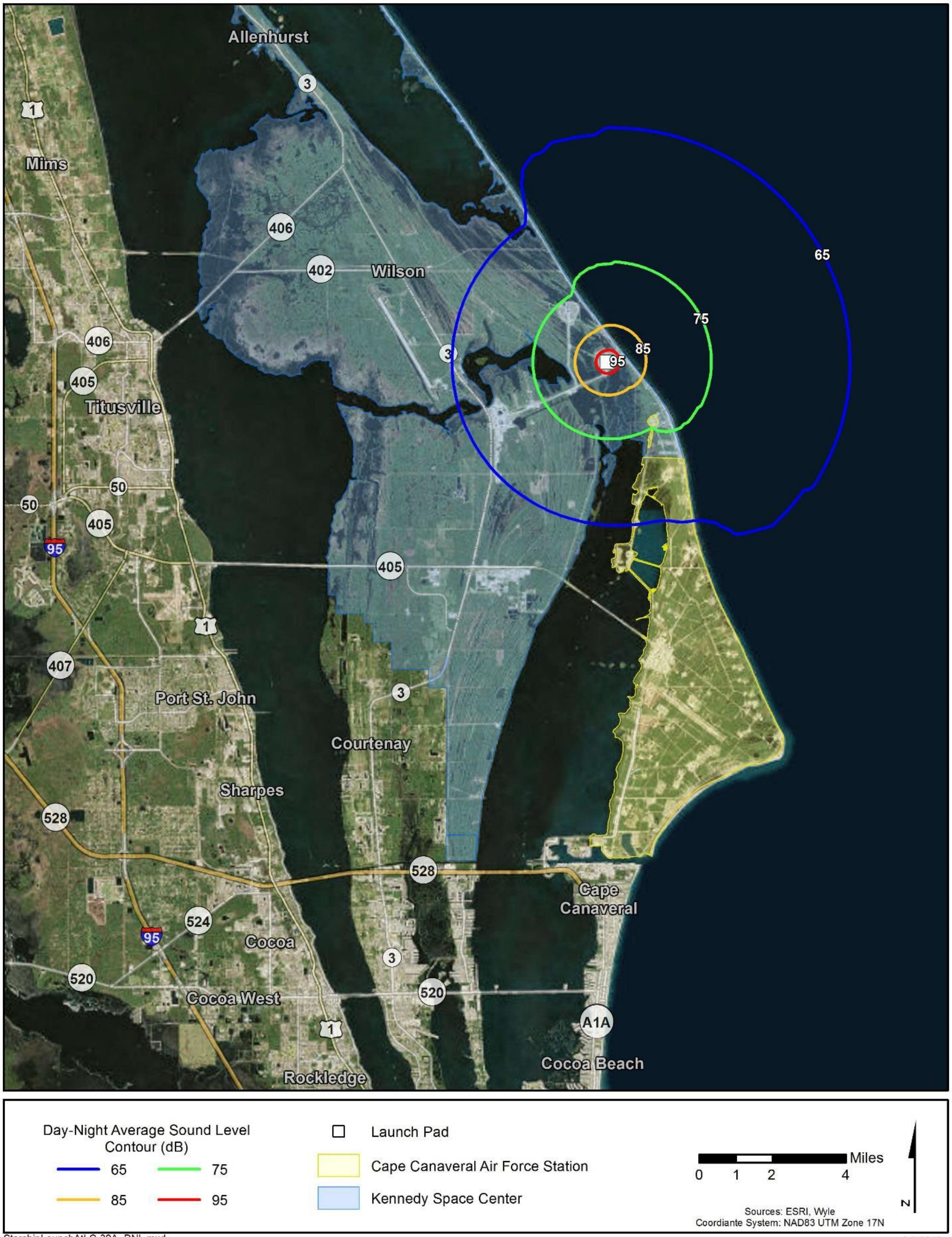

Figure 3-2. Starship/Super Heavy Launch from LC-39A: Day-Night Average Sound Levels

Landing Noise

RNOISE was used to estimate the L_{Amax}, and SEL contours for Starship landings at LC-39A and LZ-1. The potential for land landings of Starship at LC-39A will require additional analysis to fully assess the potential impacts to NASA programs, facilities, personnel and operations.. The 90 dB L_{Amax} contour stays within the CCAFs and KSC properties although residents of Titusville may notice levels between 70 and 80 dB L_{Amax}. Parts of Titusville, Merritt Island, and Cape Canaveral may be exposed to SELs higher than 100 dB. Compared with Starship/Super Heavy launch noise levels, Starship landing noise levels are considerably lower reflecting the much lower total engine thrust used for landing operations. The estimated DNL 65 dB contour for a projected 24 annual Starship landing operations at LC-39A and LZ-1 (80% daytime and 20% nighttime) are located within the CCAFS and KSC properties (Figure 3-3 and Figure 3-4).

RNOISE was used to estimate the L_{Amax} and SEL contours for Super Heavy booster landings on a droneship. The Super Heavy booster droneship landings are planned to occur no closer than 20 nm offshore; therefore, noise from these events is not expected to be noticed by residents along the coast.

Static Fire Tests

Starship static fire tests are planned to occur at LC-39A where all seven engines are fired for approximately 15 seconds. The L_{Amax} and SEL contours (90 dB and above) are entirely contained within the CCAFS and KSC properties. During tests, maximum A-weighted sound levels above 70 dB may be noticed by residents of Merritt Island. The estimated 65, 75, and 85 DNL contours over land for a projected 24 annual Starship static fire tests at LC-39A (90% daytime and 10% nighttime) are all contained within the KSC boundary (Figure 3-5).

Super Heavy booster static fire tests are planned to occur at LC-39A where all 31 engines are fired for 15 seconds. The L_{Amax} and SEL contours (90 dB and above) occurring over land are entirely contained within the CCAFS and KSC properties. During tests, maximum A-weighted sound levels above 70 dB are likely to be noticed by residents of Merritt Island and possibly by residents of Titusville. The estimated 65, 75, 85, and 95 DNL contours over land for a projected 24 annual Super Heavy booster static fire tests at LC-39A (90% daytime and 10% nighttime) are also within the KSC boundary (Figure 3-6).

Under the Proposed Action, the highest levels of noise from launches, launch support, and industrial-type activities taking place at the site would have no significant impacts 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 intense but short in duration and intermittent throughout the year. The Proposed Action would not exceed the FAA’s significance threshold for noise.

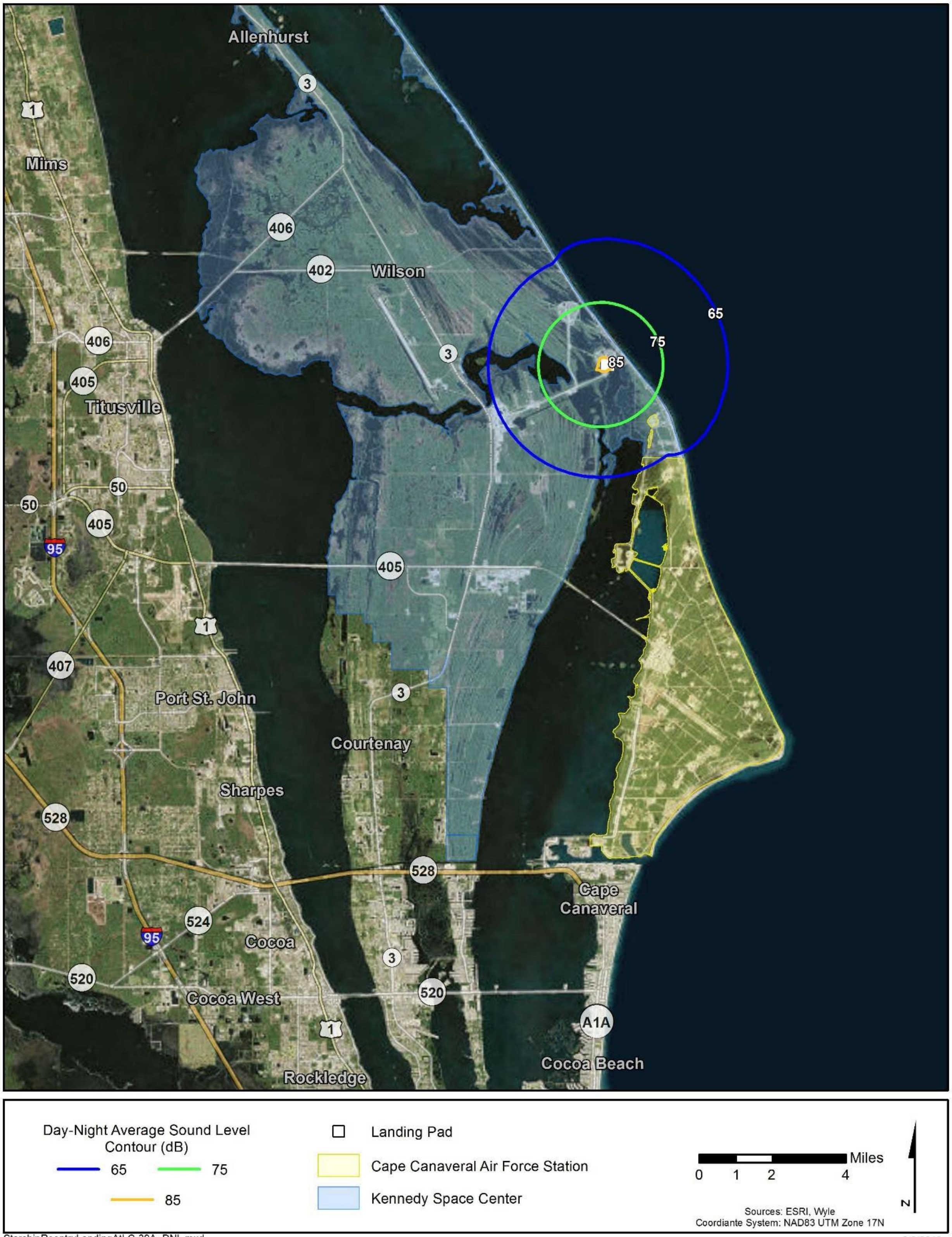

Figure 3-3. Starship Landing at LC-39A: Day-Night Average Sound Levels

Figure 3-4. Starship Landing at LZ-1: Day-Night Average Sound Levels

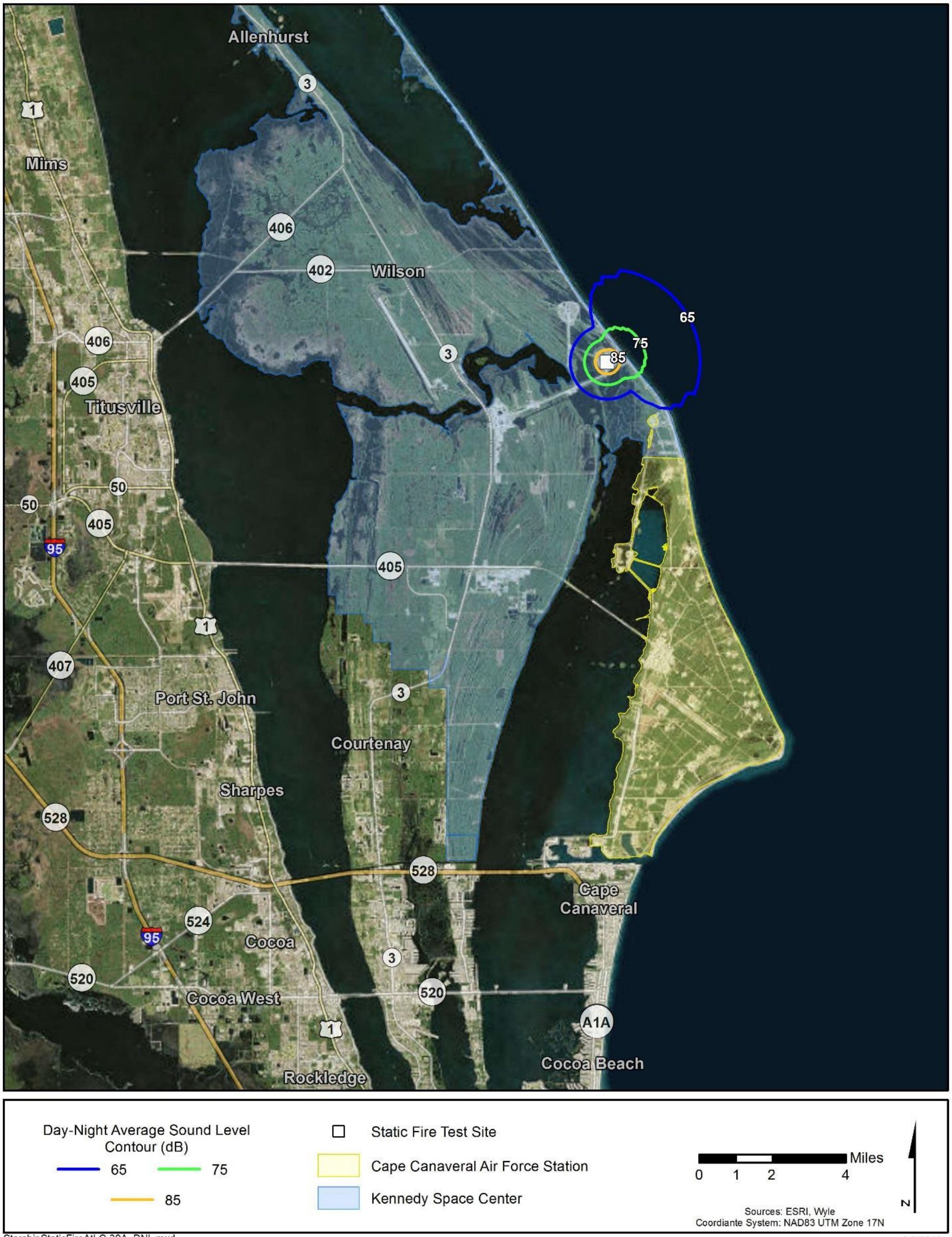

Figure 3-5. Starship Static Fire Test at LC-39A: Day-Night Average Sound Levels

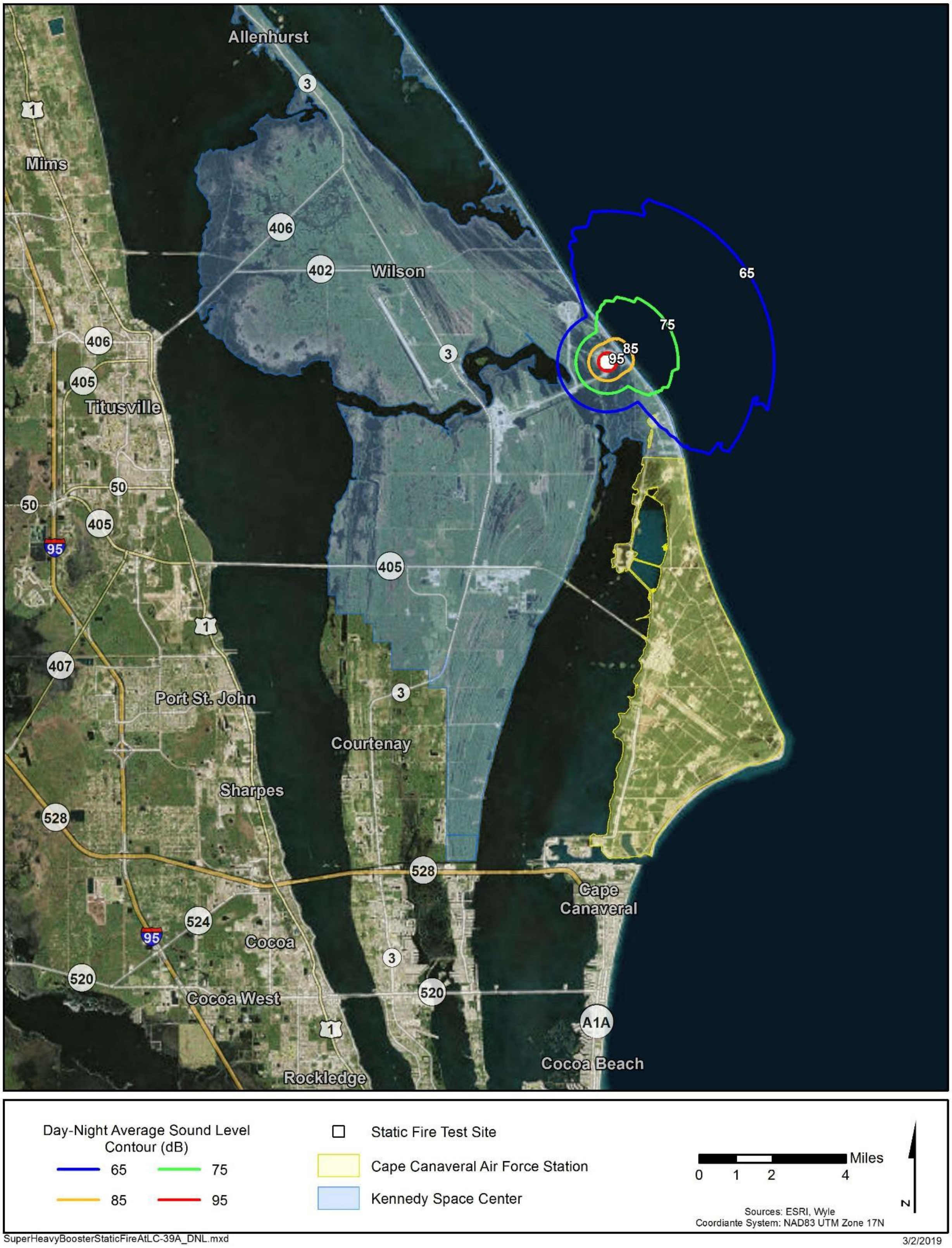

Figure 3-6. Super Heavy Booster Static Fire Test at LC-39A: Day-Night Average Sound Levels

Sonic Booms

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. A sonic boom is generated while the while the Starship and Super Heavy are supersonic during their descents, above an altitude of about 24 km and approximately 7.6 km, respectively. A sonic boom is generated during the ascent but it is directed in front of the vehicle and does not impact land areas.

Sonic boom footprints were computed separately for the Starship and Super Heavy booster (after separation) for their reentries from LEO and descent/landings. The Starship landing is planned to occur at LZ-1 at CCAFS or downrange on a droneship. The potential for land landings of Starship at LC-39A will require additional analysis to fully assess the potential impacts to NASA programs, facilities, personnel and operations. Sonic boom footprints were computed using PCBoom and are shown in (Figures 3-7, 3-8, and 3-9).

Overpressure levels of 3.0 psf and higher for Starship landings are estimated to be within 20 m of the landing site. For a LC-39A landing, areas within 10m of the landing site, including Titusville could experience overpressure levels up to 4 psf. For a LZ-1 landing, areas within 10m of the landing site, including KSC, Merritt Island and Cape Canaveral, could experience overpressure levels up to 4 psf. The boom levels in the vicinity of the landing pad range from about 4.0-4.7 psf. CNS could experience overpressures of up to 4 psf from landing at LC-39A and 2.5 psf from LZ-1 landing. The boom levels over land are not likely to cause property damage (KBRwyle 2019). The USAF analyzed sonic boom impacts of a rocket vehicle landing with overpressure levels up to 7.2 psf at LZ-1 (USAF 2017). This would be twice the level expected for Starship.

The sonic boom levels for the Super Heavy booster in the vicinity of the droneship range from about 5.0-10.0 psf. The maximum overpressure of 12.4 psf represents a focal zone that occurs near the northern tip of the crescent shaped boom contour that is farthest west from the droneship. The location of such a focal zone would vary with weather conditions, so it is unlikely that these locations would experience these levels more than once over multiple events. A droneship landing 20 nm offshore would produce overpressure levels of 3.0-5.0 psf along the coast. This would be below the overpressure levels experienced during a Falcon first stage landing at LZ-1 (USAF 2017).

Figure 3-7. Starship Sonic Boom Levels for Reentry/Landing at LC-39A

Figure 3-8. Starship Sonic Boom Levels for Reentry/Landing at LZ-1

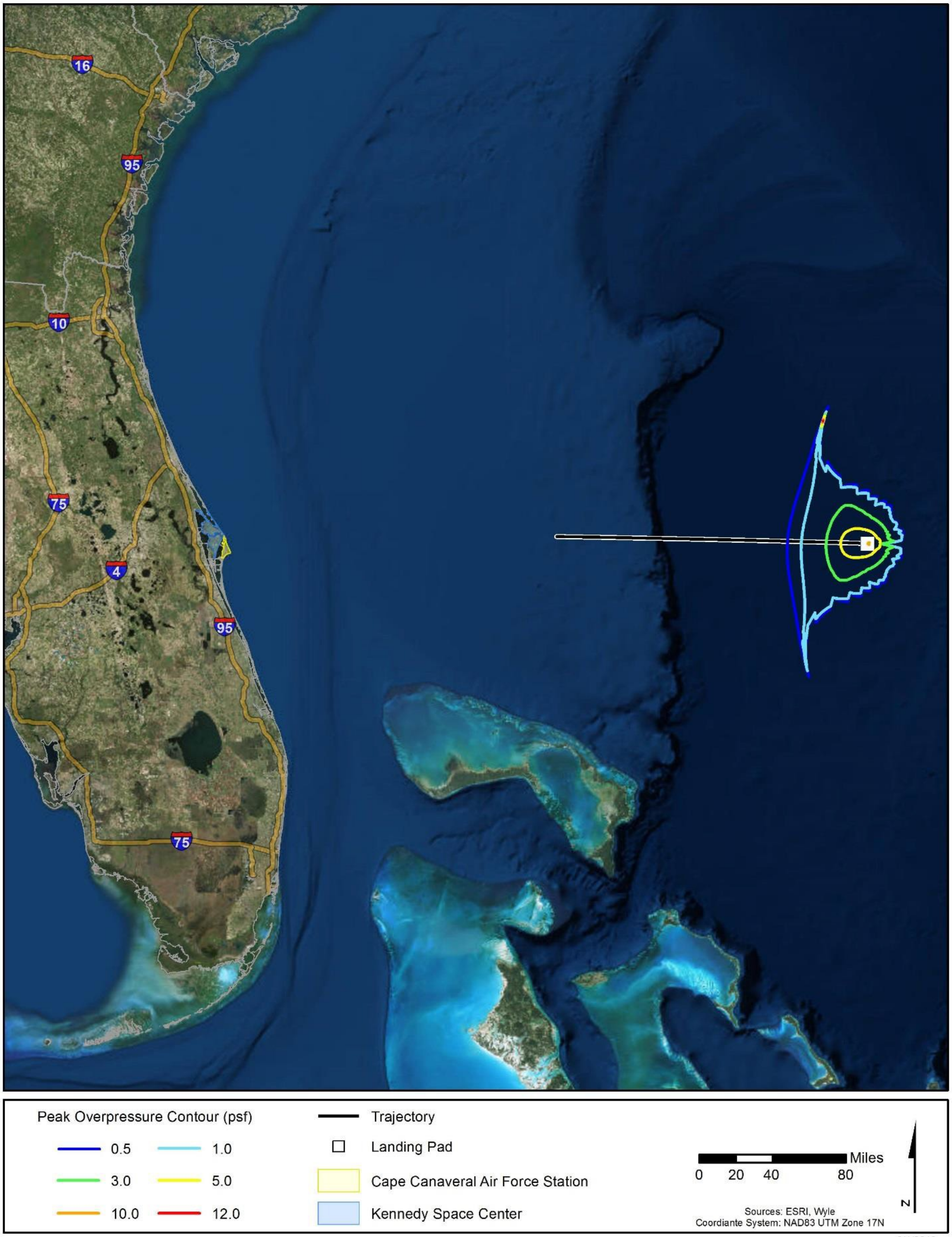

Figure 3-9. Super Heavy Booster Sonic Boom Levels for Reentry/Droneship Landing

In general, sonic booms in the 0.2 to 0.3 psf range could be heard by someone who is expecting it, but usually would not be noticed. Booms of 0.5 psf are more likely to be noticed, and booms of 1.0 psf are certain to be noticed. Therefore, people west of KSC are likely to notice booms from landings and people located at CCAFS or KSC, within the 3.0 psf and 4.5 psf region, could possibly be startled. Effects on wildlife are discussed in Section 3.3.2.

SpaceX has developed a notification plan to educate the public and announce when a landing event would take place. Announcements of upcoming Starship/Super Heavy launches and landings would serve to warn people about these noise events and would likely help reduce adverse reactions to these noise events. The plan would involve issuing statements to news outlets and law enforcement so that if and when heard, the public would understand what has occurred. While the overall impact of sonic booms would be insignificant, implementing these best management practices (BMPs) and mitigation plans would help to reduce the impact of a sonic boom event even further. The boom levels over land are not likely to cause property damage.

No Action Alternative

No construction, increase of local traffic, test fires, launches, or landings 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

Biological resources include vegetation, wildlife, and the habitats in which they live. Detailed information and descriptions of the flora and fauna of KSC are addressed in the KSC PEIS (NASA 2016) and ERD (NASA, 2015a). A summary of that information and additional site-specific descriptions of the Proposed Action area are provided in the following paragraphs.

3.3.1 Affected Environment

While KSC and CCAFS represent an industrial aerospace complex, much of the land is undeveloped and in a semi-natural state. Topography is generally flat, with elevations ranging from sea level to approximately 6 m 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. KSC is bordered on three sides by the IRL system and to the east by the Atlantic Ocean. The IRL is considered one of the most diverse estuarine ecosystems in the United States (Swain et al. 1995). It provides habitat that supports sport, commercial, and recreational fishes, as well as many shorebird and wading bird species. In addition, the IRL is developmental habitat for juvenile sea turtles including the green turtle (*Chelonia mydas*) and loggerhead sea turtle (*Caretta caretta*). While once considered an excellent oyster and clam harvesting area, the oyster reef habitat (*Crassostrea virginica)* and the hard clam (*Mercenaria mercenaria*) abundance has declined since the late 1990s (IRLNEP 2019). The Atlantic beaches are important to nesting sea turtles and shorebirds, and the coastline provides resources and navigation guidance during migration for numerous bird species. The region has several terrestrial and aquatic conservation and special designation wildlife management areas and aquatic preserves (NASA 2015). KSC, with the adjacent federal properties, is recognized as having the greatest number of Threatened or Endangered species, under the Endangered Species Act, (ESA) among federal facilities in the continental United States (Breininger et al. 1994, D. Breininger/IMSS, 2019 pers. comm.).

Details of the CCAFS barrier island landscape are described in Section 3.3.1 of the Supplemental EA for landing of the Falcon at LC-13 (USAF 2017) and the LZ-1 site is an existing, frequently, used aerospace pad surrounded by a perimeter of ruderal landcover which gives way to upland hardwood, coastal strand, oak scrub, and the Atlantic Ocean.

Oceanographic Resources

The Proposed Action would launch from KSC, however, as with all Cape Canaveral launch trajectories, this is planned over the adjacent Atlantic Ocean and stage landings would occur on the droneship located offshore greater than 5 nautical miles downrange. NASA (2015) described in detail the nearshore environment of KSC and requirements of the Magnuson-Stevens Fishery Conservation and Management Act, Public Law 104-208. This Act provides for the protection of Essential Fish Habitat (EFH) and relevant to the Proposed Action as the waters adjacent to the LC-39A Starship/Super Heavy launch site include several areas designated as EFH. The environment is of importance to sharks, game fish, lobsters, shrimp, and crabs. These habitats include soft bottom substrates, consolidated substrates, and the surf zone as well as the northern boundary of Oculina Bank. The Oculina Bank is a unique 90 nautical mile long strip of coral reefs located approximately 20 nm southeast of Cape Canaveral.

As described in the 2015 NASA Environmental Resources Document (NASA 2015), the nearshore benthic habitat consists of a series of sand ridges, which provide food or energy resources for numerous ecologically and economically important fish species and organisms at higher trophic levels. Densities of some fish and crustacean species in these waters are quite high.

Terrestrial Habitats and Vegetation

Florida's geological history has largely been determined by sea level changes that directly influenced soil formation and topography, resulting 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 narrow adjacent bands of uplands and wetlands running in a general north/south direction across the island. The dominant upland communities on KSC are scrub and pine flatwoods (Provancha et al., 1986). Forests occur on higher areas as do scrub and pine flatwoods (Breininger et al. 1994a). Adjacent to the IRL estuary that surrounds much of the KSC are salt marshes, various wetland shrub communities, and mangrove swamps.

The Proposed Action site lies within the confines of LC-39A. Land cover has been highly disturbed since the 1950s and currently consists of 20.5 ha of primary infrastructure (launch pad, roads, support structures and buildings), shallow freshwater retention ditches (0.3 ha), and ruderal herbaceous vegetation (44.1 ha of mowed grass).

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 recent study (2016-2017) of bee population declines in urban environments was conducted with collections from KSC included; however, the report is not yet available (A. Abbate/Auburn University, pers. comm. 2019). 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. Ten species are protected by the State of Florida as Threatened (Table 3-1). Nine other terrestrial species are federally protected and two additional species are candidates for federal protection; these are listed in Table 3-2 and discussed in the Threatened and Endangered Species section below.

Table 3-1. Wildlife Species Documented on KSC/CCAFS that are not Federally Listed but are Protected as Threatened by the State of Florida. Key: O = operations; CX = construction

SCIENTIFIC NAME	COMMON NAME	POTENTIAL IMPACT
Pituophis melanoleucus mugitus	Florida pine snake	None
Egretta caerulea	Little blue heron	O
Egretta tricolor	Tricolored heron	O
Egretta rufescens	Reddish egret	O
Ajaia ajaja	Roseate spoonbill	O
Falco sparverius paulus	Southeastern American kestrel	None
Grus canadensis pratensis	Florida sandhill crane	CX, O
Sterna antillarum	Least tern	None
Rynchops niger	Black skimmer	None
Haematopus palliates	American oystercatcher	None

Herpetofauna

Seventy-two species of amphibians and reptiles have been documented as occurring on KSC (Seigel et al. 2002): 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.

One of the 72 species, the Florida pine snake (*Pituophis melanoleucus mugitis*), is not federally listed but is protected by the State of Florida (Table 3-1). 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 1986); pocket gophers have not been documented on KSC.

The gopher tortoise is protected by the State of Florida as a Threatened species but 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 358 bird species (USFWS 2019a) 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 (*Aphelocoma coerulescens*) are federally protected, and the black rail (*Laterallus jamaicensis*) is a candidate species for federal listing.

In addition, nine bird species are protected by the State of Florida (Table 3-2). 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 (Smith and Breininger 1995). Long-term nest surveys conducted from 1987 through 2016 had an annual mean of 2,081 wading bird nests, yielding an estimated average adult population of 4,162 birds during the breeding season. In addition, monthly foraging habitat use surveys conducted from 1998 through 2016 indicated an average of 1,028 wading birds for 20% of the impounded wetlands on KSC. Although this survey was not designed to estimate the total wading bird population, a mean of 5,140 wading birds present at any given time is reasonably assumed (E. Stolen/IMSS, 2019, pers. comm.).

Mammals

Thirty species of mammals inhabit KSC lands and waters (Ehrhart 1976). Common 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 are the likely top mammalian predators on KSC. However, coyotes (*Canis latrans*) are becoming more numerous on KSC. In addition, feral pigs (*Sus scrofa*) remain widespread in every KSC habitat, as non-native predators and cause much environmental damage. Four species of bats have been documented, the most common being the Brazilian free-tailed bat (*Tadarida brasiliensis*).

Three species of mammals occurring on or in the KSC nearshore are federally listed: the southeastern beach mouse (*Peromyscus polionotus nivientris*), the northern right whale (*Eubalaena glacialis)*, and the West Indian manatee (*Trichechus manatus*). Bottle nosed dolphins (*Tursiops truncates*) are common in the IRL and nearshore waters and, as for all marine mammals, are federally protected in U.S. waters under the Marine Mammal Protection Act; however only those listed as threatened or endangered will be discussed below.

Threatened and Endangered Species

Carter's mustard (*Warea carteri*) and Lewtons's polygala (*Polygala lewtonii*) are endangered plants that may be found in the region (USFWS 2019), however, neither of these have not been found on KSC or CCAFS (P. Schmalzer/IMSS, 2019, Pers. comm.). There are 39 plant species that are protected by the State of Florida as endangered, threatened, or species of special concern (NASA 2015).

Seventeen wildlife species are listed as present in the ROI and Brevard County (USFWS 2019) but interrogation of long term local data from MINWR and the KSC Ecological Program records discount the presence of several of these species within KSC and CCAFS.

Fifteen federally protected wildlife species have been documented regularly on or in the near vicinity of KSC or CCAFS (Table 3-2). The Atlantic saltmarsh snake (*Nerodia clarkii taeniata*) historically occurred along the coastline from Volusia County through Brevard County south into Indian River County. However, it is now believed to be restricted to a limited coastal strip in Volusia County (USFWS 2018) and no longer expected to be found on KSC.

Six other species are extremely rare or only incidentally present on or near KSC/CCAFS and do not make important contributions to the area's biota. These include the smalltooth sawfish (*Pristis microdon)*, the hawksbill sea turtle (*Eretmochelys imbricata*), snail kite (*Rostrhramus sociabilis*), Audubon's crested caracara (*Polyborus plancus audubonii*), piping plover (*Charadrius melodus*), and roseate tern (*Sterna dougallii*). In addition, the red cockaded woodpecker (*Picoides boreali)* is listed within Brevard County but is has not been recorded on KSC or CCAFS in the last four decades (M. Legare/USFWS, 2019, pers. comm.).

The American alligator (*Alligator mississippiensis*), once on the brink of extinction, has rebounded throughout its range. However, the alligator is similar in appearance to the listed the American crocodile (*Crocodylus acutus*), and thus remains on the federally protected list. Other common species are loggerhead sea turtle (*Caretta caretta*), green sea turtle (*Chelonia mydas*), occasionally the 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.

Four marine turtles and the gopher tortoise could potentially be impacted by Proposed Action construction. These five species and an additional five species could potentially be impacted by launches and associated operations at LC-39A. These species are described in the following paragraphs and will be further discussed in Section 3.3.2 Environmental Consequences. Any potential impacts determined for all listed species under USFWS jurisdiction would require consultation with USFWS.

Table 3-2. Federally Protected Wildlife Species Documented to Occur on KSC and CCAFS.

SCIENTIFIC NAME	COMMON NAME	PROTECTION LEVEL	AGENCY EFFECTS DETERMINATION
Alligator mississippiensis	American alligator	T (S/A)	O-NLAA
Chelonia mydas	Atlantic green sea turtle	T	CX,O-NLAA
Caretta caretta	Loggerhead sea turtle	T	CX,O-NLAA
Lepidochelys kempi	Kemp's ridley sea turtle	E	CX,O-NLAA
Dermochelys coriacea	Leatherback sea turtle	E	CX,O-NLAA
Gopherus polyphemus	Gopher tortoise	C	CX,O-NLAA
Drymarchon couperi	Eastern indigo snake	T	No effect
Mycteria americana	Wood stork	T	O-NLAA
Haliaeetus leucocephalus	Bald eagle	P	No effect
Laterallus jamaicensis	Black rail	C	No effect
Aphelocoma coerulescens	Florida scrub-jay	T	O-NLAA
Calidris canutus rufa	Rufa red knot	T	No effect
Peromyscus polionotus niveiventris	Southeastern beach mouse	T	O-NLAA
Eubalaena glacialis	Northern right whale	E	O-NLAA
Trichechus manatus	West Indian manatee	T	O-NLAA
Nerodia clarkii taeniata	Atlantic salt marsh snake	T	No effect

Key: T (S/A) = Threatened due to similarity of appearance to another protected species; O = operations; NLAA=Not Likely to Adversely Affect; T = Threatened; CX = construction; E = Endangered; C = Candidate for federal protection; P = protected under the Bald and Golden Eagle Protection Act, Migratory Bird Treaty Act, and Lacey Act.

American Alligator

There are thousands of alligators in the IRL and freshwater marshes on KSC and CCAFS and they sometimes cause problems related to traffic safety and encounters with people around and within facilities. The population is reproductive and alligators of all size classes are common.

Marine Turtles

Details regarding marine turtles found within the ROI were well described in previous EAs (NASA 2013, NASA 2015, NASA 2015a, USAF 2017). All marine turtles are protected under the ESA and those four, listed in Table 3-2, have been observed using KSC beaches for nesting. The loggerhead sea turtle and green sea turtles are most abundant, particularly during their nesting season (May through October). Leatherbacks, listed as endangered, are not common on KSC but have increased nesting over the past decade and are no longer considered rare. The Kemps ridley sea turtle, also endangered, is relatively rare but there are records of nesting on the CNS and CCAFS beaches. Juvenile loggerheads, greens, and occasionally, Kemps sea turtles are found in the IRL, which provides developmental habitat for this life stage.

While KSC, CNS, and CCAFS together provide over 67 km of federally owned nesting beach, the KSC secured beach (closed to public access) adjacent to LC-39A is only 10 km long. The closest point from the center of LC-39A complex to the nesting beach is approximately 0.7 km (2,300 ft). KSC lighting from nighttime space operations has sometimes resulted in disoriented hatchlings and adults over the last two decades. The beach is monitored for sea turtle disorientation each summer. Over the last 14 years the disorientation rate attributed KSC sources ranged from 2% to 12%, with the average of approximately 5%.

As described in detail by NASA (2015), nesting occurs along the entire beach but “nesting hot spots” are documented with one high density zone located due east of LC-39A. In the last decade this area and north towards LC-39B has also experienced extensive erosion and wash overs. This dunal area has recently been enhanced with additional sand dune creation. The recent dune improvements provide some abatement to the disorientation problem by screening nesting or emerging turtles from a direct line of sight to the pad, however lighting management is still a requirement to reduce this impact.

The USFWS issued a Biological Opinion (BO) (FWS Log No. 04EF-1000-2016-F-0083, in Appendix B) for exterior light use at KSC and to USAF a revised BO regarding the SpaceX Vertical Landing at LZ-1 (FWS Log No.04EF-1000-2014-F-0259). These BOs specifically address incidental take of emergent hatchling and nesting sea turtles. They establish actions to minimize adverse impacts of artificial lighting on sea turtle reproductive success. These requirements include:

- Using special long-wavelength lighting with exceptions where color rendition is an operational or safety requirement;
- Using only the minimum lighting required for safety and security;
- Keeping light fixture mounting heights as low as possible while shielded from direct view of the beach; and
- Developing facility specific Lighting Operations Manuals (LOMs) and Light Management Plans (LMPs) to ensure only authorized use of lighting for all new construction and facility upgrades.

These required actions have been integrated into KSC and CCAFS institutional environmental requirements. For KSC tenants, these are identified in KNPR 8500.1, Rev. E (NASA 2018) and for CCAFS, the 45SW Instruction for Exterior Lighting Management (45SWI 32-7001, dated April 23, 2018) provides requirements for LMPs for all facilities.

The reasonable and prudent measures and non-discretionary terms and conditions identified in the BO for CCAFS are similar to those for KSC to aid in the reduction of lighting impacts and incidental take of sea turtles. Measures require LMP compliance inspection, enforcement, and monitoring of sea turtle orientation. Lighting not compliant with the LMP must be made compliant prior to commencement of the launch/landing/processing operation. The incidental take for CCAFS and for KSC disoriented sea turtles was set to 3% for hatchlings and 3% for adults. The Service concluded 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 (USFWS 2017).

KSC and CCAFS continue to make progress in reducing light use through development and implementation of LOMs and LMPs for launch complexes and facilities, and replacement of legacy, short-wavelength lighting with new light-emitting diodes (LED) long-wavelength light fixtures that are less disruptive to sea turtles and other wildlife (L. Phillips/NASA Environmental Management Branch, 2019, pers. comm., and A. Chambers/USAF 45SW, 2019, pers. comm.). A draft LOM specifically for LC-39A was prepared by SpaceX; approval is now pending with the USFWS. The LOM would be updated as necessary to reflect additional lighting and changes to existing lighting operations resulting from construction and operation of Starship/Super Heavy support facilities at LC-39A. The LZ-1 LMP is being updated by SpaceX (A. Chambers/USAF 45SW, 2019, pers. comm.).

Gopher Tortoise

The gopher tortoise is common, widespread, and well-studied on KSC (Breininger et al.1991, Breininger et al.1994a, Pike 2006). 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 and Franz 1982). The gopher tortoise excavates burrows for 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. Gopher tortoises occur within the boundary of LC-39A on elevated pads and along the perimeter fence line. They are occasionally relocated by a qualified biologist away from work areas within the complex depending on their location, to avoid injury.

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. 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. 64 Habitat fragmentation was found to be a critical factor impacting indigo snake population persistence. Snakes that occupied areas that were intact (i.e., less fragmented by roads and other features) had significantly higher survival rates than snakes living in places that were more highly fragmented. Road mortality was found to be the most prevalent cause of death in the radio tagged indigos studied in Brevard County. 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. (NASA 2013).

Wood Stork

Wood storks were listed as Endangered in 1984 primarily due to the loss and degradation of suitable wetlands in south Florida (USFWS 2019b). 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 2019a). Based on surveys conducted between 1984 and 2006, the number of nesting pairs has almost doubled, indicating a stable or increasing population. As a result, the wood stork's federal 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 only six to seven per survey (E. Stolen/IMSS, 2019 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, wood stork nesting has not. Population numbers increase on KSC in the winters when there is an influx of non-resident birds, and they feed more commonly in freshwater ditches than in the estuarine habitats (E. Stolen/IMSS, 2019, pers. comm.). The shallow ditches on the north and west sides of the LC-39A complex, as well as the estuarine waters (creeks, ditches, and impoundments) located just outside the LC-39A perimeter fence, provide suitable habitat for wood stork feeding.

Bald Eagle

Although the bald eagle has been removed from protection under the Endangered Species Act, it is still federally protected by the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. NASA continues to consider potential disturbance to bald eagle nests whenever siting facilities, doing outside maintenance, and during day-to-day and launch operations. Eagles use estuary for feeding and pine trees in the upland mixed forest for nesting.

Florida Scrub-Jay

KSC facilities are intermixed with fire-dependent wildland habitats including oak-palmetto scrub, pine flat woods, and marshlands. 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, including Florida Scrub-jay.

Southeastern beach mouse

The range of the threatened southeastern beach mouse once extended from Ponce Inlet to Miami Beach. 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. Southeastern beach mice inhabit the coastal dune and adjoining scrub. 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. Studies and surveys have been done 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, capture rates of beach mice were good, but less than those experienced further south on CCAFS where the expanse of suitable habitat is much wider. 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 indicated that southeastern beach mice are distributed along the entire CNS/KSC/CCAFS coastline. (NASA 2013)

Northern Right Whale

The North Atlantic right whale is described in previous, recent EAs pertinent to the Cape Canaveral launch programs (USAF 2007 and 2013, NASA 2013). This species is listed as Endangered and there are an estimated 450 Atlantic right whales (NOAA 2019). Each winter and spring, the species is observed migrating between the northwest Atlantic coast and warmer waters along Florida and Georgia with their calves. They are monitored by aerial surveys and by land based volunteer organizations along the coasts to document their persistence and individual identities along the route through unique patterns on their bodies.

West Indian Manatee

The manatee was downlisted by the USFWS from Endangered to Threatened in March of 2017. As described in recent EAs and the KSC ERD (NASA 2015, NASA 2015a, NASA 2013) the estuarine waters surrounding KSC provide year-round safe harbor and foraging areas for West Indian manatees. Manatees occur in peak numbers each spring and fall. The cold periods of the winter months influence their departure to warmer waters either south or to the neighboring power plants that produce warm water effluent into the IRL. The northern Banana River and south to near Kennedy Athletic, Recreation and Social (KARS) Park I (just northwest of Port Canaveral) is protected from entry by unauthorized motorized watercraft as part of KSC security restrictions and has been an effective manatee sanctuary since the 1990 closure to such watercraft. Over the last three decades, the numbers within the northern Banana River increased nearly tenfold; in 2012 the spring peak count was more than 1,000 individuals on one survey in this small sector of KSC waters (75 km^2). This represents 20 to 25% of the estimated Florida population.

The relative quiet of KSC waters combined with once extensive seagrass beds, provided good habitat for manatees (Provancha and Hall 1991, Lefebvre et al, 2016). However, intense algal blooms decimated approximately 90% of the once stable seagrass coverages in 2011 and 2012. Improvements in were observed but from 2016-2018 the Brown Tide returned and concomitant losses in seagrasses followed (D. Scheidt/IMSS, 2019, pers. comm.). Manatee numbers using the Banana River declined significantly with an apparent shift to other nearby waterbodies in the IRL and Mosquito Lagoon, just north of LC-39B. The long-term impacts on manatees and other seagrass dependent species are being documented. Seagrass mapping by the St. Johns River Water Management District (SJRWMD) occurs every few years and monitoring manatee distribution and abundance on KSC continues under the NASA Ecological Program.

Critical Habitats

None of the terrestrial protected species have designated critical habitats. Designated critical habitat for the Florida manatee (*Trichechus manatus latirostris*), the North Atlantic right whale (*Eubalaena glacialis*), and the loggerhead sea turtle (*Caretta caretta*) are within the ROI, adjacent to or within the Atlantic, Cape Canaveral region. The ROI for Starship/Super Heavy is the same as described for the Falcon boost-backs, splash downs, etc. (USAF 2017) with the operational goal to work at least 20 nm off of Cape Canaveral.

Manatee Critical Habitat

In 1975, the USFWS designated multiple waterways and parts of coastal Florida, from Jacksonville south to Miami and west around the peninsula to Tampa Bay, as critical habitat for manatees (Federal Register 1975). The waters around KSC and CCAFS fall into this designation. The Upper Banana River is additionally protected by NASA due to its closure to the public for safety and security measures. This is an area of particular emphasis for cautious boat operations and is managed by NASA and MINWR.

North Atlantic Right Whale Habitat

The critical habitat for the North Atlantic right whale is described by NOAA (2019) and in the previous EAs (USAF 2007, NASA 2015a). There are currently an estimated 450 North Atlantic right whales. Each year, during the months of November through April, this species travels from the northwest Atlantic coast and enters the warmer waters along Florida and Georgia with their calves or to give birth. National Marine Fisheries Service (NMFS) designated the nearshore waters as critical habitat to reduce ship-whale collisions whereby boats are prohibited within 418 m (1,371 ft) of a right whale and ships greater than 20 m (65 ft) in length for certain areas must have reduced speeds. In 2016, a final rule (81 FR 4837) was issued that extends the critical habitat of the North Atlantic right whale south to Cape Canaveral, and eastward 5 nm from the coast. The Starship and Super Heavy planned landings would farther than 5 nm offshore, outside of this critical habitat. To date there have been no reported adverse interactions with whales resulting from launching or recovery efforts for any spaceflight vehicle from KSC/CCAFS.

Loggerhead Sea Turtle

Critical habitat for the Loggerhead sea turtle is described in detail by NMFS (NMFS 2018a) and the USFWS (FR 2014). Some in-water critical habitat(s) for the loggerhead sea turtle population units (Units LOGG-N-16 and 17) occur within or near the Proposed launch area, Figures 3-10 and 3-11. The areas consist of a combination of nearshore reproductive habitat (directly off nesting beaches to 1.7km [0.9 nm]) breeding habitat, foraging, *Sargassum*, and constricted corridors. The LOGG-*N-16* unit contains nearshore reproductive habitat only (concentrated breeding area) with the boundaries including nearshore areas, mean high water line (MHW) seaward to 1.6 km (0.9 nm). The action area is also within the critical habitat titled LOGG-N-17.

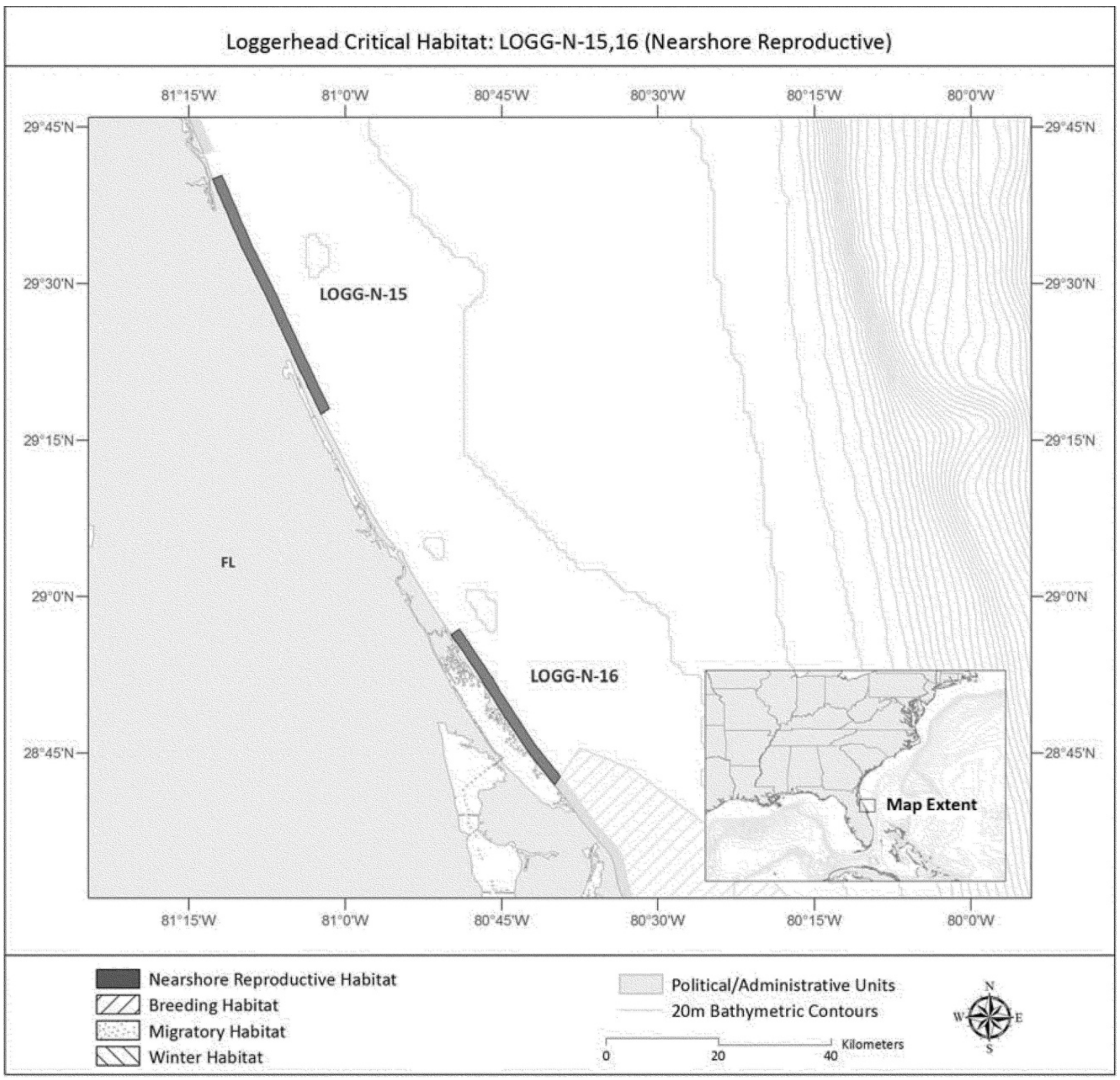

Figure 3-10. Loggerhead Sea Turtle Critical Habitat Map Unit 16 (Federal Register 2014)

This unit, Figure 3-10, overlaps habitat areas and includes *Sargassum* habitat. The concentrated breeding area extends from the MHW line to depths less than 60 m (197 ft) and south to Floridana Beach. The northern portion of the Florida constricted migratory corridor begins at the tip of CCAFS (28.46° North latitude) and ends at Floridana beach, from the MHW line to the 30 m (98 ft) depth contour. By virtue of the shared zone from the MHW line water ward, the concentrated breeding and constricted migratory habitats overlap with two nearshore reproductive habitat areas. One, near Titusville (28.46° North latitude) to the south boundary of the CCAFS and the second from Patrick Air Force Base, south to Floridana Beach (27.93° North latitude).

- The *Sargassum* habitat runs along the Atlantic coast from the Florida Straits up the western edge of the Gulf Stream eastward.
- The proposed landing areas begin at least 9.3 km (5 nm) offshore and are outside of the loggerhead sea turtle nearshore reproductive habitat (1.6 km [0.9 nm] of shore). The landing areas do overlap with the migratory and *Sargassum* habitats.

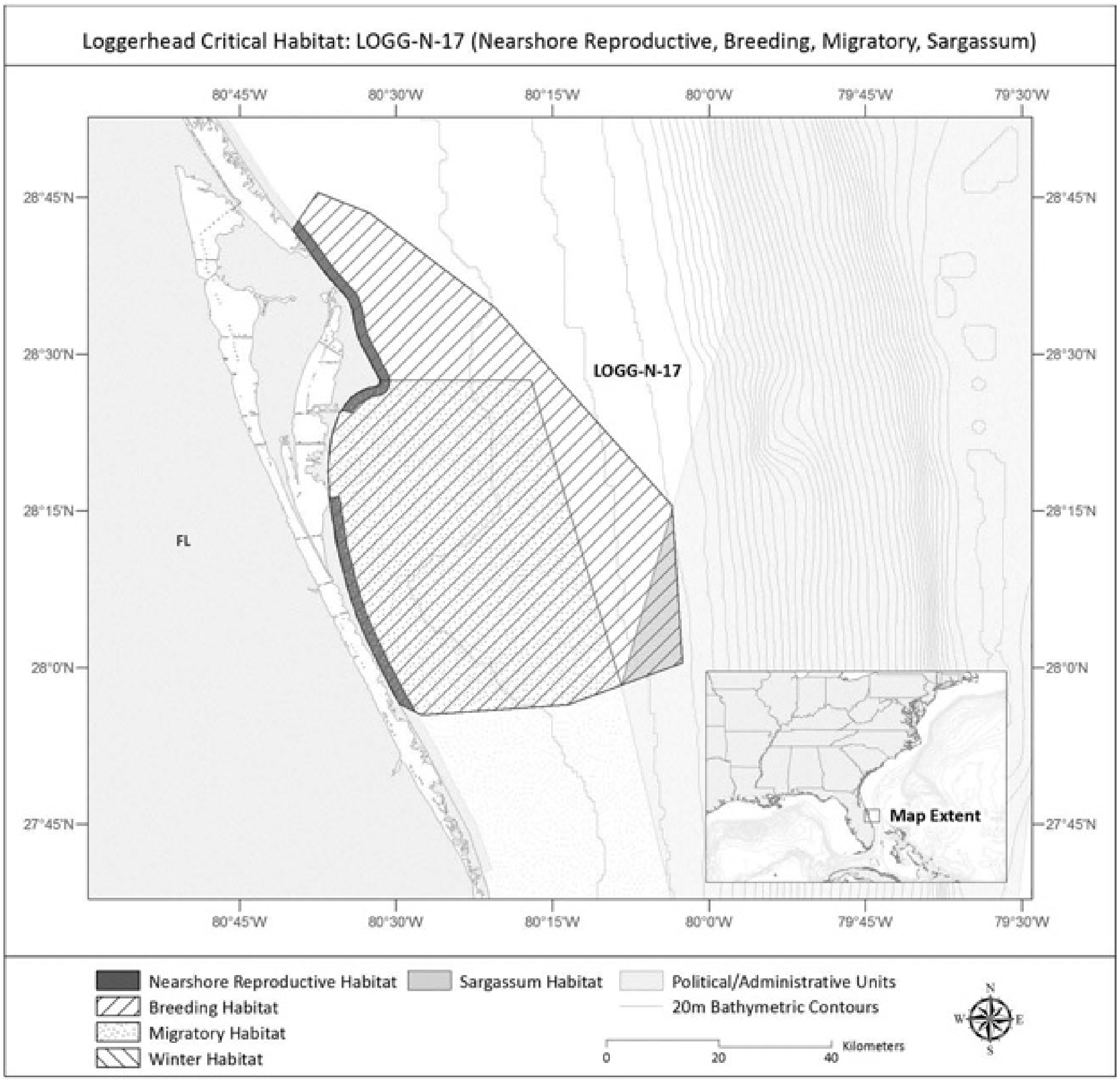

Figure 3-11. Loggerhead Sea Turtle Critical Habitat Unit 17 (Courtesy NOAA)

In 2014, the USFWS designated critical habitat for loggerhead sea turtle nesting along North Carolina through Florida beaches (50 CFR 17). Exempted from this habitat designation are the two local USAF beaches at CCAFS and Patrick Air Force Base (PAFB). These were exempted due to the mitigation measures that the Department of Defense (DOD) incorporated into their integrated natural resource management plans.

3.3.2 Environmental Consequences

The primary potential impacts from the Proposed Action would be: 1) disorientation of nesting marine turtles on adjacent beaches from lighting during construction and nighttime operations; 2) thermal stress or damage to habitat and wildlife within 440 m of Starship/Super Heavy launch mount, due to heat plume generated from launch; and 3) potential startle response impacts to wildlife from noise and sonic booms produced by launches and landings as described under 3.2.2.

Per FAA Order 1050.1F, impacts would be significant if the USFWS or NMFS determine the action would be likely to jeopardize the continued existence of a federally listed threatened or endangered species, or would result in the destruction or adverse modification of federally designated critical habitat. Any impacts that "may affect" any listed species requires consultation under the ESA and the Marine Mammal Protection Act (MMPA).

Oceanographic Resources

Direct impacts are not expected to affect the ocean from the construction at LC-39A. However, there is a potential for operations to have an effect via components from launch vehicles falling into the ocean. Because the Proposed Action has the potential for debris deposition in the Atlantic Ocean from a landing anomaly, there is consideration of operational impacts on the ocean. Components would include non-recoverable items (debris) such as rocket pieces from a launch anomaly and rapidly sink to the bottom in ocean areas cleared of shipping or air traffic. As described in previous NEPA analyses (USAF 2007, 2013, 2017) and ESA Section 7 consultations with NMFS (NMFS 2016, 2017, 2018a, 2018b), significant impacts on marine habitats and species from SpaceX's reentry and recovered operations are unlikely. These are expected to not cause any impacts of concern as previously analyzed by FAA and NOAA (USAF 2017, NASA 2013,). Similarly, impacts to fisheries and EFH are expected to not be measurable and therefore, are insignificant.

Terrestrial Habitats and Vegetation

Construction would be limited to inside the perimeter fence of LC-39A. Only ruderal herbaceous vegetation (mowed grass) would be disturbed or destroyed and the impacts would be minimal.

A flame diverter is proposed to be underneath the launch mount to direct exhaust and heat away from the launch mount and other infrastructure during liftoff. The plume is expected to reach ambient temperature at the point that it has traveled approximately 440 m, extending just beyond the southeastern boundary of the LC-39A pad and facilities. A small fringe of mangroves (2.8 ha) along the complex perimeter may become scorched after individual or repeated launches depending on the heat dissipation experienced during launch. This was common along the northern perimeter of the complex during the Shuttle Program, whereby vegetation was damaged in varying degrees and there was an eventual succession of plants to heat tolerant grasses. The LZ-1 and vicinity has had no recorded impacts to the lands or wildlife outside of the facility perimeter (A. Chambers/USAF 45SW, 2019, pers. comm.).

Terrestrial Wildlife (Herpetofauna, Birds, and Mammals)

Wildlife is sparse in the highly active LC-39A complex with only ruderal vegetation where construction would occur. Most of the species that might be directly affected are common on KSC and are not legally protected. Startle responses by wildlife, particularly, birds that may nest in the vicinity would be expected as with any launch facility. Routine and launch operations would not be expected to cause notable damage to most wildlife populations within the ROI. Exceptions are discussed in the Threatened and Endangered Species section below.

Threatened and Endangered Species

Lights, heat, noise, and debris falling (from an anomaly) into the ocean from launched rockets are the primary concerns associated with construction and operation of the Proposed Action. Table 3-3 includes the federally listed species that could potentially be impacted and these are addressed in the following paragraphs. The ESA and the MMPA applies and prohibits, with some exceptions, the “take” of listed species and marine mammals in the United States and by U.S. citizens on the high seas. The term “take” means to harass, hunt, capture, or kill or attempt to harass, hunt, capture, or kill any listed species or marine mammal. NASA is undergoing informal consultation with the USFWS Endangered Species Office for likely to affect, not likely to adversely affect for the species listed in Table 3-2. USFWS coordination will be provided in Appendix D once consultation is complete.

American Alligator

Alligators are only included on the federal protection list due to their similarity of appearance to the American crocodile, which does not occur on KSC. Even though alligators could be present at LC-39A and potentially impacted by operations, it would not be significant for the large KSC alligator population, nor the larger Florida population. Five decades of experience at LC-39A has resulted only in the removal of nuisance alligators that occasionally move into a retention pond.

Marine Turtles

Construction at LC39A is expected to take place during day and night hours. Night lighting has a potential to disorient nesting and hatching marine turtles between March and October.

The same is true for night operations at the LC-39A launch pad, the methane flare, LZ-1, and support facility lighting that may be required during Starship/Super Heavy processing and launches. This is expected to result in a moderate but not significant impact. The management of exterior lighting, described below, would assist in reducing this impact. The impact would not result in jeopardy to any sea turtle species. All facilities would operate under KSC and USAF/CCAFS exterior lighting requirements.

The KSC exterior light requirements (KNPR 8500.1, Rev. E) state that all site lighting would be operated in accordance with the LC-39A LOM (NASA 2018). In addition, the KSC actions must comply with the USFWS BO (Appendix B). The beach is monitored during the nesting season track launch operation-induced disorientation events. These data are communicated to environmental managers at CCAFS and KSC to ensure compliance with the incidental take authorization from the USFWS. The Terms and Conditions identified in the current BO are to reduce lighting impacts and incidental take of sea turtles.

Reasonable and Prudent Measures and non-discretionary Terms and Conditions identified in the USFWS BOs help reduce lighting impacts and incidental take of sea turtles. The draft LOM for LC-39A is pending approval and will be updated to reflect additional lighting and changes to existing lighting operations resulting from construction and operation of Starship/Super Heavy support facilities at LC-39A.

Operations on CCAFS at LZ-1 for landings and operations, similarly, would comply with the 45SW Instruction for Exterior Lighting Management (45SWI 32-7001, dated April 23, 2018). All CCAFS tenants are to comply with the instruction and provide a Light Management Plan (LMP) for all facilities. The USFWS provided Section 7 consultation with a revised BO for 45SW regarding the SpaceX Vertical Landing at LZ-1 (FWS Log No.04EF1000-2014-F-0259, letter dated February 12, 2016). The Reasonable and Prudent Measures and non-discretionary Terms and Conditions identified in the BO for CCAFS are similar to those for KSC to aid in the reduction of lighting impacts and incidental take of sea turtles. Measures listed are similar to those for KSC (LC-39A) and require LMP compliance inspection, enforcement, and monitoring of sea turtle orientation. Lighting not compliant with the LMP must be made compliant prior to commencement of the launch/landing/processing operation. The incidental take for CCAFS disoriented sea turtles was set to 3% for hatchlings and 3% for adults.

Any new concerns would be determined through additional Section 7 Consultation between each agency (NASA and USAF) and the USFWS Endangered Species Office.

The launch and return support vessels and boats traveling within the nearshore waters would not constitute a significant increase in water traffic of concern to marine turtles.

Gopher Tortoise

Gopher tortoises occur inside the fence at LC-39A and could potentially be impacted by construction activities. All tortoise burrows that might be impacted would be surveyed with a burrow camera to determine whether or not they were occupied. Any tortoises found would be relocated to the nearest suitable habitat outside of the impact area. Impacts would be moderate.

Tortoises inside the LC-39A perimeter fence that would not be directly impacted by construction and tortoises outside the fence in the impact zone could potentially be affected by heat and noise generated during rocket engine testing and rocket launches. These impacts are expected to be minimal because of the protection provided by the tortoises' burrows. Tortoises occur along the coast in habitat that was exposed to many years of Space Shuttle launches. No deaths or injuries to gopher tortoises from launches were observed or reported (NASA 2014), and the coastal gopher tortoise populations are the most robust on KSC.

Eastern Indigo Snake

Loss of potential eastern indigo snake habitat is not expected to occur from the Proposed Action. Based on habitat characteristics of adjacent areas there is the potential that indigos could occur outside LC-39A. If an indigo snake was observed on site during construction or observation, all work would be halted until the snake had sufficient time to move away from the site without interference. No effect is expected to occur to eastern indigo snake from the Proposed Action.

Wood Stork

Currently wood stork numbers at KSC are extremely low. However, wood storks do use the wetland habitat types outside LC-39A for feeding. Nesting has not occurred on KSC since 1991 after freezing temperatures decimated the mangroves where nests were built. Impacts from launch heat and noise could potentially disrupt wood stork behavior for short periods of time. Video surveillance of wood storks during Space Shuttle launches showed that the birds were startled by the noise that occurred prior to lift-off, but they returned shortly after the noise subsided. This startle response would effectively direct them away and reduce risk of being affected by heat. Impacts from launches to wood storks are expected to be minimal.

Bald Eagle

There would be no impacts to estuarine waters or habitat loss due to the Proposed Action. There is no habitat with LC-39A and there have been no history of nests close to the pad. Based on yearly surveys conducted for eagles' nests, the closest active nest to any of the Proposed Action project development is more than 4 km away. No impacts to bald eagles are expected from the from the Proposed Action.

Florida Scrub-Jay

The Proposed Action would not change the land use and no development or conversion of habitat would occur. The Action Area does not include areas occupied by Florida Scrub-Jay and is not designated as core habitat. The Action Area is adjacent to Fire Management Unit (FMU) 5.3 to the north and west, and approximately 0.3 km from FMU 7.4 to the southeast (Figure 5). The Proposed Action could cause a loss of burn days due to operations. NASA KSC, working with Merritt Island National Wildlife Refuge (MINWR), would continue to include SpaceX in their prescribed fire planning and coordination activities to ensure that controlled burning of adjacent land and related issues are well-communicated with the ultimate goal of limited, if any, impact to operations at the launch complex. The burn planning and operations of this operational area, as well as, the entire KSC land area adhere to a Prescribed Burn MOU, KCA-4205 Rev B (NASA 2019). This document lays out conditions and constraints for conducting prescribed burns, both on KSC and CCAFS. Impacts on nest success from increased frequency of launch noise may also be a problem that should be monitored, but the information is not available yet and wouldn't be for several years. The Proposed Action would have a likely affect, NLAA on Scrub-Jay.

Southeastern beach mouse

Heat of the plume would be contained within the boundary of the pads and the no impacts to the beach mouse is expected. No observable, measurable rocket impacts occurred for southeastern beach mice at KSC during studies of this species during the space shuttle program. However, noise levels above 95dB could cause a startle response. Impacts from launch operations to southeastern beach mice are expected likely to effect, NLAA.

Northern Right Whale

There would be no impacts to northern right whales from construction of the Proposed Action. As for operations, described for the Falcon, there is potential consequence from rocket reentry debris during a landing anomaly. However, it is highly unlikely that a right whale would be directly hit by debris due to their low density in the area; the odds of such a co-occurrence are extremely low. As of 2019, there are no recorded impacts from launch debris for any species of whale.

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. These impacts would be classified as minimal for right whales because the corrosion rates would be very slow (NMFS 2018a, NASA 2013). This was previously analyzed and NMFS concurred with a determination of "not likely to adversely affect". NMFS consultation is attached in Appendix C. The propellants used on the Starship and Super Heavy would be gaseous when released, disperse in the air, and would not impact the water.

The launch and return support vessels would not constitute a significant increase in water traffic of concern to any whale species. In addition, vessel traffic within the Right Whale critical habitat is subject to slow boat speed restrictions (81 FR 4837) which provides increased protection and risk reduction to whales near the sea surface. No significant impacts to whales are expected from the Proposed Action from vessel traffic.

Sonic booms over the ocean for the Starship would range from 0.2 to 4 0 psf (KBRwyle 2019). Boom levels for Super Heavy booster in the vicinity of the droneship range from 5.0 to 10.0 psf. With the booster descent and landing on the droneship no closer than approximately 20 nm east of Cape Canaveral, a highly ephemeral, but focused zone was estimated near the tip of the crescent-shaped contour. It would affect a small footprint with a larger overpressure of 12.4 psf. However, the footprint is extremely small and well outside of the right whale critical habitat. The likelihood of a whale migrating through the Atlantic co-occurring with this boom is extremely low. In addition, sonic booms would not influence the underwater environment to any significant degree and so impacts to this and the other marine species is considered not significant.

West Indian Manatee

Manatees found in the upper Banana River on KSC would be potentially encountered by barges transporting equipment or vehicles up the intercostal waterway to the Turn Basin near LC-39A. Numbers of manatees within this area have dropped considerably in recent years concurrent with seagrass losses. The assumption is that this drop in manatee occurrence is associated with algae blooms impacting the seagrass forage. However, even during years with extensive forage and very high densities of manatees there have been no recorded impacts from NASA vessels on manatees. The barge activity has been ongoing for various NASA operations since the late 1970s with excellent protection to manatees. The protection is through the strict prohibition of any non-essential boat traffic in the secured waters, the imposed USFWS Banana River manatee sanctuary that extends from just north of Port Canaveral to the LC-39A area, and the slow speeds required of all barge traffic. There is no expected impact on manatees from construction or operation of the proposed action.

Critical Habitats

North Atlantic Right Whale Critical Habitat

The critical habitat for the North Atlantic right whale is described in the previous EAs (USAF 2007, 2013, 2017, NASA 2015a). As described in section 3.3.1, NMFS designated the nearshore waters as critical habitat to reduce ship-whale collisions. The Starship and Super Heavy has planned droneship landings to occur beyond 20 nm offshore, thus outside of the critical habitat. In addition, the vessel traffic returning components to Port Canaveral for reuse will be compliant with all existing speed and notification requirements. To date there have been no reported adverse impacts to this habitat resulting from launching or recovery efforts for any spaceflight vehicle from KSC/CCAFS. Therefore, no impacts are expected for this critical habitat by the Proposed Action.

Manatee Critical Habitat

The Upper Banana River continues to provide critical habitat for manatees regardless of the remarkable losses of seagrasses in the area due to the recent recurring algae blooms. Recent algae blooms have impacted the seagrass forage in this area, in addition to many areas of the IRL. However, this area still offers waters with extremely limited boating of any kind. The highly controlled barge and boat activity (with slow speeds and manatee observers for certain operations) within this critical habitat has been well managed over four decades. There is no expected impact on this critical habitat from construction or operation of the Proposed Action.

Loggerhead Sea Turtle Critical Habitat

The critical habitat for the loggerhead sea turtle on beaches is protected via multiple management actions already in place, light management plans, and through the concurrent location within the above listed Right Whale Habitat. This co-occurrence offers protection for turtles occupying the same corridor, as related to reduction in vessel speeds, thus reducing potential collisions with sea turtles. There is no expectation that this critical habitat would be impacted by the Proposed Action.

No Action Alternative

Under the No Action Alternative, the LC-39A Starship/Super Heavy pad modifications and support facilities 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 significant cultural resources. The most recent version of the ICRMP covers the 2014-2018 time period (NASA 2014a). 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

In January 2000, LC-39A (constructed in 1965) and LC 39B (constructed in 1968) became the first KSC sites to be listed in the National Register of Historic Places (NRHP), under State Identification Numbers 8BR2686 and 8BR2010, respectively. There are approximately 24 contributing resources (e.g., camera pads, LOX/LH_2 facility, support buildings, etc.) at each complex. The boundary of the historic site designation extends approximately 9 m outward and parallel to the perimeter service road. The launch pads underwent major modifications from 1976 to 1985 to accommodate the Space Shuttle vehicle. The main elements of the rebuilt pads were the hardstand, the flame trench and deflector system, the fixed service structure (formerly part of the Apollo-era launch umbilical tower), and the rotating service structure, which included the payload change-out room. Other modifications were new weather protection structures and a fully computer-automated payload ground handling mechanism. LC-39A was the site of the first Saturn V launch in 1967, the Apollo 4 mission, and the Apollo 11 mission in 1969 which took astronauts Armstrong, Aldrin, and Collins to the moon. In total, 11 Apollo missions and one Skylab mission, all using the Saturn V rocket, were launched at LC-39A. On April 14, 1981, the first Space Shuttle was launched from LC-39A, followed by an additional 80 launches.

The Crawlerway (State Identification Number 8BR1689) was completed in 1965 and listed in the NRHP in January 2000. Originally nominated because of its importance to the Apollo Program, the Crawlerway gained significance in the context of the Space Shuttle Program. The Crawlerway was originally designed and built during the Apollo era as the roadway for the transportation of the combined Mobile Service Structure, launch umbilical tower/launch vehicle, and Crawler Transporter(s), between the VAB and launch pads. It performed the same function in the transportation of the Space Shuttle vehicle atop the Mobile Launcher Platforms (MLPs) and Crawler Transporters. The Crawlerway is a 40 m^2 wide, double pathway at the Kennedy Space Center in Florida. It runs between the Vehicle Assembly Building and the launch pad at Launch Complex 39A. This area is shown on Figure 2-1. The MSS Park Site falls in the middle of the Crawlerway.

In addition to historic facilities, there are archaeological and historic areas of significance on KSC within or near the project boundary. Between 1990 and 1996, Archaeological Consultants, Inc., established differential zones of archaeological potential (ZAPs) within all areas of KSC. The ZAPs were defined as low, moderate, and high probability based on background research and archaeological field surveys. In 2008-2009, NASA initiated a study of the last 200 years of KSC history, including the development of a historic context and expansion of the predictive model to include historic period archaeological sites, ca. 1700 to 1958. A total of 122 ZAPs were identified within KSC and approved by the Florida State Historic Preservation Officer (FL SHPO) in February 2010. Predictive modeling has been used as an effective tool for KSC during the early planning stages of an undertaking, for targeting field surveys, and for other management purposes. As funds become available or projects arise, areas will be groundtruthed and known archaeological sites requiring additional surveys will be reevaluated for NRHP eligibility.

There are two historic areas in the adjacent to LC-39A, #118 to the north and #119 to the northeast along Phillips Parkway (ACI 2009). Historic Area #118 consists of seven structures shown on a 1934 Intracoastal Waterway map; four structures and the label for the Canaveral Club are found on the 1949 quad map. The Canaveral Club was a hunting and fishing club composed entirely of members of the Harvard University class of 1890. The 22-room clubhouse had a concrete swimming pool, golf course, and stables. The clubhouse was destroyed by fire and the site was demolished by the construction of the launch pads. Historic Area #119 was the location of the Chester Shoals House of Refuge/Coast Guard Station; 8BR0079 is also located in this area. An 1882 Act of Congress authorized construction of the House of Refuge and it was used as a Coast Guard and training station until World War II. Historic areas #118 and #119 are recommended for future archaeological testing (ACI 2009).

Titusville Beach/8BR0079 and Bottle Dump Site/8BR2364 are known archaeological sites located near LC-39A. The 8BR0079 site is within a moderate ZAP area and contains shell middens and historic refuse. 8BR0079 was largely destroyed in the mid-1960s during construction of the railroad and Coast Guard Station, as well as the subsequent demolition of the Coast Guard Station and land clearing activities. Further, midden material for 8BR0079 may have been used as fill at LC-39A. The site has undergone additional changes since the 1960s due to extensive land leveling. The FL SHPO concurred with the findings and site management recommendations report in 1991 (FDOS 1991). Land alterations in the area of 8BR0079 can proceed without further archaeological consideration.

The Bottle Dump Site is located within Historic Area #118. During a routine post-launch ecological survey, a KSC employee observed 20 to 30 bottles along the lagoon shoreline (ACI 2009a). In November 2009, KSC conducted an archaeological survey and evaluation of the area to determine if this site was eligible for listing in the NRHP and/or connected to the Canaveral Club. Results of the survey show the site is composed of fill materials. The artifacts found at the site consisted of ceramics, glass, white ware, and bottles, etc. It is still uncertain whether the bottles found were re-deposited or were an actual intact feature (ACI 2009a). The FL SHPO concurred that the site is considered ineligible for listing in the NRHP and further testing at 8BR2364 is not warranted (FDOS 2010).

A Cultural Resource Assessment Survey was conducted at the LZ-1 site by the 45SW Cultural Resource Manager between June and August 2014. Three previously unrecorded archaeological sites were investigated and were determined to be ineligible for listing in the NRHP. Between October 2015 and January 2016, a Phase 1 Archaeological Survey and additional historical research confirmed there were no historic or archaeological sites with the LZ-1 ROI (USAF 2017).

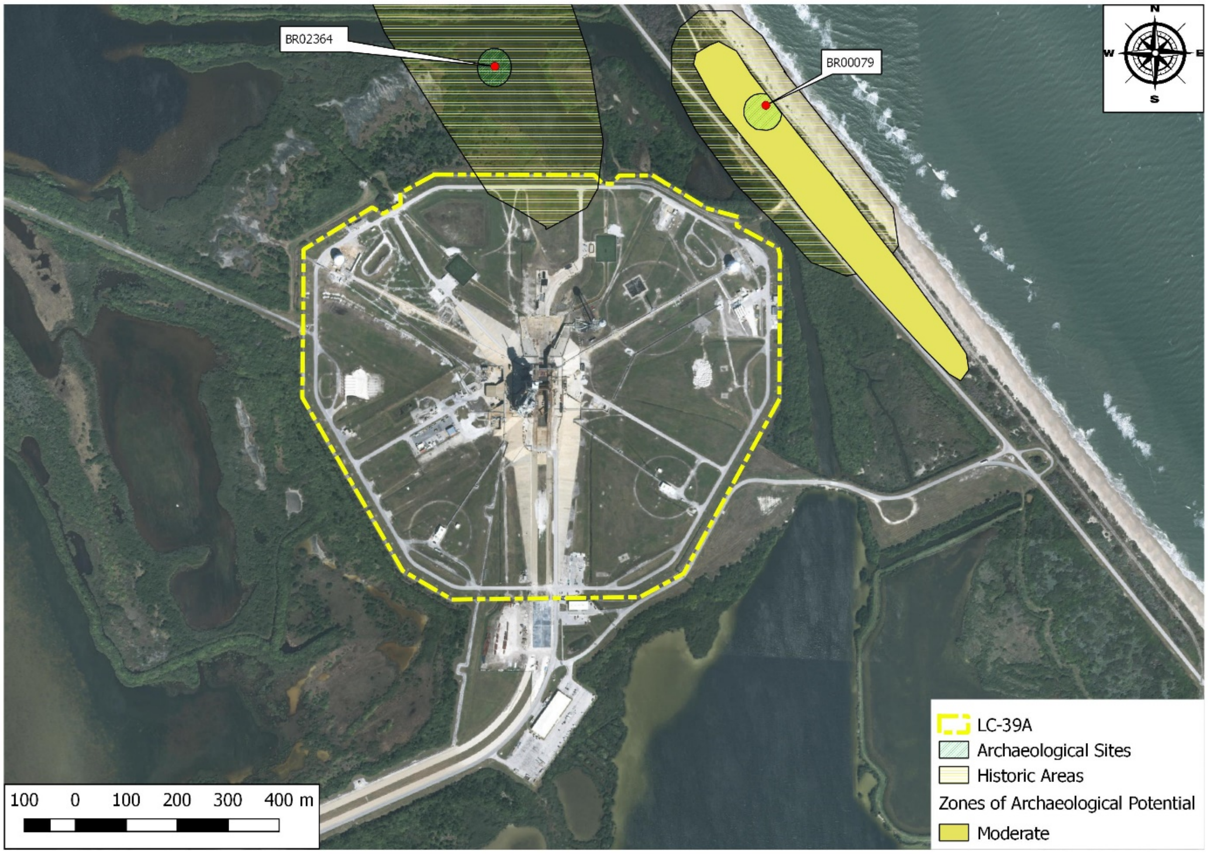

Figure 3-12. Archaeological and Historic Areas Sites at or Near Launch Complex 39A

3.4.2 Environmental Consequences

Construction

Modifications would be necessary at LC-39A in order to support the proposed Starship/Super Heavy launch vehicle. Moderate but no significant impact to the NRHP-listed LC-39A and historic districts would be expected. Under the Programmatic Agreement (PA), NASA KSC must consult with the FL SHPO pursuant to Stipulation III when an "adverse effect" to the historic property has been determined by an undertaking. The launch complexes have undergone major modifications between the Apollo, Space Shuttle, and Constellation programs to support the Agency's missions. Historic American Engineering Record (HAER FL-8-11-F), at a Level II, for the complexes was completed in 2010. The recordation package contains a written history of the complexes, process descriptions of activities that occurred at the site, interviews with program experts, as built drawings, and archival and current photos (ACI 2010). The HAER was performed to mitigate for "adverse effects" to the complexes that might occur with post Shuttle Program redevelopment. The FL SHPO, in a letter dated May 2013, concurred future consultation is not required for the reuse of LC-39A by a commercial entity. The Historic District has been mitigated with HAER recordation efforts. Artifacts such as historical signage unearthed are to be coordinated with the Education and External Relations Directorate.

There are no known archaeological resources impacted within the launch complex. Within NASA's agreement documents are environmental clauses and stipulations that protect KSC's historic properties. Prior to any modifications, an Environmental Checklist is prepared and a Record of Environmental

Consideration is completed to evaluate the impacts to cultural resources. During construction, if any archaeological material (e.g., artifacts, cultural features, or human remains) is found, work must stop immediately and the KSC Cultural Resources Manager would be contacted. Materials and remains would need to be identified per the Native American Graves Protection and Repatriation Act.

Operations

The FAA has not established a significance threshold for cultural resources. The Proposed Action at LC-39A is consistent with current operations at the site. No modifications to Crawlerway is expected from transport or operational use of Starship and Super Heavy. Staging and temporary fabrication tents could be used on the Crawlerway to support operations. The use of LC-39A and the Crawlerway by SpaceX for Starship/Super Heavy would not have an impact to the LC-39A Historic District or the historic Crawlerway. There are no historic or archaeologic resources at LZ-1; therefore, landing of Starship at the site would have no impact to cultural resources.

No Action Alternative

Under the No Action Alternative, LC-39A Starship/Super heavy launch mount and supporting infrastructure 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 2015) 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 FDEP, Division of Air Resource Management (DARM), has exclusively adopted the NAAQS. 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 3-3 shows federal ambient air quality standards.

Table 3-3. 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/m^3 0.15 µg/m^{3b}	1.5 µg/m^3 0.15 µg/m^3
Nitrogen Dioxide	Annual[c] 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/m^3	150 µg/m^3
Particulate Matter (PM2.5)	Annual[c,f] 24-hour[g]	15 µg/m^3 35 µg/m^3	15 µg/m^3 35 µg/m^3
Sulfur Dioxide	Annual[c] 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 3 years. f. Not to be exceeded more than once per year on average over 3 years. g. Annual mean averaged over 3 years. h. 99th percentile of 1-hour daily maximum concentrations averaged over 3 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 2015.

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 (Permit #0090051) which governs the air emissions from those activities. The Title V Air Operation Permit provides a list of emissions units and 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 2010 through 2017 for KSC (Table 3-4) 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 3-4. KSC History of Actual Annual Emissions (Tons per Year)

Pollutants	2017	2016	2015	2014	2013	2012	2011	2010
CO	5.70	3.21	4.62	6.12	7.22	9.57	10.77	10.39
HAP	0.32	0.48	0.62	0.49	0.55	0.55	0.66	0.60
NO_X	10.90	10.48	15.35	23.11	24.98	34.00	38.69	36.86
PM	0.25	0.68	1.13	1.45	1.69	2.36	2.68	2.55
PM10	0.15	0.68	1.08	1.44	1.69	2.35	2.67	2.56
PM2.5	N/A	0.53	0.86	1.25	1.44	2.05	2.35	2.23
SO_2	0.01	0.02	0.02	0.02	0.03	0.44	0.52	0.49
VOC	3.75	4.58	4.72	3.56	4.37	4.68	6.28	10.69

Source: FDEP 2019

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.

Air dispersion models are used at KSC to predict toxic hazard corridors for nominal launches, catastrophic launch failures, and spills of liquid propellants. Among the models used are the Rocket Exhaust Effluent Dispersion Model (REEDM), the Launch Area Toxic Risk Assessment Model (LATRA), and the Ocean Breeze/Dry Gulch (OB/DG) model. As documented in previous EAs and EISs performed for the launch vehicles at CCAFS, these emissions would not substantially impact ambient air quality or endanger public health. The potential for an accidental release of liquid propellants would be minimized by adherence to applicable USAF and NASA safety procedures (USAF 1998).

Impacts to air quality would be due to activities associated with the construction and 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.

There would be temporary increases in regulated air pollutants in the construction area during site preparation. Dust from the exposure of topsoil and exhaust from heavy machinery would impact the air quality of the site. 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 vehicles and equipment for construction and land clearing would be not be significant. These fugitive emissions would not be substantial enough to change NAAQS attainment status. Air quality impacts from construction of the proposed action at KSC would be minimal and of short duration, and therefore not considered significant.

Impacts to air quality from Proposed Action operations are also expected to be minimal and of short duration. 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 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.

Reasonably foreseeable air quality impacts from generators, vehicles, and non-toxic substances are often associated with ground processing activities. The capacities for typical operations of the size proposed at the LC-39A 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 ground processing activity emissions are estimated to have minimal air quality impacts.

Typical activities at the LC-39A Starship/Super Heavy launch site would include engine test fires and launches. The emissions during static fire and launch activities would be typical of a LOX/methane plume. The plume constituents consist of water vapor, carbon dioxide (CO_2), carbon monoxide (CO), hydrogen, methane, nitrogen oxides (NOx), and oxygen.

Effects of the vehicle dynamics and multiple engines are difficult to estimate. Necessary assumptions were made to best capture the characteristics of the LOX/methane plume. The analysis was done using a single engine firing into a stable environment within 215 m of the engine exhaust. This assumes the exhaust is efficiently entrained into the rocket exhaust. The analysis from the single engine was then extrapolated to estimate the emissions for all 31 engines (Sierra 2019). Additionally, the presence of any sound suppression water could change the environment, likely cooling the near-plume air. This could slow the rate of combustion; therefore, as the rocket gains altitude, the more efficient the combustion process becomes.

The Clean Air Act does not list rocket engine combustion emissions as ozone depleting substances (ODSs); therefore, rocket engine combustion emissions are not subject to limitations on production or use. The Proposed Action launch activities do not generate ODSs. While not regulated, rocket engine combustion is known to produce gases and particles that reduce stratospheric ozone concentrations locally and globally (WMO 1991).

Potential air emissions from the proposed launches would include activities related to liquid fuel loading (LOX and methane) and projected numbers of maximum launches. Air permits are not required for emissions from the launches as these are mobile sources, are temporary in nature, and not considered to be major emissions of criteria or HAPs pollutants. All emissions types described for the Proposed Action are exempt from air permitting requirements at KSC pursuant to FAC Rule 62-210.300(3)(a), Categorical Exemptions. These types of categorically excluded emissions units or activities are considered to produce "insignificant" emissions pursuant to FAC Rule 62-213.430(6). The liquid fuel loading operations are included as categorically excluded from air permitting and are considered insignificant sources of air pollution by the FDEP. Although permitting is not required, the air emissions of the Proposed Action are still required to be analyzed for potential impacts.

The Starship and Super Heavy booster are driven by Raptor engines that use LOX and methane as propellants. The primary emission products are CO_2, CO, water vapor (H_2O), and small amounts of NOx formed when the plume mixes with the air. Most CO emitted by the liquid fuel engines is oxidized to CO_2 during afterburn in the exhaust plume. 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. A small amount of thermal NOx is formed, all as NO. The CO and NOx emissions would be emitted at no greater than 0.36

kg/s for the Super Heavy booster and 0.08 kg/s for Starship (Sierra 2019). The launch of Starship/Super Heavy would be expected to reach the upper limit of the mixing area, or 914.4 m (3,000 ft), within approximately 30 seconds. For the maximum launch frequency of 24 launches per year, Starship/Super Heavy launch vehicle would emit 0.29 tons per year of NOx and CO each. During landing, 0.016 tons per year of NOx and CO would be emitted total for the Starship and 0.036 tons per year of NOx and CO for the Super Heavy booster. Static fire tests conducted prior to launch, lasting approximately 15 seconds each, would emit 0.13 and 0.03 tons per year respectively for the Super Heavy booster and Starship of NOx and CO. The emission of NOx and CO during launch and landing represents a small percentage of Brevard County regional emission of 15,869 tons and 114,734 tons, respectively, reported in the EPA National Emissions Inventory (EPA 2014). These levels are also well below the 90,718.5 kg (100 tons) per year General Conformity Rule threshold established for each criteria pollutant. While the General Conformity Rule does not apply for regulatory reasons since Brevard County is in attainment, these values are useful for assessing the scale of the operational emissions. All of the emissions are well below the General Conformity Rule de minimis thresholds and would be expected to have little or no impact on regional air quality.

Based on these estimates and a review of additional EAs and reports for activities involving rockets using similar propellants, the total potential emissions of any criteria pollutants under the Proposed Action would not be expected to cause exceedances of the NAAQS (FAA 2006, USAF 2007, FAA 2010). Emissions below 915 m would be of short duration (a matter of seconds) as the vehicle rises above the launch pad and accelerates. The high temperatures of the exhaust products cause them to rise rapidly and disperse with prevailing winds. Therefore, impacts to air quality from launch and landing activities are not expected to be significant.

No Action Alternative

Under the No Action Alternative there would be no construction of new launch structures or Starship 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 2015) 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

The east central Florida weather is subtropical with short, mild winters, and hot humid summers and no recognizable spring or fall seasons (NASA 2015a). Climatic conditions in east-central Florida are influenced by latitude and proximity to the Atlantic Ocean and the IRL system. Summer conditions predominate for nine months of the year with average temperatures ranging between 21^{o} Celsius (C) and 32^{o} C. Winter months are January through March with average temperatures between 4.5^{o} C and 24^{o} C. Brevard County experiences distinct wet and dry seasons. From 1981 to 2010, precipitation averaged 132 centimeters (cm) per year, with high precipitation months averaging 19.3 cm for August and September, and January, the driest month averaging 5.8 cm (NASA 2015a).

At the coast, mean sea level (MSL) is defined as the height of the sea with respect to a local land benchmark, averaged over a period of time long enough to eliminate the effects of wave, tidal, and seasonal fluctuations. Changes in MSL as measured by coastal tide gauges are called “relative sea level changes,” because they can come about either by movement of the land on which the tide gauge is situated or by changes in the height of the adjacent sea surface.

At KSC and CCAFS, mean sea level (MSL) is determined from data collected discontinuously from the Trident Pier tide gauge (NOAA 2019). Referencing the North American Vertical Datum of 1988 (NAVD88), and based on the monthly mean of data collected from Trident Pier between 2011 and 2019, the mean sea level is -0.211 m, mean high water (high tide) is 0.322 m, and mean low water (low tide) is -0.746 m yielding a range of 1.068 m. The level of the IRL is determined from the Haulover Canal stage recorder (USGS 2019) data collected discontinuously over approximately 8 years between 2011 and 2019. Again referencing NAVD88, mean water level of the IRL is -0.16 m. The IRL at this location is microtidally influenced by Ponce Inlet to the north and can have significant wind driven seiche effects. With these in mind, the 25th and 75th percentile data points at the Haulover Canal are -0.22 m and -0.09 m, respectively, yielding a range of 0.13 m. Between 1996 and 2018, the annual mean sea and lagoon levels have risen approximately 0.15 m.

A eustatic sea level change is that which is caused by an alteration to the volume of water in the world ocean. According to the International Panel on Climate Change (IPCC), global MSL continues to rise due to thermal expansion of the oceans in addition to the loss of mass from glaciers, ice caps and the Greenland and Antarctic Ice Sheets (Church et al. 2001).

Climate Change and Sea Level Rise

Climate change resulting from greenhouse gas (GHG) emissions is a cumulative global phenomenon, so the affected environment and ROI is the global climate. 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 GHG concentrations (primarily CO_2) have been identified as the principal factors 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 GHG 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 22^{o} C (72^{o} F) (NASA 2015a). Climate forecasts indicate that average temperatures will increase by as much as 3.3^{o}C (6^{o}F) during the latter part of the century. Other anticipated impacts are described in the KSC Shoreline Protection EA (NASA 2015a). A study by Elsner concluded that as climate change causes the atmosphere and the seas to warm, the ocean stores more energy that is converted to hurricane wind. This analysis was the first to directly relate climate change to hurricane activity in the Atlantic (Elser 2006).

The NASA Climate Adaptation Science Investigators Working Group concluded that a sea level rise of between 13 and 61 cm by the 2050s is projected for the coastal centers. Storm surge elevations in 2029 are projected to be greater than 0.3 m over the Crawlerway. In addition, there is a possibility that higher groundwater conditions may impact the limerock base of the Crawlerway. By 2029, approximately 2.4 km of KSC roadways are expected to have base courses that may be in danger of degradation due to high groundwater (NASA 2019). LC-39A is elevated and is less vulnerable to sea level rise, higher water table, and storm surge than roadways and underground utilities, which are needed to support operations and transport to the launch complex.

Emissions of CO_2 at KSC are primarily associated with vehicle traffic, ground support operations, and launch events. On KSC, CO_2 emissions in 2016 were estimated at 99,025.2 MT, equaling a 54% reduction in sources controlled by the government and a 32% reduction from non-government sources from 2008 baseline emission statistics (unpublished data summarized in NASA 2016).

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 in the last 20 years as measured at the Trident Pier in adjacent Port Canaveral. As a result, FDEP has categorized the area as “critically eroded” (FDEP 2016). Between 2010 and 2019 over 5.8 km of artificial dunes were created along the KSC coastline to protect space program assets and important wildlife habitat. An additional 1.5 km of new dune is planned for completion in 2020, along with reinforcement of about 1.5 km of previously created dune east of LC-39A and LC-39B.

Greenhouse Gases

GHG are gas emissions that trap heat in the atmosphere. These emissions occur from natural processes and human activities. Some scientific evidence indicates a trend of increasing global temperature over the past century which may be due to an increase in GHG emissions from human activities. The climate change that may be associated with this global warming may produce negative economic and social consequences across the globe.

The FAA has developed guidance for considering GHGs and climate under NEPA, as published in the Desk Reference to Order 1050.1F (FAA 2015). Considering GHG emissions for an FAA NEPA review should follow the basic procedure of considering the potential incremental change in CO_2 emissions that would result from the proposed action and alternative(s) compared to the No Action Alternative for the same timeframe, and discussing the context for interpreting and understanding the potential changes. For FAA NEPA reviews, this consideration could be qualitative (e.g., explanatory text), but may also include quantitative data (e.g., calculations of estimated project emissions). Proxy measurements such as delay time or fuel burn can be used in qualitative considerations, for example, to explain that the proposed action would cause no change or a decrease in emissions.

Each GHG is assigned a global warming potential (GWP) which is the ability of a gas or aerosol to trap heat in the atmosphere. The GWP rating system is standardized to CO_2, which has a value of 1. The equivalent CO_2 rate is calculated by multiplying the emission of each GHG by its GWP and adding the results to produce a single, combined emission rate representing all GHGs. This value is defined as the carbon dioxide equivalent (CO_2e).

Discussion of the estimated GHG emissions associated with the Proposed Action and the impact analysis can be found in cumulative impact analysis in Section 4.2. Table 3-6 shows trends in GHG emissions at KSC from 2008 through 2017. Emissions in Scope 1 and 2 pertain to sources owned or controlled by the government (e.g. government fleet, stationary sources), and purchased electricity, heat, or steam. Scope 3 emissions are from activities not directly controlled by the government such as emissions from non-government vehicles (e.g., employee travel). NASA’s goal is to reduce Scope 1 and 2 GHG emissions by 22.4% and Scope 3 emissions by 15.2% by FY2020, as compared to emissions in 2008 (NASA 2017a).

Table 3-6. NASA KSC Greenhouse Gas Emissions Trends (FY2008 through FY2017)

GHG Emission Scope and Category	GHG Emissions MT CO_2e			
	FY2008	FY2015	FY2016	FY2017
Scope 1 Stationary Combustion; Mobile Emissions	27,051.1	9,309.5	10,343.4	14,032.4
Scope 2 Purchased Electricity Consumption	149,861.7	76,337.9	77,068.3	67,731.6
Scope 3 Transmission and Distribution; Travel; Wastewater Treatment, Solid Waste Disposal	24,289.3	15,939.1	16,880.4	14,880.9

Source: NASA 2017a

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 GHG 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.

GHG emissions from construction activities related to the Proposed Action would be minimal and insignificant, and the source of emissions would be temporary, occurring only during the construction period. After the first year, construction activities would not contribute to annual GHG emissions. No vegetation clearing would be required since project area is within LC-39A perimeter. This would reduce emissions from heavy equipment compared to development of launch sites in previously undisturbed areas. SpaceX calculated GHG emissions for construction of the new facilities within the vertical launch and control center areas at their Texas launch site (FAA 2014). GHG emissions were calculated to be less than 800 mt/year CO_2 for the two years of construction. Compared to the Texas launch site construction, Starship/Super Heavy site development and construction would be of shorter duration and cover a smaller footprint. Based on the preliminary site plan (Figure 2-2), construction at LC-39A would require less than 20% of the trenching, 50% of the grading, and encompasses approximately 50% of the building and pavement footprint required for the Texas site.

The Proposed Action would involve mobile source fuel combustion that would generate GHG emissions from associated launch and landing operations. There are no significance thresholds for aviation or commercial space launch GHG emissions, nor has the FAA identified specific factors to consider in making a significance determination for GHG emissions. There are currently no accepted methods of determining significance applicable to aviation or commercial space launch projects given the small percentage of emissions they contribute. CEQ has noted that “it is not currently useful for the NEPA analysis to attempt to link specific climatological changes, or the environmental impacts thereof, to the particular project or emissions, as such direct linkage is difficult to isolate and to understand” (CEQ 2010). Accordingly, it is not useful to attempt to determine the significance of such impacts. There is a considerable amount of ongoing scientific research to improve understanding of global climate change and FAA guidance will evolve as the science matures or if new federal requirements are established (FAA 2015).

The GHG emissions associated with the estimated emissions for the launch, static fire test, and landing of Starship and Super Heavy is compared to global, U.S., and KSC GHG emissions in Table 3-7 below. The KSC GHG Emissions in the table do not include launch activity. Twelve launches from KSC occurred in 2017 which would’ve resulted in a higher value reported in the table. Starship/Super Heavy GHG emissions would be similar in scale to GHG emissions from other launch activity on KSC. The estimated CO_2 emissions from annual operations of Starship/Super Heavy are significantly less than the total GHG emissions generated by the United States in 2018 and the total CO_2 emissions generated worldwide (EIA 2018; WRI 2018). CO_2 emissions from landing of the Starship or Super Heavy booster, whether on a droneship, at LZ-1, or at LC-39A, would be appreciably less than emissions from launches because fewer engines would be relit. In addition, planned reuse of first stage boosters would reduce potential emissions compared to manufacturing and shipping a new booster to the launch site.

Therefore, the emissions of GHGs from Starship/Super Heavy launch, static test fire, and landing events are insignificant and would not cause any appreciable addition of GHGs into the atmosphere. At present, no methodology exists that would enable estimating the specific impacts (if any) that this incremental change in GHGs would produce locally or globally.

Table 3-7. Estimated Carbon Dioxide (CO_2) Emissions Comparison

Annual Emissions Source (24 launches)	Metric Tons CO_2e per Year
Global 2018 Total CO_2 Emissions	$3,710 \times 10^{11}$
U.S. 2018 Total GHG Emissions	$5,140 \times 10^{6}$
2017 KSC GHG Emissions*	96,645
24 Starship/Super Heavy launches	83,794
24 Starship Landings	1,369
24 Super Heavy booster Landings	5,544
24 Starship Static Fire Tests	4,294
24 Super Heavy Static Fire Tests	16,526

*Source: EPA 2018, Tables C-1 and C-2 to Subpart C of 40 CFR 98; *Emissions from launch operations are not included.*

No Action Alternative

Under the No Action Alternative, there would be no construction or Starship/Super Heavy launch operations taking place at LC-39A. Therefore, there would be no greenhouse emissions resulting in climate change impacts.

3.7 Hazardous Materials/Hazardous Waste, Solid Waste, and Pollution Prevention

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 United States 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 (CERCLA); 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. The term hazardous materials includes both hazardous wastes and hazardous substances, as well as petroleum and natural gas substances and materials (see 49 CFR 172.101).

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.

Solid waste is defined by the implementing regulations of the RCRA generally as any discarded material that meets specific regulatory requirements and can include such items as refuse and scrap metal, spent materials, chemical by-products, and sludge from industrial and municipal waste water and water treatment plants (40 CFR 261.2).

Pollution prevention describes methods used to avoid, prevent, or reduce pollutant discharges or emissions through strategies such as using fewer toxic inputs, redesigning products, altering manufacturing and maintenance processes, and conserving energy.

The KSC Spill Prevention, Control, and Countermeasure (SPCC) Plan (KSC-PLN-1920) 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 approaches for preventing and addressing spills. SpaceX is complaint with this program and strives to prevent and reduce various forms of pollution.

The ROI for hazardous materials, hazardous waste, solid waste, and pollution prevention include KSC (launch and potential landing), CCAFS (LZ-1 landing), the Atlantic Ocean (droneship landing), and Port Canaveral, which could be affected by the materials transported, stored, and used; waste generated; or spills/releases that may occur during operations.

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 would be accommodated at the Proposed Action site to include nitrogen (LN_2), LOX, and LCH_4. The fuel farms on site that would support the liquid propellants would have a capacity to accommodate approximately 1.2Mkg of LN_2, 3.4 Mkg of LOX, and 2 Mkg of LCH_4, at their respective fuel farms. SpaceX is responsible for the proper management of any hazardous materials stored at this location.

Hazardous Waste

Vehicle stages would land on land, on the droneship, or in the Atlantic Ocean and would be recovered for reuse. There is a potential for recoverable items to contain residual fuels, if not consumed by combustion. Upon return, it is estimated up to 2% could remain in the vehicle fuel tank.

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 SWMU has been identified within the Proposed Action project area with the potential for contaminated media due to past operations. LC-39A has been designated as SWMU #008. RCRA Facility Investigation (RFI) activities were performed at LC-39A from early 1998 through mid-2000, with an RFI Addendum in 2003. Contaminants of Concern (COCs) were identified in each medium. As a result of elevated concentrations of PCBs and polycyclic aromatic hydrocarbons (PAHs) detected in soils, a soil removal to achieve FDEP Industrial Soil Cleanup Target Levels was conducted as part of an Interim Measure (IM) in 2000. A site-wide groundwater and soil investigation was conducted between 2011 and October 2012 to further evaluate contaminants resulting from former launch activities. The investigation confirmed the presence of COCs in groundwater and soil at concentrations greater than FDEP Groundwater Cleanup Target Levels (GCTLs). The COCs in soil at LC-39A included arsenic, barium, copper, lead, nickel, thallium, PAHs, total PCBs, dioxins/furans, and total recoverable petroleum hydrocarbons (TRPH). An IM was conducted in 2014 and 2015, to mitigate human health risks associated with direct contact exposure to soil by removing soil with COCs concentrations greater than residential Soil Cleanup Target Levels (SCTLs). Following completion of the soil removal and confirmation that residential SCTLs were achieved for the COCs, no further action was recommended for soil at the site in the IM report dated October 2015, and approved by FDEP in November 2015. Groundwater is the only medium of concern at LC-39A with the primary contaminants detected being trichloroethene, ciz-1,2-dichloroethene, and vinyl chloride. The remedy for groundwater is air sparging (initiated in 2015), and monitored natural attenuation. There is an interim Land Use Control currently in place for groundwater at SWMU #008 (NASA, 2017).

Solid Waste

General solid refuse at KSC is collected by a private contractor and disposed of off-site at the Brevard County Landfill, a 78 ha Class I landfill located near the City of Cocoa. KSC has an unlined Class III Landfill with permit restrictions that can only accept construction and demolition debris. Solid wastes would be placed in covered receptacles until disposed of off-site to minimize accidental entry into marine waters or contact with stormwater and prevent offsite deposition from wind. Solid wastes would be salvaged or recycled to the maximum extent practicable and the remaining solid waste disposed of in appropriately permitted landfills. With the implementation of appropriate handling and management procedures, solid wastes generated as a result of recovery operations would have no significant impacts to the environment.

Pollution Prevention

The International Convention for the Prevention of Pollution from Ships (MARPOL) is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes and was adopted at the International Maritime Organization in 1973. The Convention includes regulations aimed at preventing and minimizing pollution from ships, both accidental pollution and that from routine operations, and currently includes six technical Annexes. Special Areas with strict controls on operational discharges are included in most Annexes. Annex I covers prevention of pollution by oil from operational measures as well as from accidental discharges. Annex II details the discharge criteria and measures for the control of pollution by noxious liquid substances carried in bulk. Annex III contains general requirements for the issuing of detailed standards on packing, marking, labeling, documentation, stowage, quantity limitations, exceptions, and notifications. Annex IV contains requirements to control pollution of the sea by sewage. Annex V deals with different types of garbage and specifies the distances from land and the manner in which they may be disposed. Annex VI sets limits on sulphur oxide and nitrogen oxide emissions from ship exhausts and prohibits deliberate emissions of ozone depleting substances.

3.7.2 Environmental Consequences

The FAA has not established a significance threshold for hazardous materials, solid waste, and pollution prevention. 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.

All generated wastes would be properly containerized, stored, labeled, manifested, shipped, and disposed of in full regulatory compliance utilizing practices that minimize the potential for accidental releases. Hazardous wastes generated by users of SpaceX and their contractors would be manifested, shipped, and disposed of under the appropriate SpaceX's EPA identification number. 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-39A 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. However, BMPs in place for the handling of hazardous materials and hazardous waste would result in minimal impacts from the Proposed Action.

Impacts from recoverable components from launch activities are planned to occur in broad ocean areas cleared of shipping or air traffic prior to launch. Rocket stages are designed for recovery. Efforts would be made to recover any stages that land in the ocean and not on the droneship as intended. Safeguards, including multiple system redundancies in case of damage upon reentry, are in place to minimize the release of toxic chemicals in the environment. All accidental releases of polluting substances would be responded to quickly and appropriate clean up measures would be implemented in accordance with applicable laws to minimize impacts to the environment. To avoid collision with marine vessels and to further ensure public and environmental safety, a Notice to Mariners (NOTMAR) would be issued 3-6 days prior to reentry and recovery efforts. As a result, no significant impacts in regards to pollution prevention would occur as a result of the Proposed Action.

Launch failure, as a result of rocket malfunction, could result in debris and hazardous materials being distributed in the immediate pad area of the Proposed Action. Since all applicable federal, state, county, and USAF rules and regulations would continue to be followed for the proper handling and disposal of hazardous materials, the Proposed Action would be classified as minimal.

Large commercial vessels, such as the droneship that would be used to land the stages on, routinely discharge ballast water, gray and black water, bilge water, and deck runoff consistent with applicable international and national standards. Discharges of sewage (also known as black water) and gray water, which is the effluent generated from wash basins and showers on board ships, are regulated under MARPOL Annex IV. Discharges of black water are prohibited except for specific conditions stipulated under the Annex. In addition to the international standards established under MARPOL Annex IV, the U.S. regulates vessel discharges of sewage, gray water, bilge water, and a variety of other vessel discharges through the EPA's Clean Water Act (CWA) National Pollutant Discharge Elimination System (NPDES) Program. Based on these requirements, impacts from the droneship 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, no increase in the generation of hazardous materials/waste or solid waste at the site, and no need for additional pollution prevention measures required at this location.

3.8 Water Resources

Chapter 3.4 of the KSC Master Plan PEIS (NASA 2016) and Section IV of the ERD (NASA 2015) describe in detail the water resources (water quality, regulations, permitting, etc.) within KSC. The affected environment for water resources associated with the proposed launch and landing sites has been described in previous EAs (NASA 2013, USAF 2007, 2013, 2014, and 2017). Water resources include groundwater and surface water (their physical, chemical, and biological characteristics), floodplains, and wetlands. A concise review of these resources located within the Starship/Super Heavy ROI is provided in the following sections. The ROI for groundwater includes the local aquifers that are directly or indirectly used by KSC and CCAFS. The surface water ROI is the watershed in which KSC and CCAFS are located and within the Atlantic Ocean offshore within the defined booster landing and recovery zone. The ROI for floodplains and wetlands is primarily within the LC-39A perimeter but also includes wetlands outside and immediately east of the launch complex perimeter.

3.8.1 Affected Environment

Groundwater

The State of Florida has created four categories used to rate the quality of groundwater. 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, which means that it is a potential potable water source and generally has a total dissolved solids content of less than 10,000 mg/l. The groundwater at LC-39A has been classified as Class G-III because of their proximity to the ocean. The subsurface of KSC is comprised of the surficial aquifer, the intermediate aquifer, and the Floridian aquifer. Recharge to the surficial aquifer system is primarily due to precipitation. Of the approximately 140 cm 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 and CCAFS 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 (NASA 2015).

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 2015). Various studies conducted by the NASA Remediation Office have been completed or are ongoing to identify, monitor, and in some cases remediate contaminated groundwater at LC-39A. Chlorinated solvents are the predominant contaminant of the surficial aquifer, in both shallow (<20 ft below land surface (BLS)) and deep (>20ft BLS) groundwater. Trichloroethylene, 1,2-dichloroethene, trans and cis isomers, and vinyl chloride were detected at concentrations above risk based concentrations. Chloroform, trans-1,3-dichlrorethene and vinyl chloride were detected in the deep groundwater. Only trace concentrations of semivolatile compounds, primarily PAHs and phenols, were detected in either shallow or deep groundwater (NASA 2011).

Surface Waters (Inland) and Wetlands

The inland surface waters in and surrounding KSC are shallow estuarine lagoons, and saltmarsh impoundments that include portions of the Indian River, Banana River, Mosquito Lagoon, and Banana Creek collectively known as the IRL. The U.S. EPA designated the IRL as an "estuary of national significance" in 1990 and the IRL supports over 400 species of fishes, 260 species of mollusks, and 479 species of shrimps and crabs (NASA 2015a). Lagoon habitats serve as important nursery areas for fish resident within the lagoon, as well as many offshore species. It also supports several protected species including mammals and sea turtles, which are discussed in Section 3.3.1

The area of Mosquito Lagoon within the KSC boundary, 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 the MINWR are designated as Outstanding Florida Waters (OFW) as required by Florida Statutes for waters within national wildlife refuges. Surface water quality at KSC has been relatively good compared to other locations of the IRL where the adjacent watershed supports high density development. The best water quality is typically found adjacent to more remote, undeveloped areas of the IRL, such as Mosquito Lagoon and the northernmost portions of the Indian and Banana Rivers (NASA 2015). However, since the phytoplankton “superbloom” of 2011 (SJRWMD 2012), and the numerous other blooms and fish kills that have followed within the upper IRL in the last several years, water quality may be in decline due to large seagrass die-offs and release of nutrients fueling harmful algal blooms (T. Price/Leidos, 2019, pers. Comm.). Long-term water quality 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. FDEP, in compliance with the EPA Numeric Criteria Standards for pollutants, has set TMDLs for many impaired waters in the State. The following waters within the boundary or adjoining KSC are identified as impaired:

a. Atlantic Ocean (Brevard County, Volusia County): mercury in fish tissue
b. Indian River (Brevard County): mercury in fish tissue, copper, nickel, and nutrients
c. Banana River (Brevard County): mercury in fish tissue, and nutrients
d. Mosquito Lagoon (Brevard County, Volusia County): mercury in fish tissue.

The north IRL segments adjoining KSC and the north Banana River have been identified by FDEP as impaired for dissolved oxygen via nutrient nitrogen and phosphorus, and mercury in fish tissue. Mosquito Lagoon is also impaired for mercury in fish tissue (FDEP 2017). Basin Management Action Plans (BMAPs) addressing the first five years of a 15-year restoration period, for the Banana River Lagoon, and the North IRL have been developed and adopted. These BMAPs only address nutrient impairment. A comprehensive statewide TMDL for mercury is also under development.

Fresh surface waters within KSC and CCAFS are rare and primarily derived from the surficial groundwater, which is recharged by rainfall. Most of the freshwater bodies within Starship/Super Heavy ROI are excavated drainage ditches and borrow pits constructed during the early period of development of these installations. Shallow groundwater also supports freshwater wetlands including marshes, interdunal swales, and scrub-shrub wetlands that are periodically inundated during the seasonally high water table typically coinciding with tropical storm season into the winter months.

Estuarine wetlands within the ROI include saltmarsh, mangrove fringe, and estuarine scrub-shrub habitats associated with the Banana River estuary immediately adjacent to LC-39A. Many estuarine wetlands were impounded for mosquito control and have been isolated from the estuary since the late 1950s and 1960s. The water quality of these impoundments varies, depending on the amount of exchange that exists between them and the lagoon via culverts. Dissolved oxygen may periodically become too low to sustain most aquatic life. Likewise, salinities may fluctuate substantially during the course of a year depending on the amount of rainfall.

Surface Waters (Atlantic Ocean)

The ROI for ocean waters is the recovery zone positioned between 5 nm for Starship and 20 nm for the Super Heavy booster to 500 nm off the eastern coast of Florida from CCAFS to southern Florida. Ocean waters within the ROI include offshore, deep high salinity waters that are defined by prevailing currents. Water quality in ocean waters may be characterized by temperature, salinity, dissolved oxygen, and nutrient levels.

Floodplains

Executive Order (EO) 11988 directs agencies to consider alternatives to avoid adverse effects and incompatible development in floodplains. Due to lack of significant topographic relief, floodplains on KSC and CCAFS extend beyond the coastal dune and wetlands into portions of all of the upland plant communities. The majority of KSC and CCAFS lies within the 100-year floodplain. FEMA Flood Insurance Rate Map #12009C0255G was examined for the proposed Starship/Super Heavy launch pad, landing pad, methane fuel farm, and deluge basins to be constructed within LC-39A. The Proposed Action site is located within two different Federal Emergency Management Agency (FEMA) flood zone categories. Zone X, Shaded and Zone X, Unshaded. Zone X, shaded (X500), represents areas of moderate flood risk (between 0.2% and 1% annual chance flood hazard). Flood Zone X500 represents areas between the limits of the 100-year and 500-year floodplains, or certain areas subject to 100-year flood with average depths less than 0.3 m, or where the contributing drainage area is less than 2.6 km$^{2.}$ Zone X Unshaded lands are outside of the 100-year and 500-year floodplains and have minimal flood risk (subject to flooding less than 0.2% annual chance flood hazard on an annual basis).

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.

- 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.
- 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.
- 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*.

Starship/Super Heavy activities include LC-39A modification construction, launches, and landing on a droneship, LZ-1, or LC-39A. Impacts from the Falcon operations on KSC and CCAFS are well documented and assessed in previous EAs (NASA 2013 and 2019; USAF 2007, 2013, 2014, and 2017). Impacts to water resources from the proposed Starship/Super Heavy are summarized below. Overall, environmental consequences to water resources from Starship/Super Heavy construction and operation are not expected to be significant. The potential local impacts to hydrology and water quality from the construction and operation of the Starship/Super Heavy are summarized in Table 3-8.

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 would be lessened with BMPs; therefore, no significant impacts are anticipated.

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 the launch deck, deluge basin, and road, 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.

The groundwater quality at the proposed site will be affected by runoff from new impervious surface, percolation of launch deluge and washdown water at LC-39A, or accidental spills that percolate into the surficial aquifer. The construction of required stormwater management systems, previously discussed, intentionally enhances percolation of water from the 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, if stormwater treatment and industrial wastewater systems are properly designed and operated in accordance with permit conditions. Impacts to groundwater from accidental spills are possible but would be mitigated by proper design redundancies of commodity storage facilities, containment around all hydraulic systems, safety measures included in launch vehicle processes, and spill response and clean-up measures employed at KSC and CCAFS.

Table 3-8. General Site-Specific Impacts to Hydrology and Water Quality Associated with Construction and Operations of Roads and Launch Facilities (Adapted from NASA 2018).

Activity	Impact
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.
Landscaping	Alters local evapotranspiration processes, runoff, storage, and infiltration rates. Use of fertilizers and pesticides. Mowing and other maintenance often required.
Stormwater Conveyance	Alters local evapotranspiration processes, runoff, storage, and infiltration rates. Impacts to surficial aquifer.
Stormwater Retention Ponds & Deluge Wastewater Percolation Ponds	Alters local evapotranspiration processes runoff, storage, and infiltration rates. Impacts to surficial aquifer.
Motor 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.

Land disturbing activities during construction at the Proposed Action site have the potential to result in temporary but insignificant impacts to seasonally wet surface water ditches within the LC-39A perimeter. Portions of the surface water drainage ditch network within the launch complex may be filled and rerouted, or incorporated into the new stormwater management system that would be permitted and constructed to treat stormwater runoff from new impervious surface area supporting the Starship/ Super Heavy. Impacts would be lessened with the implementation of BMPs required by the FDEP NPDES Stormwater Construction Permit, and the SJRWMD Environmental Resource Permit (ERP). Employing BMPs such as silt fences, turbidity barriers, and stormwater management systems would reduce impacts to surface waters and offsite wetlands receiving storm runoff from LC-39A. There are no wetland resources located within LC-39A, and no direct impacts to wetlands are expected from Starship/Super Heavy construction actions.

Once operational, surface water discharges from the site would be managed according to requirements of the SJRWMD conditions for issuance of ERPs. The 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 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.

Nominal operations at LC-39A would have minimal impacts on the surface water quality. Surface waters at the launch complex would drain to existing swales within the Pad perimeter. Stormwater runoff generated from the launch pad drains to various manmade grass swales that radiate from the pad. The grassed swales discharge via culverts to a swale that runs parallel to the perimeter access road. The perimeter access road swale discharges to receiving waters on the periphery of the site.

Launch deluge and pad washdown water generated from the new Starship/Super Heavy launch pad at LC-39A would be isolated from the existing Falcon 9/Heavy deluge system and flow into a new containment (impervious basin) and disposal (percolation pond) system shown in Figure 2-2. This system would be designed to satisfy FDEP industrial wastewater permitting requirements for attenuation and onsite disposal of launch-related wastewater. Industrial wastewater would be contained in an impervious basin until discharge water quality criteria set in the FDEP permit are met, and released into a pervious percolation area for dissipation into the surficial water table. No chemical treatment of deluge wastewater is anticipated.

The launch exhaust cloud formed from the exhaust plume and evaporation and subsequent condensation of deluge water could affect surface water drainage systems from LC -39A as well as adjacent surface waters and wetlands associated with the upper Banana River located immediately east of LC-39A. The exhaust cloud would consist largely of steam with insignificant amounts of hazardous materials from LOX and LCH_4 propellants that would degrade quickly. The temporary and minimal volume of water condensing from the exhaust cloud outside of the LC-39A perimeter would have no significant impacts to adjacent surface water quality and wetland habitats. Although nominal operations are expected to have minimal impacts, the potential impact to inland surface waters or the Atlantic Ocean as a result of a failed launch or landing could be moderate depending on the resource impacted. No residual spilled fuel is expected from a failed launch or landing as any cryogenic propellants would either be combusted or would rapidly become gaseous.

Direct impacts are not expected to affect the ocean from the construction/development of launch, landing facilities, and support facilities. However, there is low potential for operations to have an effect via reentry components from launch vehicles and launch hardware recovery operations. Components could include non-recoverable items (debris) from a landing anomaly that would sink to the ocean bottom. Recovery operations will result in typical discharges to surface waters (bilge water, residual diesel fuel #2, oils, and lubricants) associated with commercial shipping activities. These impacts and potential larger fuel spills would be mitigated by adherence to proper marine vessel operating procedures and use of appropriate BMPs in the event of a spill. Therefore, the proposed Action is expected to have no significant impact on ocean water resources.

Nearly half of LC-39A lies within floodplain zone X500, which represents areas between the limits of the 100-year and 500-year flood. Some of the proposed action construction could occur within the X500 floodplain. NASA would ensure that actions on KSC 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 only available option for SpaceX to construct facilities to support the Starship/Super Heavy as discussed in detail in Chapter 2 of this EA. Therefore, NASA has concluded there is no practicable alternative to constructing new facilities at LC-39A within a floodplain. 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 Starship/Super Heavy construction or Starship/Super Heavy launch operations taking place at LC-39A or CCAFS/LZ-1. Therefore, there would be no impacts to water resources.

3.9 Geology and Soils

Detailed discussions of geology and soils at KSC are available in the KSC PEIS (NASA 2016) and ERD (NASA 2015). Data regarding the geology and soils of KSC are also well described in "Geology, Geohydrology and Soils of Kennedy Space Center: A Review" (Schmalzer and Hinkle 1990). The ROI for geology and soils is limited to previously disturbed land within the LC-39A perimeter fence where proposed construction activities would occur to support Starship/Super Heavy. A concise review of those resources is provided in the following subsections.

3.9.1 Affected Environment

Geology

Florida has a complex geologic history with repeated periods of deposition when the Florida plateau was submerged under the ocean, alternating with periods of 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 a current surface strata of primarily unconsolidated white to brown quartz sand containing beds of sandy coquina of Pleistocene and Holocene age (NASA 2015). Fluctuating sea levels with the alternating glacial interglacial cycles have shaped the formation of the barrier islands. The formation of Merritt Island may have begun as much as 240,000 years ago, but most of the surface sediments are not that old. Cape Canaveral was probably formed less than 7,000 years ago, as was the barrier strip separating Mosquito Lagoon from the Atlantic Ocean. Deep aquifers beneath KSC are recharged inland, but are highly mineralized in the coastal region and interact little with surface vegetation. The Surficial Aquifer is recharged by local rainfall and sand ridges in the center of Merritt Island. Discharge is from evapotranspiration and seepage to canals, ditches, interior wetland swales, impoundments, lagoons, and the ocean. This aquifer exists in dynamic equilibrium with rainfall and with the freshwater/saline water interface. Freshwater wetlands depend on the integrity of this aquifer and it provides freshwater discharge to the lagoons and impoundments. 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 (NASA 2013).

Soils

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). Fifty-eight soil series and land types are represented, even though Merritt Island is a relatively young landscape formed from coastal plain deposits. The primary source of parent material for KSC soils is sands of mixed terrestrial and biogenic origin (NASA 2015). Soils on the barrier island section east of Banana River and Mosquito Lagoon are younger than those of Merritt Island and, therefore, have had less time to weather. Well-drained soil series (e.g., Palm Beach and Canaveral) in these areas still retain shell fragments in the upper layers, while those inland on Merritt Island (e.g., Paola and Pomello) do not. The presence of shell fragments influences soil nutrient levels, particularly calcium and magnesium, and pH (Schmalzer and Hinkle 1990). The eastern and western sections of Merritt Island differ in age. The eastern section of Merritt Island, inland to near State Road (SR) 3, has ridge/swale topography, presumably retained from its formation as a barrier island. West of SR 3, the island is flatter, without obvious ridges and swales, probably due to its greater age. Differences in age and parent material account for some soil variations, but on landscapes of Merritt Island with similar age, topography has a dramatic effect on soil formation. Relatively small elevation changes cause dramatic differences in the position of the water table that, in turn, affect leaching, accumulation of organic matter, and formation of soil horizons. In addition, proximity to the lagoon systems influences soil salinity (NASA 2015).

LC-39A was constructed using dredged material to fill low-lying coastal salt marshes and narrow upland ridges. The fill material consisted of a mixture of fine-coarse sand and shell fragments dredged from an adjacent wetland area that is now referred to as Gator Hole, located northwest of the launch pad. The fill was graded and compacted to meet operational specifications (NASA, 2011). Soils at LC-39A are highly disturbed since the site was used as an industrial facility launching rockets over the last 50 years. In addition, the NASA Remediation Office has investigated various locations of contaminated soils within the launch pad perimeter, primarily consisting of PCBs and PAHs, resulting from past launch-related activities (Apollo and Shuttle era). Areas of delineated soil contamination were removed and replaced with clean sand fill under various IM soil removal projects for SWMU #008. A summary of all soil removal IMs is included in the Environmental Baseline Survey prepared prior to SpaceX operations at LC-39A (NASA 2011). Review of the NRCS Web Soil Survey maps show greater than 99% of the launch complex area classified as urban land.

3.9.2 Environmental Consequences

Construction of LC-39A modifications required to support Starship/Super Heavy would directly impact existing soils classified as Urban Land including over-topping with additional clean fill, overlaying existing soils with concrete, asphalt or other impervious surfaces, excavation of basins for stormwater and deluge water retention, and trenching for new underground utilities. No native soil profiles would be affected by the proposed action. No significant impacts are expected from construction for the Proposed Action.

Once operational, Starship/Super Heavy is not expected to have any measurable impacts to soils within or immediately adjacent to LC-39A. Studies conducted at KSC and CCAFS 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 areas of acid deposition impacts were experienced following Space Shuttle launches. 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 water blasting painted metal structures (NASA 2014). These operational impacts are not expected to occur from Starship/Super Heavy at LC-39A since the launch vehicles would not use solid rocket propellant, and proposed design features would eliminate the potential sources of contaminants from a launch stand or other steel infrastructure on the pad.

The underlying geology of the proposed action area would not be impacted by either construction of facilities or Starship/Super Heavy launch operations at LC-39A. No unique geologic features of exceptional interest or mineral resources occur within the project area. Prior to and during construction, erosion and sediment control measures such as silt fences are required to retain sediment on-site. Therefore, overall impacts would be considered none to geology and minimal to soils.

No Action Alternative

The No Action Alternative would preclude implementation of Starship/Super Heavy, eliminating construction of a new launch pad and support facilities within LC-39A and would have no impact on geology or soils at 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 1960s. 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 908 km of roads, including 296 km of paved roads, 612 km 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 3.7 m wide lanes with sand stabilized turf shoulders. KSC’s main arterials, Kennedy Parkway (SR 3) and NASA Parkway, are separated by 9-12 m and 3-6 m medians respectively. As depicted in Figure 3-13 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 U.S. 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.

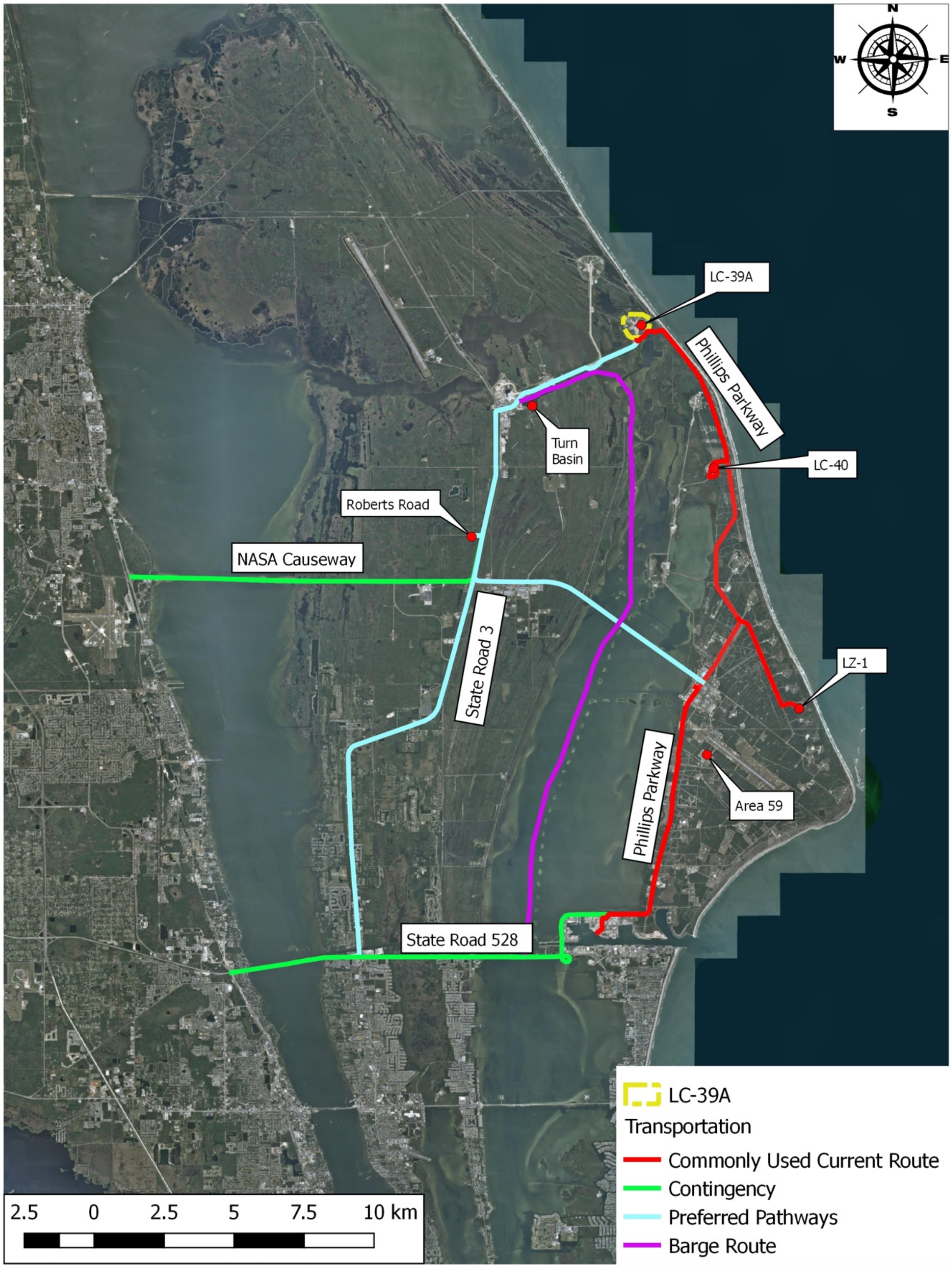

Figure 3-13. Transportation Routes for Operations and Construction Associated with the Starship/Super Heavy

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 2013). Currently, the south (main) gate on SR 401, serves as the primary entrance and exit to CCAFS for cargo and personnel. SR 401 eventually leads into Phillips Parkway, which is the main north-south artery for the installation. The LC-39 Area Turn Basin was originally built to allow barges to offload rocket vehicle stages where they were then rolled into the VAB. It was also used to receive and offload the Space Shuttle's external tank. The turn basin is maintained a depth of 3 to 4.6 m at the cargo transfer point and deepens to approximately 7.6 m near the middle (KSC 2017).

3.10.1 Affected Environment

Transportation of Starship/Super Heavy, cargo, and payloads to LC-39A would occur over roadways and waterways and involve accessing the site from the south by way of Kennedy Parkway to Saturn Causeway as the primary route of transportation. Alternative routes include transportation from the west over NASA Parkway to Phillips Parkway, and from the CCAFS gate on Phillips Parkway to the LC-39A site or Roberts Road Operations Area if components require processing.

Transport of rocket components and payloads over roadways in and around KSC is a common occurrence. The Crawlerway is a unique dual-lane roadway for carrying crawler-transporter vehicles and their loads to LC-39A and LC-39B. The LC-39 area Turn Basin and dredged channel in the Banana River provide a direct water connection between the Atlantic Ocean and space launch processing activities at KSC.

Starship/Super Heavy would be delivered by barge from SpaceX facilities at Boca Chica in Texas and Cidco Road in Cocoa through the Turn Basin. The Crawlerway would be used to transport the vehicles to the launch pad. Previously flown components would be delivered via barge to the launch pad in the same manner as described for the new launch vehicles. Components needing refurbishment would be delivered via barge from the Turn Basin (Figure 3-13) and transported to the Roberts Road facility, MSS Park Site, or Crawlerway. Starship or Super Heavy booster would be moved on roadways using a mobile transporter similar to the transports performed for Falcon. This would involve taking SR 3 to Saturn Causeway, which leads directly to LC-39A. SpaceX does not intend to transport the booster to Area 59 and thus a transportation route is not included on Figure 3-13.

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-39A could accommodate up to 24 launches per year. Short- and long-term adverse but insignificant 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 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 impacts, 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. The proposed Starship/Super Heavy 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 with 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

KSC is a retail electricity, natural gas, and fuel oil customer. The Utilities Systems land use classification 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 system that meets all requirements of FDEP and EPA Safe Drinking Water Act regulation. The City of Cocoa provides potable water to both KSC and CCAFS systems and operates the Claude H. Dyal Water Treatment Plant which treats the raw water primarily from a Floridian Aquifer wellfield located in east Orange County, and also has the ability to draw surface water from the Taylor Creek Reservoir, located in Brevard County. The City has a Consumptive Use Permit (CUP) with the SJRWMD allowing withdrawal of up to 45 million liters (l) per day from the aquifer. Because KSC is a consecutive system and purchases water from Cocoa, CUPs are not required. Water from the Dyal Plant is transmitted to KSC via interconnects at the southern end of the system. The KSC distribution system is also connected at the NASA Causeway and at the northern extreme of the system near LC-41. Throughout KSC, there are various storage systems and secondary pump systems to supply water needs for fire suppression, launch activities, and potable water (NASA 2015a). The replacement of water lines throughout KSC is ongoing, with the fifth and last phase scheduled to be completed in 2019. Pipeline replacement includes critical water mains, facility service lines and fire hydrants, as well as the replacement of KSC’s primary pump station (KSC 2017). The potable water interconnect for the facilities within the perimeter of LC-39A is the backflow preventer east of the Crawlerway and north of the gate. The potable water system is typically operated at a pressure of 65 psi.

Some areas at KSC, that are too distant from the distribution for cost-effective connection, have well water provided for some industrial purposes. Wells are registered with the State of Florida through either the SJRWMD or the Florida Department of Health.

Industrial water, segregated from drinking, potable, water, and used for Firex and sound suppression systems, enters the launch complex from the west along Pad A Emergency Road from pump station, J7-1388. The industrial water system can be distinguished from the potable system by pressure, and is typically operated at 150 psi.

Domestic and Industrial Wastewater

The majority of domestic wastewater at KSC is treated at the CCAFS Regional Waste Water Treatment Facility (RWWTF), operated by the USAF under FDEP Permit FL0102920. The RWWTF meets all FDEP and EPA requirements under FAC and the CWA, 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. KSC operates 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. SpaceX obtained an industrial wastewater permit from FDEP (Permit Number 05-FLA010307) to construct and operate an industrial wastewater treatment and disposal system for their operations located at LC-39A. Launch deluge and pad washdown water at LC-39A flows down two concrete flumes into east and west treatment tanks. These tanks have a net lined holding capacity of 704,146 gallons. No chemicals are used for treatment of the wastewater. It is allowed to settle and attenuate pH over time in the containment tanks before being land applied to a 0.9 ha bermed disposal area operated as a spray field.

The existing deluge system would be isolated from the new Starship/Super Heavy launch pad and would not be used for deluge water retention and disposal during Starship/Super Heavy launches. A new 2,839,000 l impervious holding pond and a pervious percolation disposal pond would be constructed at the eastern quadrant of LC-39A at the edge of the flame deflector area to provide the necessary industrial wastewater facilities for Starship/Super Heavy. Deluge water would need to be captured via trenches and graded concrete and routed to the holding pond. This pond would be used for treatment as required, a simple pumping system would then route the water to a new pervious percolation pond.

Discharge of industrial wastewater to the domestic wastewater system at KSC must follow the Process Waste Questionnaire/Technical Response Package (PWQ/TRP) procedure. 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.

Stormwater

Stormwater runoff from constructed impervious area of greater than 836 m^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 new impervious at LC-39A would require submittal of plans for stormwater treatment systems to the SJRWMD as part of the ERP application process and receive permits prior to beginning construction.

Five permitted stormwater systems represent modification to the complex after implementation of stormwater regulation. The remainder of the complex predates regulation.

Permit 24279-1 e encompasses a portion of the east side of the Crawlerway slope and impervious areas previously housing temporary structures. A dry detention pond east of the Crawlerway and north of the impervious area provides treatment.

Permit 33450-1 collects stormwater from the parking area south of J8-2008. A dry detention area south of the parking lot provides treatment. Pad A By-Pass Road located east of J8-2008 drains to a second dry detention area north of the road.

Permit 81270-1 encompasses the impervious areas surrounding J8-2190. Stormwater is conveyed by ditch to a wet pond north of Pad A Bypass Road for treatment.

Permit 81270-2 provides stormwater treatment for the Falcon Hangar. The dry retention stormwater management system treats 3.1 ha.

Permit 81270-11 for the Construction Trailer/Crane Path encompasses a 1.5 ha project. Stormwater system consists of three independent dry retention swales.

Stormwater falling on the elevated impervious areas of J7-1708 is directed to the industrial wastewater system. Gates on the flumes leading to the treatment basin are typically closed discharging the stormwater to grade. When the gates are open in preparation for launch, stormwater is collected in the treatment basins and pumped to the percolation pond. This water is not tested prior to discharge under agreement with FDEP but volume is recorded and reported on the industrial wastewater permit required discharge monitoring report.

There are numerous grassy swales around each launch complex through which water discharges via culverts to swales that run along the perimeter access roads. At LC-39A, the access road swale discharges to receiving waters located around the periphery of the complex, including marsh areas, impounded wetlands, Pintail Creek, and Broadaxe Creek. Stormwater runoff at LZ-1 drains to pervious surfaces around the pad and infiltrates.

In compliance with the CWA, operators of stormwater discharges associated with certain industrial activities (Sectors) are authorized to discharge to waters of the United States in accordance with the eligibility and NOI requirements, effluent limitation, inspection requirements, and other conditions set forth by NPDES Multi Sector General Permit. The FDEP identifies sectors of industrial activity by Standard Industrial Classification (SIC) code. Sector S, "Storm Water Discharges Associated with Industrial Activity from Vehicle Maintenance Areas, Equipment Cleaning Areas, or Deicing Areas Located at Air Transportation Facilities," contains SIC 45* which is identified as "Air Transportation." SpaceX operates under SIC 4522 and therefore requires a Multi Sector General Permit.

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 two megawatt located in the Industrial Area provides clean power directly to KSC 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

The KSC communications system provides a variety of services including conventional telephone services, transmission of voice data and video, and operation and maintenance of KSC's cable plant. There are three major distribution and switching stations located in the Industrial Area (First Switch) and in the VAB Area (Second and Third Switches). These three stations provide service for over 18,500 telephones on KSC.

Solid Waste

General solid refuse such as putrescible waste and office trash is collected by a private contractor at KSC and currently taken to the Brevard County Landfill, a 78 ha Class I landfill located near the City of Cocoa, for disposal. In 2009, the landfill received 1.3 million kg of waste per day, of which less than 1% came from KSC and CCAFS (http://ww3.brevardcounty.us/swr/landfilltour.cfm). KSC has an unlined Class III landfill with permit restrictions that allow only certain types of waste and limit the capacity. Putrescible waste and general office trash are among the types of waste not permitted at the KSC Class III landfill. The life expectancy of the KSC landfill is 13 – 49 years. This is based on assumed disposal rate scenarios of 317,514 kg per day (13 years) or 81,647 kg per week (49 years) (NASA 2015a). Arrangements would need to be made for disposal of wastes not accepted at the KSC Class I landfill to an approved offsite waste disposal facility. A list of authorized solid wastes that can be disposed of at the KSC Class I landfill can be found in Section 13 of the NASA document KNPR 8500.1.

3.11.2 Environmental Consequences

The Proposed Action would require the construction of a launch mount and landing pad, CH_4 fuel farm, a transport road to the launch mount, and modification of existing infrastructure. A new water tank farm area would be constructed at LC-39A near the launch mount. The proposed water-cooled diverter would need new tanks that can deliver the pressures needed.

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 not be significant. These utilities and services are currently available at or within reasonable proximity to the Proposed Action site. 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 and insignificant.

Construction and ground support activities of the Proposed Action is anticipated to have minimal impacts on the current wastewater treatment (domestic and industrial), potable water resources, electricity and natural gas, communications, and solid waste resources on KSC. All of these utilities are currently available in the general vicinity of LC-39A, and tie-ins could be established without significantly affecting the local areas. In some cases, utilities ducts would need to be laid, but these would be routed along roadways and other easements, areas that are already maintained for those purposes. All of the utilities and services at each of the proposed site options are expected to be able to absorb the additional demands. Existing substations and wastewater treatment plants would have sufficient capacities for anticipated needs.

Construction of new impervious surfaces including the launch mount and landing pad, road, methane farm, water retention pond, and water tank farm would require stormwater management systems and permits. A stormwater treatment system would be built on site for any modifications within launch pad perimeters or compensatory stormwater treatment would be provided elsewhere.

Operations at LC-39A would not have significant impacts on the surface water quality. Surface waters at the launch complex would drain to existing swales within the pad perimeter. Stormwater runoff generated from the launch pad drains to various manmade grass swales that radiate from the pad. The grassed swales discharge via culverts to a swale that runs parallel to the perimeter access road. The perimeter access road swale discharges to receiving waters on the periphery of the site. Implementing procedures already in place and adhering to permit conditions would mitigate impacts from stormwater runoff and keep them to a minimum.

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 Starship/Super Heavy 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 is contained in NASA NPR 8715.5A and KSC 4360, 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 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 (KDP-KSC-P-3008).

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. CCAFS 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 personnel at KSC 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.

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, applicable NASA regulations or instructions, and SpaceX internal procedures 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. The loudest noise generated at LC-39A would result from test fires and launches, however during these events, personnel would be cleared from the area. Operators are required by OSHA and NASA regulations to be equipped with hearing protection devices during routine operations. 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 area 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, 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 and insignificant.

The separate stages of Starship/Super Heavy are designed to be 100% recoverable and reusable, unlike any other space vehicle. In the unlikely event of an anomaly, the majority of spacecraft components do not survive the intense reentry environment. For the minority of those that 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 insignificant impacts to the environment as the vehicle stages are designed to be recovered and reused.

SpaceX would comply with all applicable federal, state, and local and company safety regulations for storage, use, and transfer of toxic and hazardous materials associated with Starship/Super Heavy. 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 would 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.

Some operations at LC-39A, such as test fires and launches, would require temporary removal of personnel from the area. During a Starship/Super Heavy launch, heat would extend 440 m from the launch mount before reaching ambient temperature. In addition, explosive site safety actions at KSC must account for public safety distances and may require temporary road closures. 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 (R. Russo/NASA, 2019, pers. comm.). Coordination between LC-39A 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 probability of an accidental release would increase due to the increased activities and quantity of materials on site. Any potential releases of hazardous materials would be managed according to federal, state, and local regulations including SpaceX's Hazardous Materials Emergency Response Plan, and implementation of BMPs would ensure this increased risk is minimal. Due to the potential storage of significant quantities of hazardous commodities on site, NASA requires LC-39A 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 and insignificant 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 the KSC vicinity and the State of Florida is provided in several recent documents (NASA 2016, NASA 2018a). NASA also identified potential socioeconomic issues resulting from the multi-user spaceport concept over the 20-year period from 2012 to 2032 in the KSC Master Plan (KSC 2013).

3.13.1 Affected Environment

The KSC PEIS (NASA 2016) presented detailed data for Brevard and Volusia counties and compared them to demographic and economic data for the State of Florida. Vital statistics for this EA came from the latest data (2017) from the US Census Bureau, accessed January 16, 2019 (https://www.census.gov/quickfacts/fact/table/brevardcountyflorida). The 2017 population estimate for Brevard County was nearly 590,000 residents, while the Volusia County population was 538,600. Median income for Brevard and Volusia counties was approximately $51.5K and $43.8K, respectively, and the percent of the population living in poverty was 12.4% and 15.2%, respectively. The Florida statewide percentage of the population living in poverty was 14%. The most current data on employment is for the years 2015-2016 and the percentage change was an increase of 3.7% in Brevard and 2.7 % in Volusia.

In December 2018, Florida's Space Coast was selected as Turnaround of the Year by Space News because of the area's successful commercial launch programs and an 8.8% drop in unemployment since 2010. Space News is a print and digital worldwide space industry news source with more than 13,600 subscribers (https://spacenews.com).

Starship/Super Heavy at LC-39A fits within the range of several planned and notional programs evaluated in the KSC PEIS (NASA 2016). SpaceX estimates only a temporary increase in jobs (up to 300) associated with the construction of the additional structures at LC-39A. Once completed, the current local SpaceX staff of approximately 140 workers is expected to support both Falcon and Starship/Super Heavy operations.

3.13.2 Environmental Consequences

The FAA has not established a significance threshold for socioeconomics. Overall, the direct, economic impacts resulting from the Proposed Action would be positive. The LC-39A enhancements and the improved capabilities and longevity of SpaceX operations at KSC would continue to provide beneficial impacts and labor income over the next two decades. Indirect and long-term impacts from this project on the local economy depend on financial commitment to the aerospace industry by NASA, DOD, and commercial customers. If the commitment is sustained over the long-term, indirect economic impacts could be substantial. Implementing Starship/Super Heavy at LC-39A would represent continued or increased purchasing power that supports 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 such aerospace programs.

No Action Alternative

Should the proposed project not be implemented, socioeconomic changes might occur in Brevard or Volusia counties. By not implementing improvements to spaceflight through this proposed action there could be a reduction in SpaceX manifests with the possibility of cascading downsizing of operations and the workforce. There could be minor but negative change to employment, population, income, housing, economic activity, or quality of life.

3.14 Environmental Justice and Children’s Environmental Health and Safety

The FAA has not established a significance threshold for environmental justice and children’s environmental health and safety. Currently, as described in detail in the KSC PEIS (NASA 2016), the population inhabiting 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 levels for Brevard County are lower or comparable to the rest of Florida. Within the ROI, the majority (84%) 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. Similarly, the Proposed Action does not have the potential to lead to a disproportionate health or safety risk to children. In summary, the Proposed Action would not result in significant impacts related to environmental justice and children’s environmental health and safety.

No Action Alternative

Under the No Action Alternative, additional facilities would not be built and enhanced capabilities would not occur at LC-39A, and there would be no Starship/Super Heavy launches from KSC. 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 Department of Transportation Section 4(f)

Section 4(f) refers to the original section within the U.S. Department of Transportation Act of 1966, which established the requirement for consideration of park and recreational lands, wildlife and waterfowl refuges, and historic sites in transportation project development. Properties eligible for protection under Section 4(f) include the following:

- Parks and recreational areas of national, state, or local significance that are both publicly owned and open to the public;
- Publicly owned wildlife and waterfowl refuges of national, state, or local significance that are open to the public to the extent that public access does not interfere with the primary purpose of the refuge; and
- Historic sites of national, state, or local significance in public or private ownership regardless of whether they are open to the public (see 23 U.S.C. §138(a) and 49 U.S.C. §303(a))

Section 4(f) applies to projects that receive funding from or require approval by an agency of the U.S. Department of Transportation (USDOT), including the FAA. Section 4(f) does not apply to NASA or USAF actions.

The regulation known as Section 4(f) was originally established in the U.S. Department of Transportation Act of 1966 (49 U.S.C. §1653(f) and later recodified as 49 U.S.C. § 303). In 2005, Congress enacted legislation that required the USDOT to issue additional regulations that clarify Section 4(f) standards and procedures (USDOT 2012). The USDOT finalized new regulations in March 2008 (23 CFR Part 774). Section 4(f) mandates that the Secretary of Transportation will not approve any transportation project requiring the use of publicly owned parks, recreation areas, wildlife and waterfowl refuges, or significant historic sites, regardless of ownership, unless the following conditions apply:

- There is no prudent and feasible alternative to using that land; and
- The program or project includes all possible planning to minimize harm to the public park, recreation area, wildlife or waterfowl refuge, or significant site, resulting from that use.

To be protected under Section 4(f), public parks, recreation facilities, and wildlife or waterfowl refuges must be considered significant (USDOT 2012). Pursuant to 23 CFR §771.135(c), Section 4(f) resources are presumed to be significant unless the official having jurisdiction over the site concludes that the entire site is not significant. Historic sites qualifying for Section 4(f) protection must be officially listed on or eligible for inclusion on the NRHP, or contribute to a historic district that is eligible for or listed on the NRHP.

A *use* of a property protected under Section 4(f) occurs under either of the following conditions (23 CFR 35 §771.135(p)):

- Land from a qualifying Section 4(f) property is acquired and permanently incorporated into a transportation facility; and/or
- There is a temporary occupancy of Section 4(f) land during construction of the transportation facility that is considered adverse to the preservationist purposes of the Section 4(f) statute.

In addition, a *constructive use* could occur when no land is acquired from a Section 4(f) property, but the proximity of the project results in indirect impacts that would substantially impair the current use of the property, such as visual, noise, or vibration impacts or impairment of property access.

The regulations require coordination with the official(s) having jurisdiction over affected Section 4(f) properties for a number of situations, including, but not limited to, determining if a property is significant, for determining constructive use, for evaluating the reasonableness of measures to minimize harm, and prior to making approvals.

3.15.1 Affected Environment

To adequately capture all publicly owned parks, recreation areas, or wildlife and waterfowl refuges potentially eligible for protection under Section 4(f), the FAA developed a conservative ROI. Section 4(f) properties may experience impacts amounting to use through two primary mechanisms, each of which was considered in the development of the ROI:

The ROI for Section 4(f) includes the footprint of the proposed construction at LC-39A where permanent incorporation could result for any eligible Section 4(f) properties.

The ROI includes a larger area where proximity-related impacts might result in a substantial impairment of the activities, attributes, or features of a Section 4(f) property, also known as constructive use. Because the proximity-related impacts are the farthest reaching, an ROI developed to cover potential constructive use would also cover areas where permanent incorporation and temporary occupancy could occur.

To include a full range of possible proximity impacts that may impair Section 4(f) properties and potentially result in constructive use, the ROI includes areas where noise impacts from construction activities, facility operations, and launch and landing activities would occur. It also includes hazard and closure areas where public access would be limited or restricted.

FAA Order 1050.1F states, in most locations, a significant noise impact would occur if the Proposed Action would cause noise sensitive areas to experience a 1.5 dBA DNL increase when compared to the no action alternative during the same time frame and the end-state noise level would be at or above 65 dBA DNL. Although this threshold is commonly used to evaluate noise impacts, it is not used to develop the Section 4(f) ROI in this EA for two primary reasons. First, as noted in FAA Order 1050.1F, the 65 dBA DNL threshold does not fully address the effects of noise on visitors to areas such as national parks or wildlife refuges where a quiet setting is a recognized attribute and purpose of the area. Additionally, DNL is a day-night average sound level that is typically used to evaluate noise impacts from regularly occurring transportation sources such a railroads, highways, and airports. For these reasons, the FAA defined the Section 4(f) ROI using a maximum A-weighted noise level (or $L_{A,max}$) to evaluate the short-duration, high-intensity nature of Starship/Super Heavy launch and landing noise. While DNL is a cumulative noise metric that typically expresses values as the average level over a 24-hour day, $L_{A,max}$ represents the maximum sound level achieved over the duration of the event. A composite of 90 dBA $L_{A,max}$ noise contours from all launch trajectories was modelled and used to delineate the Section 4(f) ROI. Because launch noise is anticipated to propagate farther than landing noise (see the noise report in Appendix A), the ROI based on launch noise includes noise impacts from landing operations. The 90dBA $L_{A,max}$ contour represents the geographic extent that noise from launches would result in a maximum noise level of 90 dBA or greater.

The FAA conducted an initial screening of the ROI to identify properties eligible for protection under Section 4(f) that have the potential to be affected by the Proposed Action. The FAA evaluated each property to determine if it is publically owned; is open and accessible to the public; has the major or primary purpose for park, recreation, or refuge activities; and is significant as a park, recreation area, or refuge. Section 4(f) properties located at KSC include LC-39A, LC-39B, the Crawlerway, a portion of the KSC railroad track, the VAB, Launch Control Center, Press Site Flag Pole, Central Instrumentation Facility, Headquarters (HQ) Building, and Operations and Checkout Building, all of which are listed on the NRHP. Section 4(f) properties adjacent to KSC include CCAFS (listed on NRHP), MINWR, and CNS. MINWR and CNS property within KSC boundaries, along with the section of IRL National Scenic Byway located within MINWR, are also Section 4(f) properties.

3.15.2 Environmental Consequences

Launch operations would not result in a physical use (direct taking) or temporary occupancy of any Section 4(f) property. The only Section 4(f) property that would be impacted by construction activity is LC-39A. New construction of a launch mount, methane farm, landing pad, and associated infrastructure would occur within the boundary of LC-39A. Development of the facility for offloading Starship, Super Heavy, or other launch vehicle elements would not adversely impact LC-39A. LC-39A is designated by NASA as launch facility for launch operations. The use of the Crawlerway for transport of Starship/Super Heavy from the Turn Basin to LC-39A would not require any modifications to the Crawlerway. Therefore, the FAA has determined that SpaceX's modifications to LC-39A and use of the Crawlerway would not result in a Section 4(f) use of LC-39A or the Crawlerway. NASA concurs with this determination.

In addition to assessing the potential for permanent incorporation or temporary occupancy of a Section 4(f) property, the FAA must consider the potential for constructive use of 4(f) properties. In order for this type of use to occur, the Proposed Action must result in substantial impairment to the property's activities, features, or attributes that qualify the property for protection under Section 4(f). As a general matter, this means that the value of the resource, in terms of its Section 4(f) purpose and significance, will be meaningfully reduced or lost (USDOT 2012). As noted in FHWA's Section 4(f) Tutorial, "[c]onstructive use involves an indirect impact to the Section 4(f) property of such magnitude as to effectively act as a permanent incorporation."

At this time, the FAA does not have enough information about SpaceX's proposal to conduct a sufficient 4(f) analysis with respect to potential constructive use. Specifically, the details regarding potential closures of Section 4(f) properties is unknown. Therefore, the FAA cannot reach a 4(f) determination for potential launch-related impacts. Once the FAA receives a license application from SpaceX for Starship/Super Heavy operations at LC-39A, the FAA will conduct a 4(f) analysis prior to issuing a decisional document for the FAA's environmental review or any launch or reentry license. As part of the FAA's 4(f) analysis, the FAA will coordinate with the officials that have jurisdiction over the Section 4(f) properties (e.g., USFWS and NPS) in determining potential for use under Section 4(f). The following paragraphs discuss the types of potential impacts that Section 4(f) properties could experience during Starship/Super Heavy launches. As stated above, construction activities would not result in a use of Section 4(f) properties.

Due to the proximity of the Section 4(f) properties within the ROI, these Section 4(f) properties might experience increased light emissions or sky glow generated during nighttime operations. Whenever SpaceX is working on the launch vehicle while the vehicle is on the pad, pad lighting would be turned on and remain on throughout the night. The number of times this would occur during a year is unknown. Regarding launches, the EA assumes 20 percent of annual Starship/Super Heavy launches and static fire tests (about five per year) would occur at night. All nighttime lighting would comply with the KSC Lighting Operations Plan (KSC-PLN-1210, Rev A), thereby avoiding or minimizing any potential lighting impacts to the Section 4(f) properties.

The Section 4(f) properties would experience noise from Starship/Super Heavy launches, landings, and engine tests. Noise levels at these 4(f) properties would increase temporarily during launches (including landings) and static engine tests. The increased noise level would only last a few minutes during a launch (i.e., takeoff; 24 per year), less than a minute during a landing (24 per year), and a few seconds during a static engine test (48 per year). Additionally, a sonic boom would be audible within the Section 4(f) properties during a Starship landing. The boom would last less than a second. The increased noise levels during takeoff and landing, as well as the sonic boom, could occur on the same day, minutes from launch or months later, depending on the Starship mission.

As stated in Chapter 2, there is a possibility of temporary restricted access on portions of KSC property managed by USFWS (MINWR) and NPS (CNS), as have occurred for recent and past SpaceX launch operations at LC-39A. Closures due to safety hazards are dependent upon the risk assessment performed by the USAF Range Safety office and the FAA (for commercially licensed launches) using the specific launch trajectory and fuel loads on the rocket prior to launch. SpaceX does not anticipate that static engine tests would require closing public access to MINWR or CNS; however, the details regarding closures are unknown. The risk assessments for launch and landings are still being developed as the trajectories and rocket develops. Any required CNS or MINWR closures would be coordinated between SpaceX and the respective agency, NPS and/or USFWS.

No Action Alternative

Under the No Action Alternative, there would be no new construction at LC-39A, and Starship/Super Heavy launch operations would not occur at LC-39A. Therefore, the no action alternative would not affect Section 4(f) properties.

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."

The CEQ regulations further require that NEPA environmental analyses address connected, cumulative, and similar actions in the same document (40 CFR § 1508.25). Additionally, the CEQ further explained in Considering Cumulative Effects Under the NEPA (CEQ 1997) that “each resource, ecosystem and human community must be analyzed in terms of its ability to accommodate additional effects, based on its own time and space parameters.” Therefore, a cumulative effects analysis normally will encompass geographic boundaries beyond the immediate area of the Proposed Action, and include past, present, and reasonably foreseeable future actions, in order to capture these additional effects.

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) 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.

LC-39B is under the process of redevelopment for the Space Launch System (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 39C, was designed and constructed to accommodate Small Class Vehicles. Located in the southeast area of the LC-39B perimeter, this new concrete pad measures about 15 m wide by about 30 m long. Launch Pad 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 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.

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., VAB
- 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

KSC is in the process of designing LC-48 as a multi-use launch complex for Small Class Launch Vehicles. This launch complex would be located approximately 1,981 m (6,500 ft) southeast of LC-39A and 1,591 m (5,220 ft) north of LC-41. Development could also include construction of a Horizontal Integration Facility, Manufacturing and Refurbishment Facility, and Vertical Landing Facility near the launch complex, on other undeveloped areas at KSC, in an area sited for industrial use, on CCAFS, or elsewhere off Center property.

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 and Falcon Heavy vehicles. SpaceX successfully launched the first of several Falcon 9 v1.1 at LC-39A on February 19, 2017, and as of March 2019, there have been 17 Falcon launches from LC-39A. The Falcon Heavy launched for the first time on February 6, 2018. On March 2, 2019, SpaceX successfully launched the first test flight of the Crew Dragon spacecraft on top of a Falcon 9 rocket. The Falcon Heavy launched for the first time on February 6, 2018. The second Falcon Heavy launch is scheduled for April 2019.

SpaceX has conducted refurbishment of and upgrades to the existing support buildings and launch pad to bring LC-40 on CCAFS back into operation as a launch facility for the Falcon launch vehicle. As of March 2019, SpaceX has launched the Falcon 9 vehicle from LC-40 41 times. SpaceX plans to increase the Falcon launch frequency to 20 launches per year from LC-39A and up to 50 launches per year from LC-40 by the year 2024. However, as Starship/Super Heavy launches gradually increase to 24 launches per year, the number of launches of the Falcon would decrease. The Starship and Super Heavy would exceed the lift capabilities of the Falcon and Falcon Heavy. Due to the higher lift capability, Starship/Super Heavy could launch more payloads and reduce the overall launch cadence from LC-39A. A single Starship/Super Heavy launch would be equivalent to two Falcon launches.

Over the past several years, SpaceX has developed the technology and ability to boost-back and land the Falcon 9 first stage booster on land or on a droneship in the Atlantic Ocean. This led to construction on CCAFS of a main landing pad (LZ-1) and later an additional landing pad referred to as LZ-2. After its maiden launch, SpaceX landed two of Falcon Heavy's first stage boosters at LZ-1 and LZ-2.

SpaceX recently obtained access to and use of a set of buildings named Area 59, located adjacent to and south of the CCAFS runway known as the Skid Strip. The area was previously used for satellite processing and associated hypergolic fuel-related operations, which is consistent with SpaceX's use of the facility. The area is used for Dragon capsule processing.

SpaceX will develop a campus facility in an area of KSC currently known as the Roberts Road site. The campus would support ongoing Falcon 9 and Falcon Heavy launches at LC-39A and LC-40, as well as future Starship/Super Heavy launches at LC-39A. The proposed campus could include a facility for a launch and landing control center, booster and fairing processing and storage facility, rocket garden, security office, and utilities yard.

Blue Origin operates a manufacturing facility in Exploration Park Phase 2 located on the west side of Space Commerce Way Operations at the manufacturing and processing facility that include supporting development of reusable launch vehicles utilizing rocket-powered Vertical Take-off and Vertical Landing systems (GSDO, 2017). Blue Origin is beginning expansion on a parcel of land south of the current manufacturing facility site for additional manufacturing, assembly, and test facilities with the first structure expected in May of 2020.

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.

Increased 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.

The CCAFS/PAFB Installation Development Plan aligns the future vision for CCAFS and PAFB with the priority of achieving short- and long-term sustainability of the installation. The 45 SW 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 2017a). 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.

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. LC-11 is located adjacent to LC-36 and will be used to conduct test firings of the BE-4 engine. Blue Origin's New Glenn rocket is scheduled for its maiden launch from LC-36 in 2021.

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 LEO or geostationary orbit. All vehicles are expected to carry payloads, including satellites (FAA 2008). A Minotaur IV rocket was launched from LC-46 in August 2017. This was the first launch of an Orbital ATK Minotaur rocket from CCAFS. The mission launched a surveillance satellite for the USAF. LC-46 will also be used by NASA for the Ascent Abort-2 test mission of Orion planned for 2019. This mission 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. Space Florida has also leased SLC-20 to Firefly Aerospace, where they intend to launch small-lift launch vehicles beginning in 2021.

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. United Launch Alliance (ULA) launched a GPS satellite on March 15, 2019.

LC-41 is currently used by ULA for Atlas V launches. Most recently, a communications satellite was launched 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, and use new BE-4 booster engines that consume liquid oxygen and liquid natural gas for the first stage, and 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.

In January 2019, Relativity Space entered into a lease with USAF for SLC-16 on CCAFS. Relativity Space plans to build and operate the LC-16 and launch the Terran 1 rocket by 2020.

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 launch complex would accommodate up to 24 launches per year as well as up to 24 static fire 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. 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.

4.2 Cumulative Impact Analysis on Resources

Cumulative impacts result from the incremental effect of an action when added to other past, present, and reasonable 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.

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

The Land Use designation of LC-39A is already Vertical Launch and would not change as a result of Starship/Super Heavy launches. The land use would need to be amended to include landing activities of the Starship. Any proposed land use changes for LC39-A will be initiated and managed by the KSC Center Planning and Development office. There would be no additional impact on prescribed burn management activities. Coordination between facility operators and MINWR would continue. No significant adverse cumulative impacts to Land Use, 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 and wildlife within 440 m would occur from heat generated during launch. Disorientation of nesting marine turtles could result from lighting during nighttime construction and operations. Noise from launches and landings could cause a startle response in wildlife. Launch and landing operations are short in duration and spread out over time and would not be expected to have residual effects past each operation. Compliance with the NMFS consultations and implementation of environmental protection measures would minimize impacts to special-status species. Therefore, implementation of the Proposed Action in conjunction with other past, present, or reasonably foreseeable projects would not result in significant cumulative impacts to biological resources.

4.2.4 Cultural Resources

Cumulative effects or impacts on historic facilities are not expected to be significant. HAER (FL-8-11-F), for LC-39A was completed in 2010. The HAER was performed to mitigate for "adverse effects" to the complexes that might occur with post Shuttle Program redevelopment. The FL SHPO, in a letter dated May 2013, concurred future consultation is not required for the reuse of LC-39A by a commercial entity. The Proposed Action is not anticipated to result in significant cumulative impacts on cultural resources.

4.2.5 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. In addition, the atmospheric emissions associated with launches, landings, 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.

4.2.6 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 at LC-39A 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.

4.2.7 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.

4.2.8 Water Resources

With the implementation of stormwater management systems, development of the site would have a moderate cumulative effect on hydrology and water quality. 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.

Compliance with all state and federal regulations and implementation of proper management of materials and wastes would minimize impacts to water resources as a result of the Proposed Action. Therefore, implementation of the Proposed Action in conjunction with other past, present, or reasonably foreseeable projects would not result in significant cumulative impacts to water resources.

4.2.9 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.

4.2.10 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 insignificant and not expected to result in cumulative impacts to regional transportation.

4.2.11 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 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. Any impacts to electrical service would occur within KSC and result in relatively small cumulative impacts to regional service providers. Potable water supply could become more limited. Future operations and personnel could implement water conservation measures and evaluate alternative water sources in order to minimize impacts on this resource. The commitment of energy and natural resources to implement the Proposed Action in conjunction with past, present, and reasonably foreseeable future actions, is not anticipated to be excessive or significant in terms of region-wide usage.

4.2.12 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.

4.2.13 Socioeconomics

Any cumulative impacts from the Proposed Action would be beneficial to KSC, CCAFS, and surrounding communities. The temporary increase in employment opportunities during construction and long-term employment for personnel supporting Starship/Super Heavy would be considered positive and would potentially augment other businesses and industries in the local communities.

The Spaceport (KSC and CCAFS) is Brevard County's major employer. The presence of these employers causes a chain of economic reactions throughout the local region and nearby counties. These actions have, or will have a positive influence on socioeconomics, through contributions to the local economy. As a result, the overall cumulative effect of the Proposed Action when considered with other past, present, and reasonably foreseeable future actions on socioeconomics is considered beneficial and less than significant.

4.2.14 Environmental Justice and Children's Environmental Health and Safety

There would be no cumulative impacts from the Proposed Action on environmental justice or children's health and safety.

4.2.15 Section 4(f) Properties

Cumulative impacts to Section 4(f) properties include noise and visual impacts generated by launch operations at KSC and CCAFS throughout the year. Note that launches occur individually; thus, there would be no combined noise or visual impacts from more than one launch at a given time. Potential cumulative impacts to Section 4(f) properties also include the possibility of launch-related closures throughout the year at MINWR or CNS. Closures are dictated by Range and FAA safety analyses as described earlier in this EA.

5.0 LIST OF PREPARERS AND CONTRIBUTORS

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

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APPENDIX A. KBRwyle and Sierra-Noise and Air Studies

STARSHIP NOISE AND SONIC BOOM ASSESSMENT FOR FLIGHT AND STATIC TEST OPERATIONS AT KENNEDY SPACE CENTER

TN 19-02

July 2019

Prepared for:

Space Exploration Technologies Corporation

KBRwyle
We Deliver

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1 Introduction

Noise and sonic boom levels have been estimated for SpaceX's Starship rocket which is currently under development. Starship, which has a length of about 180 feet and a diameter of about 9 meters, will be mated with a Super Heavy Booster rocket (length of about 207 feet) to provide space travel capability to the moon and Mars. Both vehicles have vertical take-off and landing (VTOL) capability and are reusable. This study was conducted to estimate noise levels from future Starship (and Booster) launches, Starship landings, booster landings, and static fire tests at Kennedy Space Center (KSC); sonic boom levels were also estimated for Starship and booster atmospheric reentry and descent flights for landing.

The Starship uses seven Raptor engines, and the Super Heavy Booster uses thirty-one Raptor engines, that each provide sea-level thrust of about 375 Klbf. Starship launches and static fire tests are planned to occur at Kennedy Space Center Launch Complex 39 (LC-39A) as are booster static fire tests. Starship landings are planned to occur at LC-39A and Landing Zone 1 (LZ-1) while booster landings could occur at LC-39A or on a drone ship located off the coast. This assessment was conducted to estimate the single event and cumulative noise levels, and single event sonic boom levels in the vicinity of KSC due to all of these rocket operations.

SpaceX provided the following data for noise modeling:

- Launch trajectory for the Starship and Super Heavy Booster from liftoff to stage separation.
- Raptor engine operating data and nominal ascent thrust profile.
- Starship and Super Heavy Booster reentry and descent/landing trajectories from separation to landing with descent thrust profiles.
- Static fire test parameters for the Starship and Super Heavy Booster.
- Projected annual launch, landing, and static fire test operations at KSC.

Noise levels were estimated for Starship and Super Heavy Booster flight and static test operations conducted at LC-39A and Booster landings on a drone ship using Wyle's RNOISE model. RNOISE[1,2] is a far-field (distances beyond several hundred feet) community noise model for launch noise assessment. Sonic boom was assessed for reentry operations using Wyle's PCBoom model[3,4].

In the following sections of this report, sonic boom background is provided in Section 2 followed by an assessment of Starship and Super Heavy Booster reentry sonic boom levels in Section 3. A description of rocket noise fundamentals and noise metrics is provided in Section 4 followed by estimated noise levels for Starship launches (Section 5), Starship and Super Heavy Booster landings (Section 6), and static fire tests for both vehicles (Section 7). The noise estimates (Sections 4 through 7) describe single event and cumulative noise levels for projected future launches, landings, and static fire tests.

2 Sonic Boom Background

A sonic boom is the wave field about a supersonic vehicle. As the vehicle moves, it pushes the air aside. Because flight speed is faster than the speed of sound, the pressure waves can't move away from the vehicle, as they would for subsonic flight, but stay together in a coherent wave pattern. The waves travel with the vehicle. Figure 1 is a classic sketch of sonic boom from an aircraft in level flight. It shows a conical wave moving with the aircraft, much like the bow wave of a boat. While Figure 1 shows the wave as a simple cone, whose ground intercept extends indefinitely, temperature gradients in the atmosphere generally distort the wave from a perfect cone to one that refracts upward, so the ground intercept goes out to a finite distance on either side. Boom is not a onetime event as the aircraft "breaks the sound barrier" but is often described as being swept out along a "carpet" across the width of the ground intercepts and the length of the flight track. Booms from steady or near-steady flight are referred to as carpet booms.

The waveform at the ground is generally an "N-wave" pressure signature, as sketched in the figure, where compression in the forward part of the vehicle and expansion and recompression at the rear coalesce into a bow shock and a tail shock, respectively, with a linear expansion between.

Figure 1 is drawn from the perspective of aircraft coordinates. The wave cone exists as shown at a particular time, but is generated over a time period. Booms can also be viewed from the perspective of rays propagating relative to ground-fixed coordinates. Figure 2 shows both perspectives. The cone represents rays that are generated at a given time, and which reach the ground at later times. The intercept of a given ray cone with the ground is called an "isopemp." When computing sonic booms the ray perspective is appropriate, since one starts the analysis from the aircraft trajectory points and each isopemp is identified with flight conditions at a given time. As sketched in Figure 2, the isopemps are forward facing crescents.

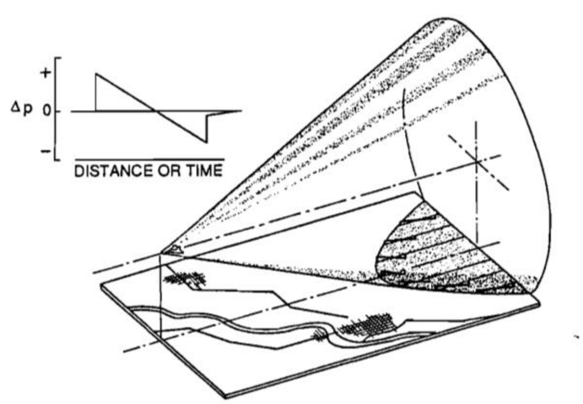

Figure 1. Sonic Boom Wave Field

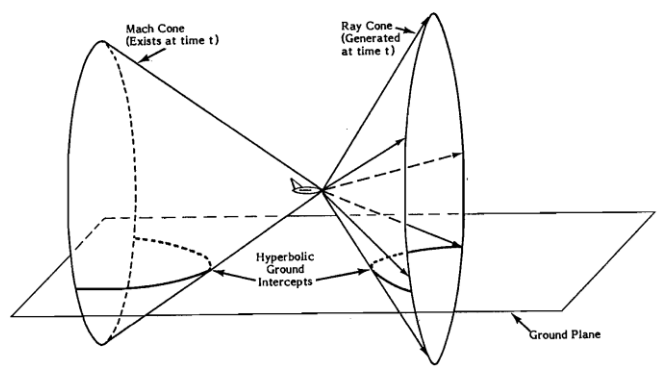

Figure 2. Wave versus Ray Viewpoints

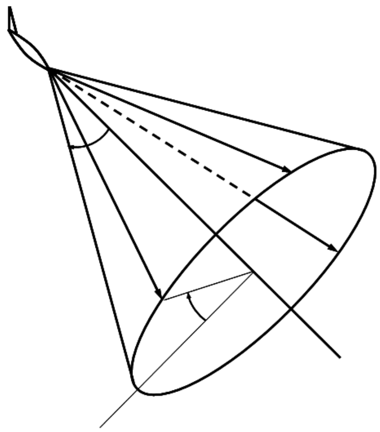

Figure 3. Ray Cone in Diving Flight

Figures 1 and 2 are drawn for steady level flight. If the aircraft climbs or dives, the ray cone tilts along with it. Figure 3 shows a ray cone in diving flight. At the angle in the figure the isopemp would still be a forward facing crescent, but would wrap around further than shown in Figure 2. In a steeper dive the isopemp could go full circle. If the vehicle is climbing at an angle steeper than the ray cone angle, there will be no boom at the ground. During very steep descent (near vertical) and at high Mach numbers the rays can be emitted at a shallow enough angle that they would refract upward and not reach the ground. For a descending vehicle that eventually decelerates to subsonic speed, some part of the trajectory will generate boom that reaches the ground.

Supersonic vehicles can turn and accelerate or decelerate. That affects the boom loudness, and under some conditions cause focused superbooms. Figure 4 is a sketch of rays from an accelerating aircraft. As the Mach number increases the ray angles steepen. The rays cross and overlap, with the focus along the "caustic" line indicated in the figure. The boom on a focusing ray is a normal N-wave before it gets close to the caustic, is amplified by a factor of two to five as it reaches the caustic, then is substantially attenuated as a "post-focus" boom after it passes the caustic.

Figure 5 shows the isopemps for this type of acceleration focus. The focal zone is the concentrated region at the left end of the footprint. The maximum focus area – where the boom is more than twice the unfocused normal boom – is very narrow, generally a hundred yards or less.

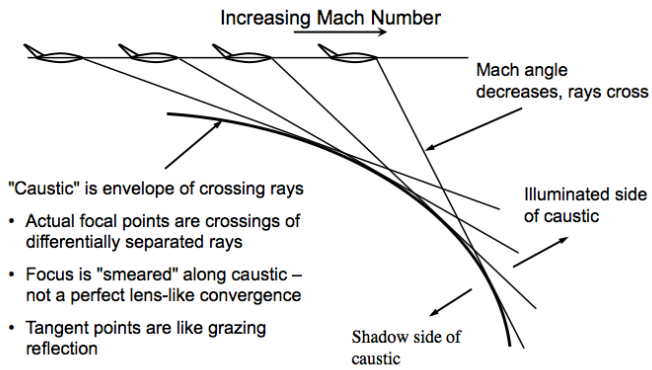

Figure 4. Ray Crossing and Overlap in an Acceleration Focus

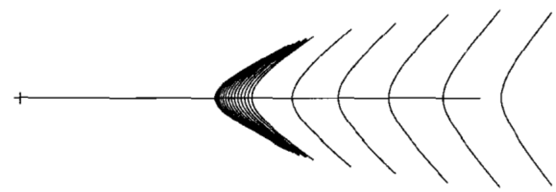

Figure 5. Isopemp Overlap in an Acceleration Focus

3 Vehicle Reentry Sonic Boom Levels

Sonic boom footprints were computed separately for the Starship and Super Heavy Booster (after separation) for their reentries from low Earth orbit (LEO) and descent/landings. The Starship landing is planned to occur at either LC-39A or LZ-1 at KSC; in this study the Super Heavy Booster landing is planned to occur on a drone ship off coast, although it may also land back at KSC.

Sonic boom is generated while the Starship is supersonic during descent, above an altitude of about 78,000 feet. Likewise, sonic boom for the Super Heavy Booster is generated above approximately 25,000 feet. Section 3.1 describes the estimated sonic boom levels for the Starship in the vicinity of LC-39A and LZ-1 and Section 3.2 describes the estimated boom levels for the Super Heavy Booster in the vicinity of a drone ship.

3.1 Starship Reentry Sonic Boom Levels for Landings at LC-39A and LZ-1

SpaceX provided the data file "Starship_LEO_39A_Landing_80_12.ASC" which contains the nominal LEO reentry and landing trajectory of the Starship. The reentry reaches hypersonic speeds above Mach 25 and slows to supersonic speeds until it passes through an altitude of about 78,000 feet where vehicle speeds are subsonic until landing at LC-39A.

The boom footprint was computed using PCBoom.[3,4] The vehicle is a cylinder, with tapered nose cone, modeled with an angle of attack of 135 degrees with respect to the velocity vector. Figure 6 shows the sonic boom footprint, in the form of overpressure contours, pounds per square foot (psf) for the landing at LC-39A. The ground track of the Starship reentry trajectory is also shown in Figure 6. Overpressure contours of 0.2 psf are shown along and to the side of the trajectory. Levels of 1.0 psf and higher extend from several hundred nautical miles, to the west, before the landing site to about 30 nautical miles east of the landing site. Levels of 3.0 psf and higher are estimated to be within about 20 nautical miles from the landing site. In the vicinity of the landing site there is an oval shaped boom footprint region generated as the vehicle descends below 150,000 feet at a heading of approximately 81 degrees and until its speed becomes subsonic.

- The boom levels in the vicinity of the landing pad at LC-39A range from about 4.0-4.7 psf with the maximum overpressure estimated to be 4.7 psf. The location of maximum overpressure will vary with weather conditions, so it is unlikely that any given location will experience the maximum estimated level more than once over multiple events.

- Boom levels along the coastline, within about 20 nautical miles are expected to be between 3.0-4.0 psf.

Figure 7 shows the sonic boom footprint, in the form of overpressure contours, pounds per square foot (psf) for the landing at LZ-1. The contours are similar to those estimated for the landing at LC-39A except LZ-1 is approximately nine miles south of LC-39A along the coast.

In general, booms in the 0.2 to 0.3 psf range could be heard by someone who is expecting it and listening for it, but usually would not be noticed. Booms of 0.5 psf are more likely to be noticed, and booms of 1.0 psf are certain to be noticed. Therefore, people west of KSC are likely to notice booms from Starship landings and people located at CCAFS or KSC, within the 3.0 psf and 4.5 psf region, could possibly be startled. Announcements of upcoming Starship launches and landings serve to warn people about these noise events and are likely to help reduce adverse reactions to these noise events. The boom levels over land are not likely to cause property damage.

Figure 6. Starship Sonic Boom Levels for Reentry/Landing at LC-39A

Figure 7. Starship Sonic Boom Levels for Reentry/Landing at LZ-1

3.2 Super Heavy Booster Sonic Boom Levels for Reentry and Drone Ship Landings

SpaceX provided the data file "Super_Heavy_LC-39A_90_deg_azxf_LEO_Entry_Landing_80_12.ASC" which contains the descent and landing trajectory of the Super Heavy Booster. The Super Heavy Booster reaches an altitude of about 425,000 feet and then on descent reaches hypersonic speeds above Mach 6 before slowing to subsonic speeds, below 25,000 feet, prior to landing on a drone ship.

The boom footprint was computed using PCBoom.[3,4] The vehicle is a cylinder, generally aligned with the velocity vector. Figure 8 shows the sonic boom footprint, associated with the landing, in the form of overpressure contours, pounds per square foot (psf). The ground track of the booster trajectory is also shown in Figure 8. Overpressure contours shown in Figure 8 range from 0.5 psf to above 12 psf. Levels of 1.0 psf and higher are estimated to be within about 30 nautical miles from the drone ship. Levels of 3.0 psf and higher are estimated to be within about 20 nautical miles from the drone ship. In the vicinity of the landing site there is an oval shaped boom footprint region generated as the vehicle descends below 170,000 feet at a heading of approximately 94 degrees and flight path angle of -40 degrees until its speed becomes subsonic.

- The boom levels in the vicinity of the drone ship range from about 5.0-10.0 psf.
- The maximum overpressure of 12.44 psf represents a focal zone that occurs near the northern tip of the crescent shaped contour that is farthest west from the drone ship. The location of such a focal zone will vary with weather conditions, so it is unlikely that this location will experience these levels more than once over multiple events.
- People living on the east coast are not expected to hear the sonic boom generated by the descent/landing of the Super Heavy Booster.

As mentioned previously and in general, booms in the 0.2 to 0.3 psf range could be heard by someone who is expecting it and listening for it, but usually would not be noticed. Booms of 0.5 psf are more likely to be noticed, and booms of 1.0 psf are certain to be noticed. People working in the vicinity of the drone ship during a landing/recovery operation are likely to be startled by landing booms of 5.0-10.0 psf, although such booms would be anticipated. Drone ship landing booms will be generated far enough off coast that they are not expected to cause property damage in coastal areas.

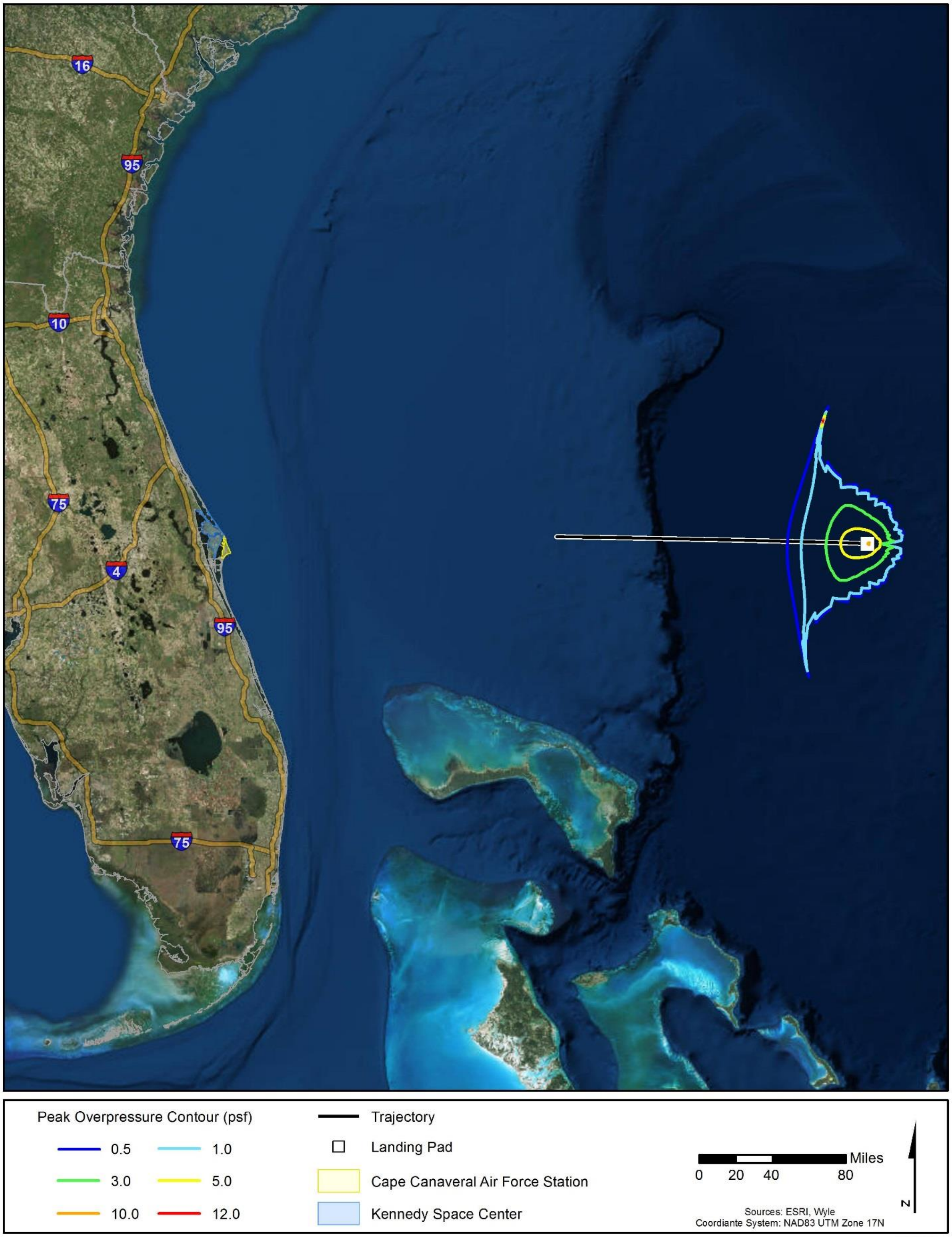

Figure 8. Super Heavy Booster Sonic Boom Levels for Reentry/Drone Ship Landing

4 Rocket Noise Background and Metrics

4.1 Background

Rockets generate significant noise from the combustion process and turbulent mixing of the exhaust flow with the surrounding air. Figure 9 is a sketch of rocket noise. There is a supersonic potential core of exhaust flow, surrounded by mixing region. Noise is generated in this flow. It is directional, with the highest noise levels at an angle of 40 to 50 degrees from the direction of the exhaust flow. The fundamentals of predicting rocket noise were established by Wilhold et al.[5] for moving rockets and by Eldred et al.[6] for static firing. Sutherland[7] has refined modeling of rocket source noise, improving its consistency relative to jet noise theory. Based on those fundamentals, Wyle has developed the PAD model for near field rocket noise[8] and the RNOISE model for far field noise in the community. RNOISE was used for the current analysis.

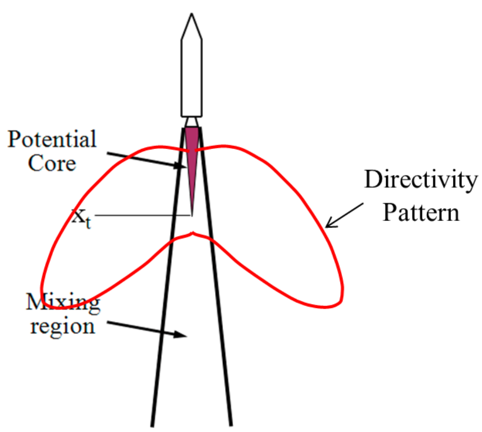

Figure 9. Rocket Noise Source

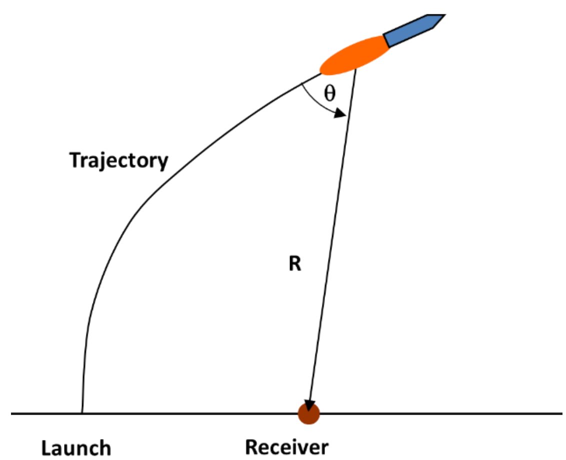

Figure 10. Modeling Rocket Noise at the Ground

Figure 10 is a sketch of far field rocket noise as treated by RNOISE. The vehicle position and attitude is known from the trajectory. Rocket noise source characteristics are known from the engine properties, with thrust and exhaust velocity being the most important parameters. The emission angle and distance to the receiver are known from the flight path and receiver position. Noise at the ground is computed accounting for distance, ground impedance,[9] and atmospheric absorption of sound.[10] RNOISE propagates the full spectrum to the ground, accounting for Doppler shift from vehicle motion. It is a time simulation model, computing the noise at individual points or on a regular grid for every time point in the trajectory. Propagation time from the vehicle to the receiver is accounted for, yielding a spectral time history at the ground. A variety of noise metrics can be computed from the full calculated noise field and the metrics commonly used to assess rocket noise are described in the following section.

4.2 Noise Metrics

FAA Order 1050.1E specifies Day-Night Average Sound Level (DNL) as the standard metric for community noise impact analysis, but also specifies that other supplemental metrics may be used as appropriate for the circumstances. DNL is appropriate for continuous noise sources, such as airport noise and road traffic noise. The noise metrics used for rocket noise analysis are:

- DNL, as defined by FAA Order 1050.1E;
- SEL, the Sound Exposure Level, for individual events;
- L_{Amax}, the maximum A-weighted level, for individual events;
- OASPL, the maximum overall sound pressure level, for individual events; and
- One third octave spectra at particular sensitive receptors.

As mentioned, DNL is necessary for policy. The next two metrics (L_{Amax} and SEL) are A-weighted and provide a measure of the impact of individual events. Loud individual events can pose a hearing damage hazard to people, and can also cause adverse reactions by animals. Adverse animal reactions can include flight, nest abandonment, and interference with reproductive activities. The last two metrics, OASPL and spectra, may be needed to assess potential damage to structures and adverse reaction of species whose hearing response is not similar to that of humans.

L_{Amax} is appropriate for community noise assessment of a single event, such as a rocket launch or static fire test. This metric represents the highest A-weighted integrated sound level for the event in which the sound level changes value with time. The L_{Amax} metric indicates the maximum sound level occurring for a fraction of a second. Slowly varying or steady sounds are generally integrated over a period of one second. The maximum sound level is important in judging the interference caused by a noise event with conversation, TV or radio listening, sleep, or other common activities. Although it provides some measure of the intrusiveness of the event, it does not completely describe the total event, because it does not include the period of time that the sound is heard.

SEL is a composite metric that represents both the intensity of a sound and its duration. Individual time-varying noise events (e.g., aircraft overflights) have two main characteristics: a sound level that changes throughout the event and a period of time during which the event is heard. SEL provides a measure of the net impact of the entire acoustic event, but it does not directly represent the sound level heard at any given time. For example, during an aircraft flyover, SEL would include both the maximum noise level and the lower noise levels produced during onset and recess periods of the overflight. SEL is a logarithmic measure of the total acoustic energy transmitted to the listener during the event. Mathematically, it represents the sound level of a constant sound that would, in one second, generate the same acoustic energy as the actual time-varying noise event. For a rocket launch, EL is expected to be greater than L_{Amax}.

Estimated noise results for Starship and Super Heavy booster launch, landing, and static fire test operations, presented in Sections 5 through 7, include L_{Amax} and SEL contours for single event noise assessment over the study area and DNL contours for cumulative noise based on 24 projected annual operations of each type of noise event.

5 Launch Noise Levels

5.1 Starship Launches at LC-39A

RNOISE was used to estimate the L_{Amax}, and SEL contours for Starship Launch at LC-39A using trajectory data, from liftoff to stage separation, provided by SpaceX in file 'Starship_LC-39A_90_deg_azxf_LEO_Ascent_80_12.ASC'. The L_{Amax} contours indicate the maximum sound level at each location over the duration of the launch where engine thrust varies according to the ascent thrust profile provided. The Starship launch vehicle is comprised of the Starship (vehicle with payload) mated with the Super Heavy Booster.

RNOISE computations were done using a radial grid consisting of 128 azimuths and 100 intervals out to 500,000 feet from the launch point. Ground areas were considered to be acoustically soft, and water acoustically hard. Ground effect was based on a weighted average over the propagation path. As will be shown in the resulting noise contour maps (Figures 11 through 15), the shape of the innermost contours is approximately circular. The shape of the outermost contours is due to rocket noise directivity and the difference between acoustically hard water and acoustically soft ground. The launch pad location at LC-39A is indicated in the map legends as are the Cape Canaveral Air Force Station (CCAFS) and KSC properties.

The L_{Amax} 70 dB through 110 dB contours shown in Figures 11 and 12 represent the maximum levels estimated for the Starship launch at LC-39A; Figure 12 shows these contours using a zoomed in map scale to better show the extent of the noise exposure relative to cities located around LC-39A. The higher L_{Amax} contours (100 – 140 dB) are located entirely within both the CCAFS and KSC properties, although the 90 dB contour extends into parts of Titusville, west of LC-39A, and Courtenay, southwest of LC-39A. If a Starship launch occurs during the day, when background levels are in the 50 dB to 60 dB range, residents of Titusville, Merritt Island, and Cape Canaveral may notice launch noise levels above 70 dB. If the same launch occurs during the night, when background levels are lower than during the day (e.g., below 40 dB to 50 dB range), these residents may notice launch noise levels that exceed 60 dB. A prevailing on-shore or off-shore breeze may also strongly influence noise levels in these communities.

Estimated SEL contour levels of 90, 100, 110, 120, 130, 140, and 150 dB are shown in Figures 13 and 14 for the Starship launch at LC-39A with Figure 14 showing a zoomed in map scale. As mentioned previously, SEL is an integrated metric and is expected to be greater than the L_{Amax} because the launch event is up to several minutes in duration whereas the maximum sound level (L_{Amax}) occurs instantaneously. Figure 13 indicates that the 110 dB and higher level SEL contours are expected to remain entirely within the CCAFS and KSC properties. The 100 dB SEL contour extends past Titusville to the west and beyond Cocoa Beach to the south.

Figure 15 shows the estimated Day-Night Average Sound Level (DNL) contours for a projected 24 annual Starship launch operations (80% daytime and 20% nighttime). The DNL 65 dB contour is located within the CCAFS and KSC properties.

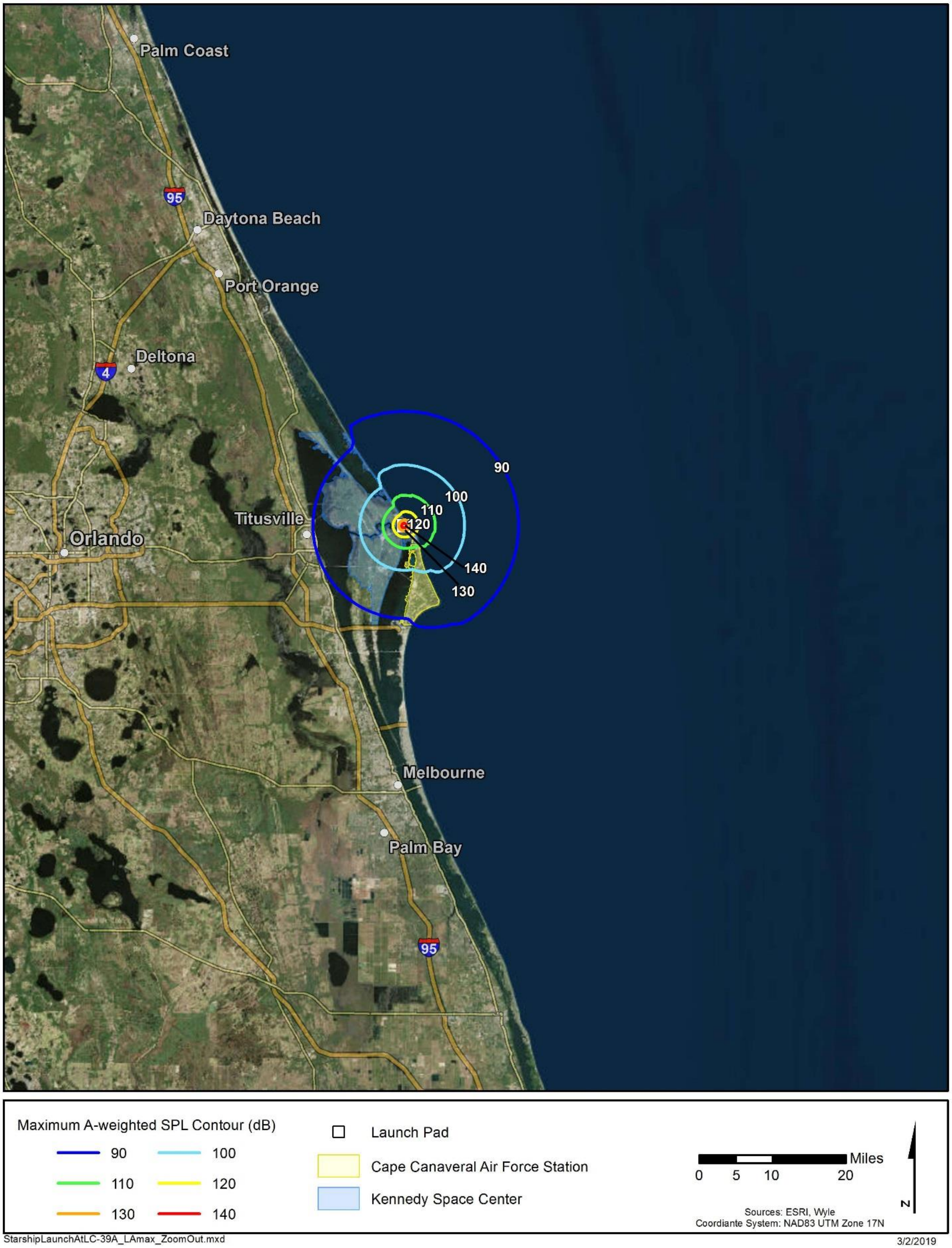

Figure 11. Starship Launch from LC-39A: Maximum A-Weighted Sound Levels

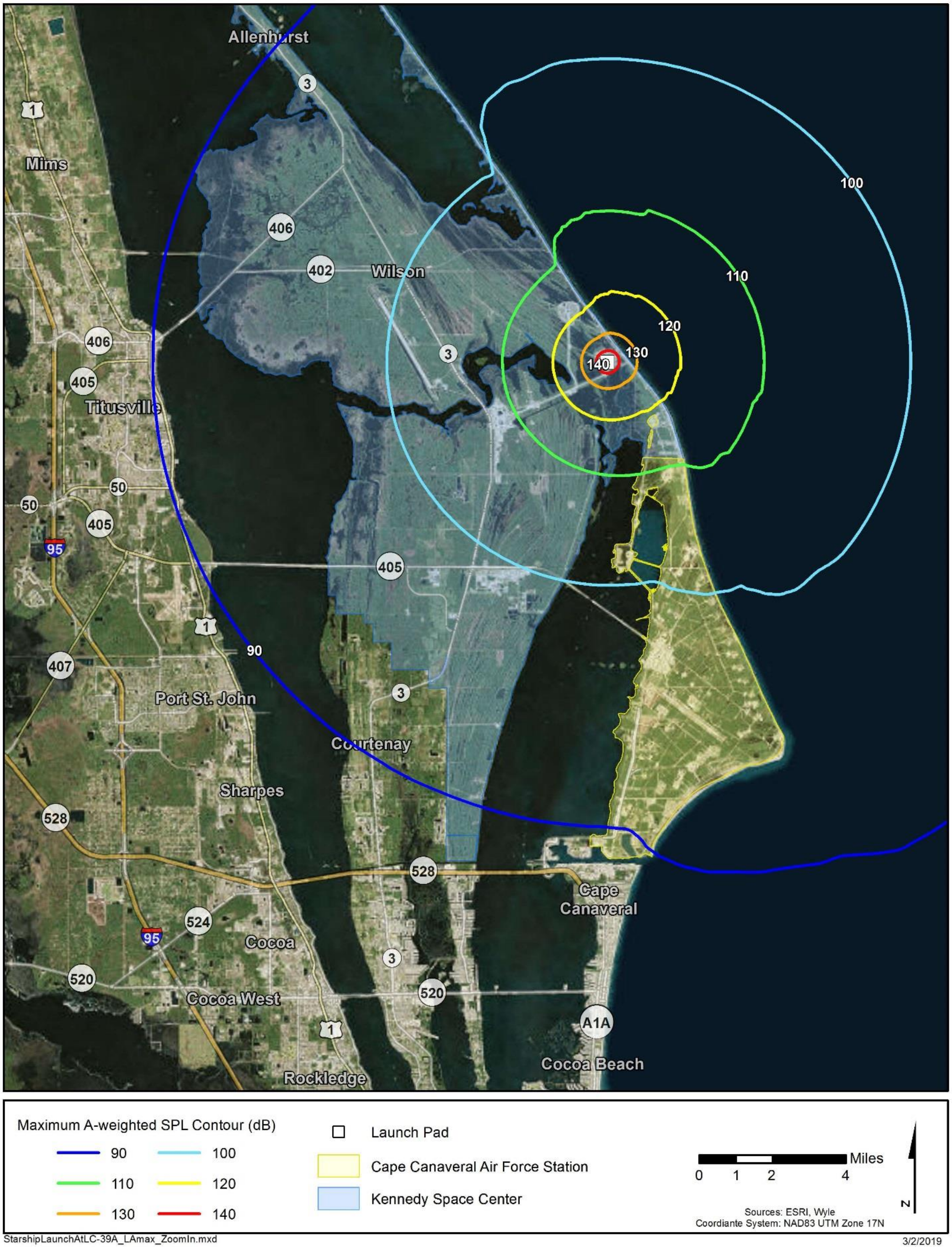

Figure 12. Starship Launch from LC-39A: Maximum A-Weighted Sound Levels (Zoomed in)

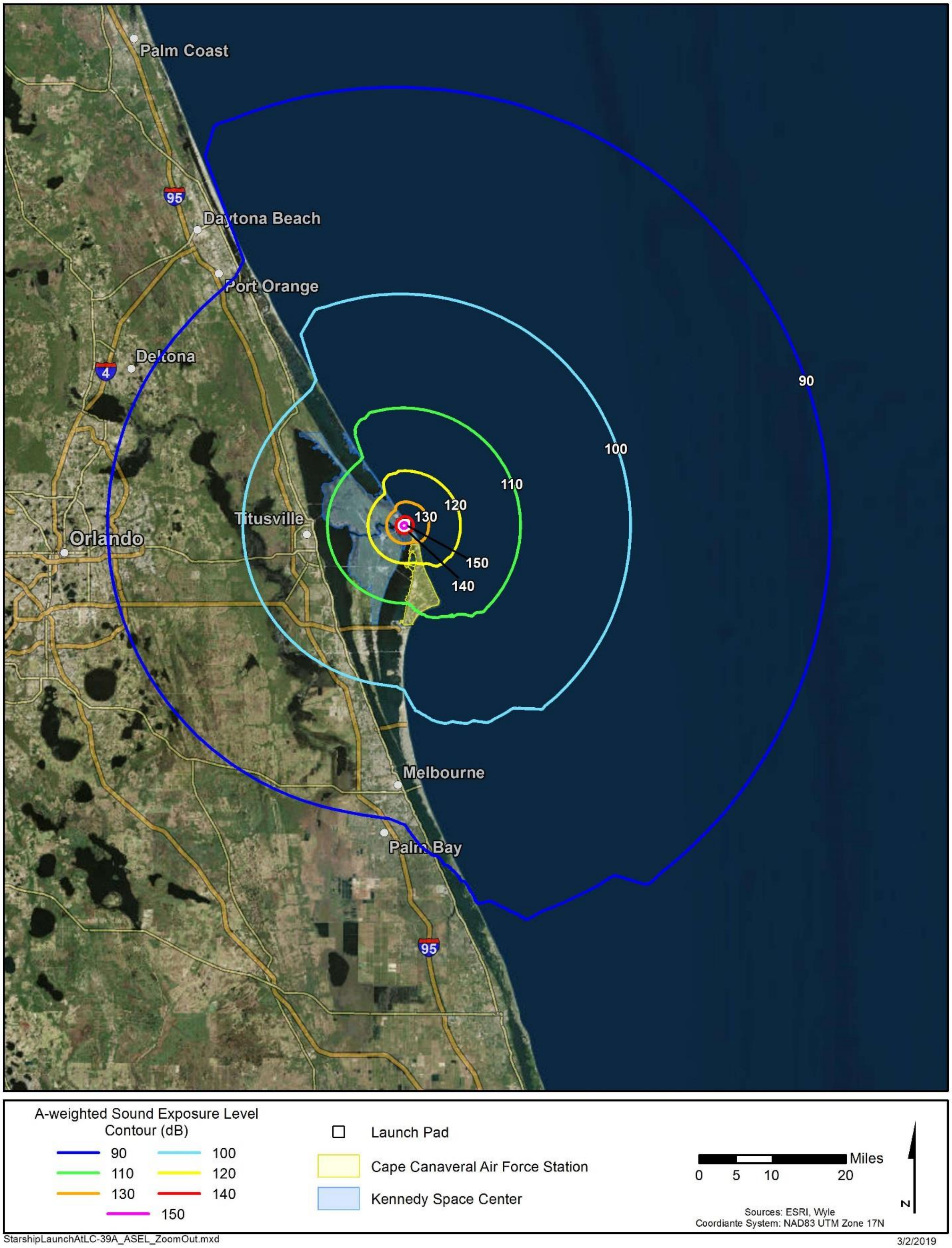

Figure 13. Starship Launch from LC-39A: Sound Exposure Levels

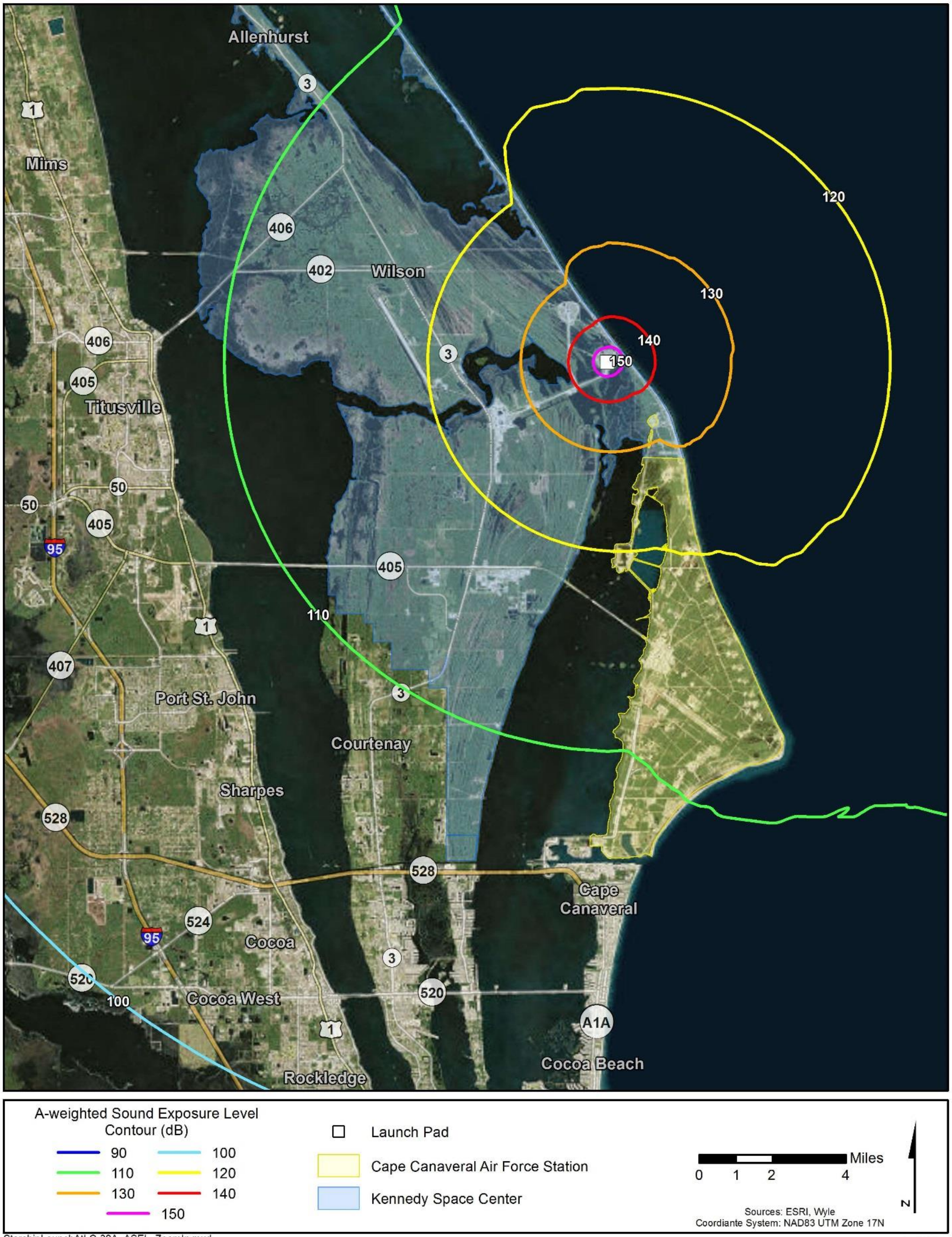

Figure 14. Starship Launch from LC-39A: Sound Exposure Levels (Zoomed in)

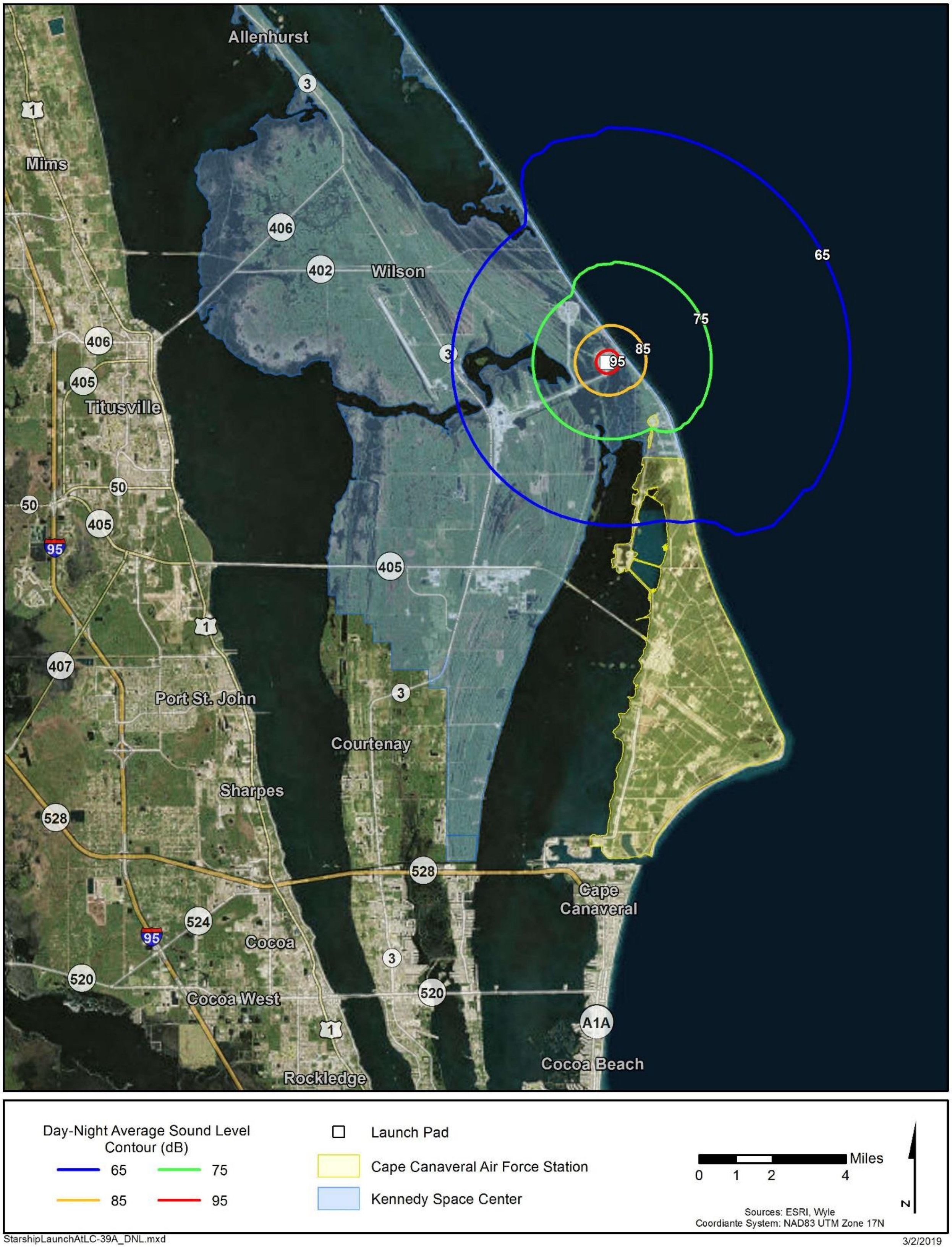

Figure 15. Starship Launch from LC-39A: Day-Night Average Sound Levels

6 Reentry/Landing Noise Levels

6.1 Starship Landings at LC-39A and LZ-1

RNOISE was used to estimate the L_{Amax}, and SEL contours for Starship landings at LC-39A. The Starship reentry and descent/landing trajectory was provided by SpaceX in file 'Starship_LEO_39A_Landing_80_12.ASC'. L_{Amax} contours indicate the maximum sound level at each location over the duration of the landing where engine thrust varies according to the reentry/descent thrust schedule provided.

RNOISE computations were performed as noted in Section 5.1. Ground areas were considered to be acoustically soft, and water acoustically hard. Ground effect was based on a weighted average over the propagation path. The L_{Amax} contours for the Starship landing at LC-39A are shown in Figures 16 and 17 (zoomed in). Similarly, the SEL contours for the Starship landing at LC-39A are shown in Figures 18 and 19 (zoomed in). The landing pad location at LC-39A and landing trajectory are indicated in the map legends as are the CCAFS and KSC properties. In Figures 16 and 17 the 90 dB L_{Amax} contour stays within the CCAFs and KSC properties although residents of Titusville may notice levels between 70 and 80 dB L_{Amax}. Parts of Titusville, Merritt Island, and Cape Canaveral may be exposed to SELs higher than 100 dB. Compared with the Starship launch noise levels presented in Section 5, Starship landing noise levels are considerably lower reflecting the much lower total engine thrust used for landing operations.

Figure 20 shows the estimated Day-Night Average Sound Level (DNL) contours for a projected 24 annual Starship landing operations at LC-39A (80% daytime and 20% nighttime). The DNL 65 dB contour is located within the CCAFS and KSC properties. Figure 21 shows the estimated Day-Night Average Sound Level (DNL) contours for these same projected 24 landing operations at LZ-1. The DNL 65 dB contour at LZ-1 is located within the CCAFS property.

The next section presents single event and cumulative noise levels for Super Heavy Booster landings on a drone ship.

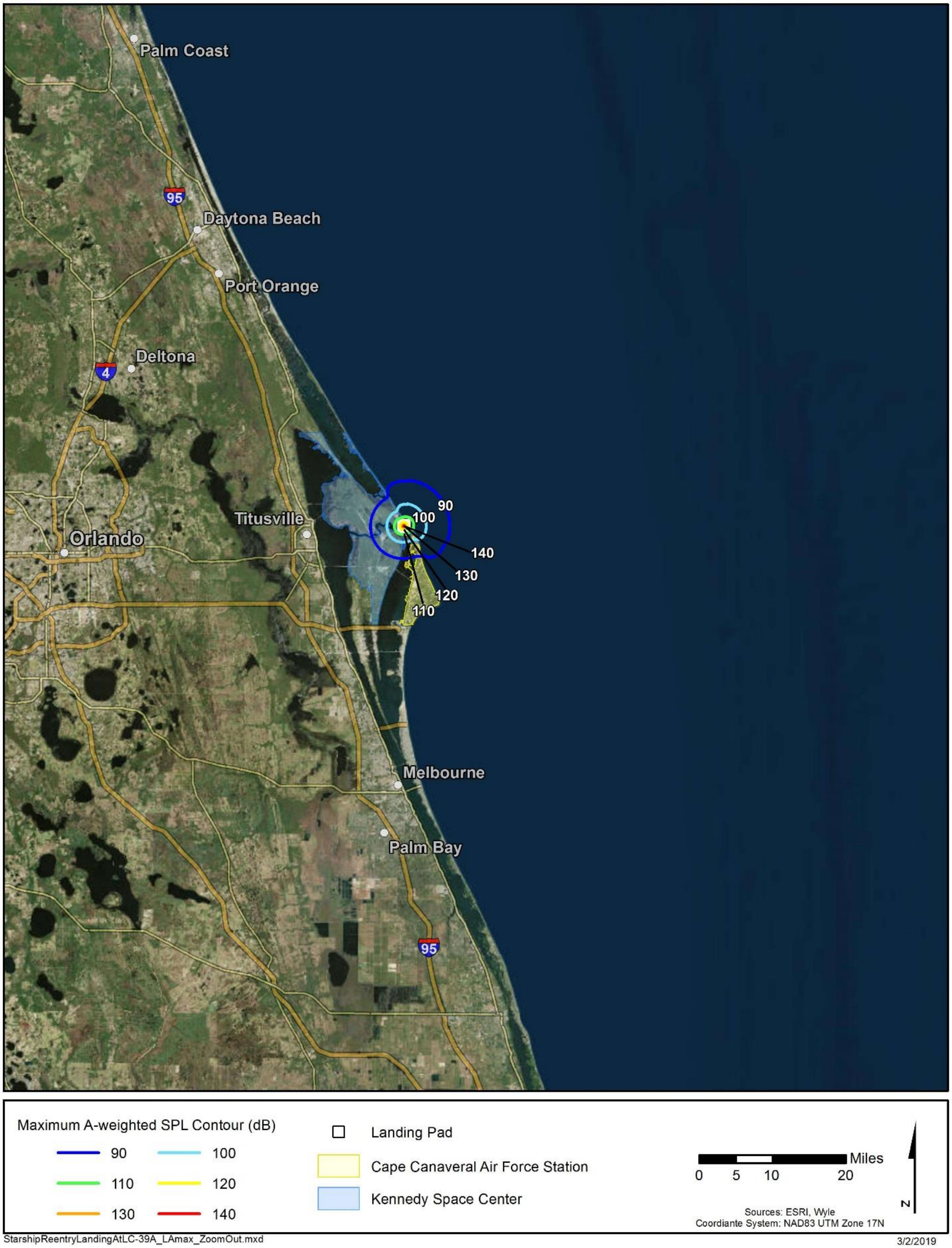

Figure 16. Starship Landing at LC-39A: Maximum A-Weighted Sound Levels

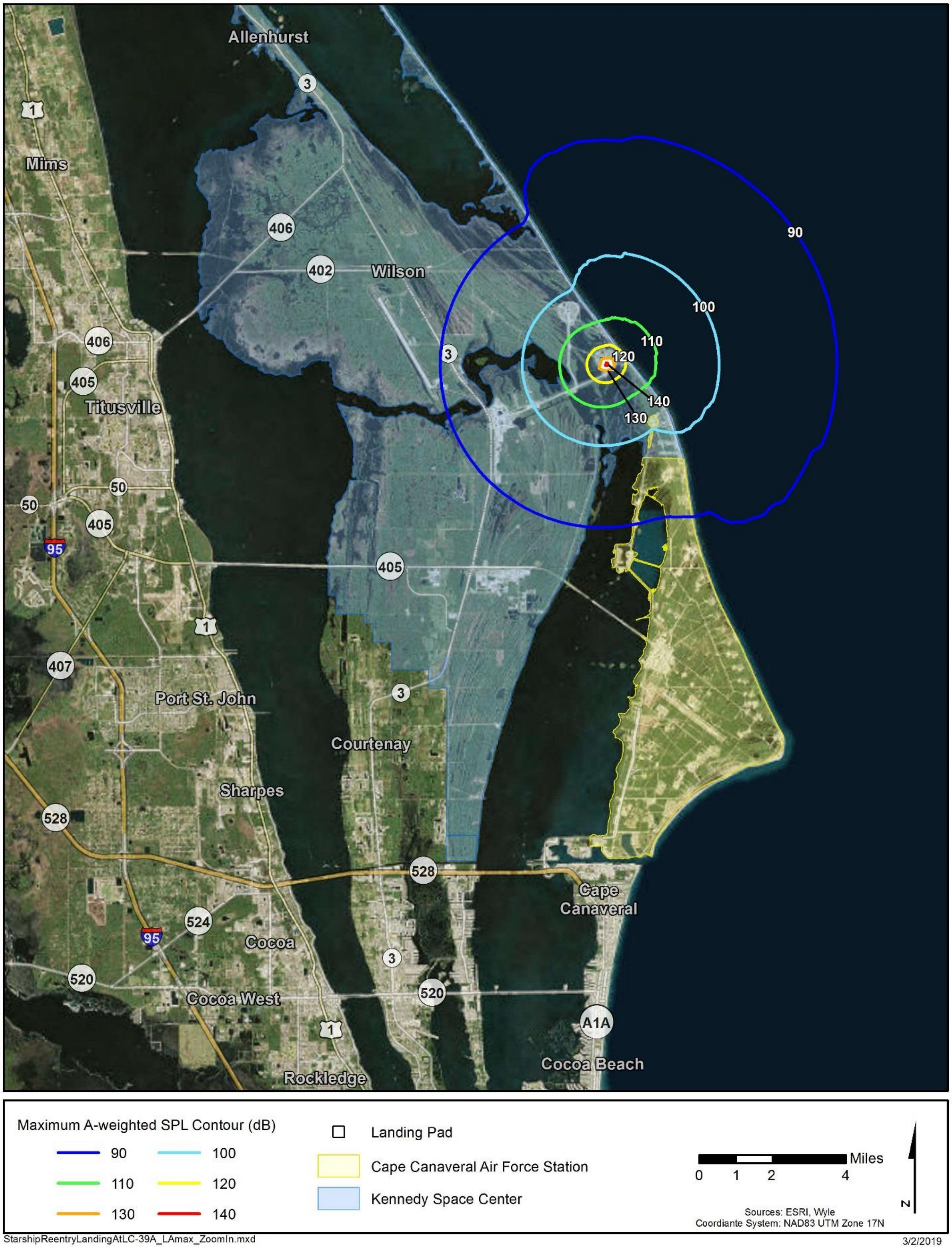

Figure 17. Starship Landing at LC-39A: Maximum A-Weighted Sound Levels (Zoomed in)

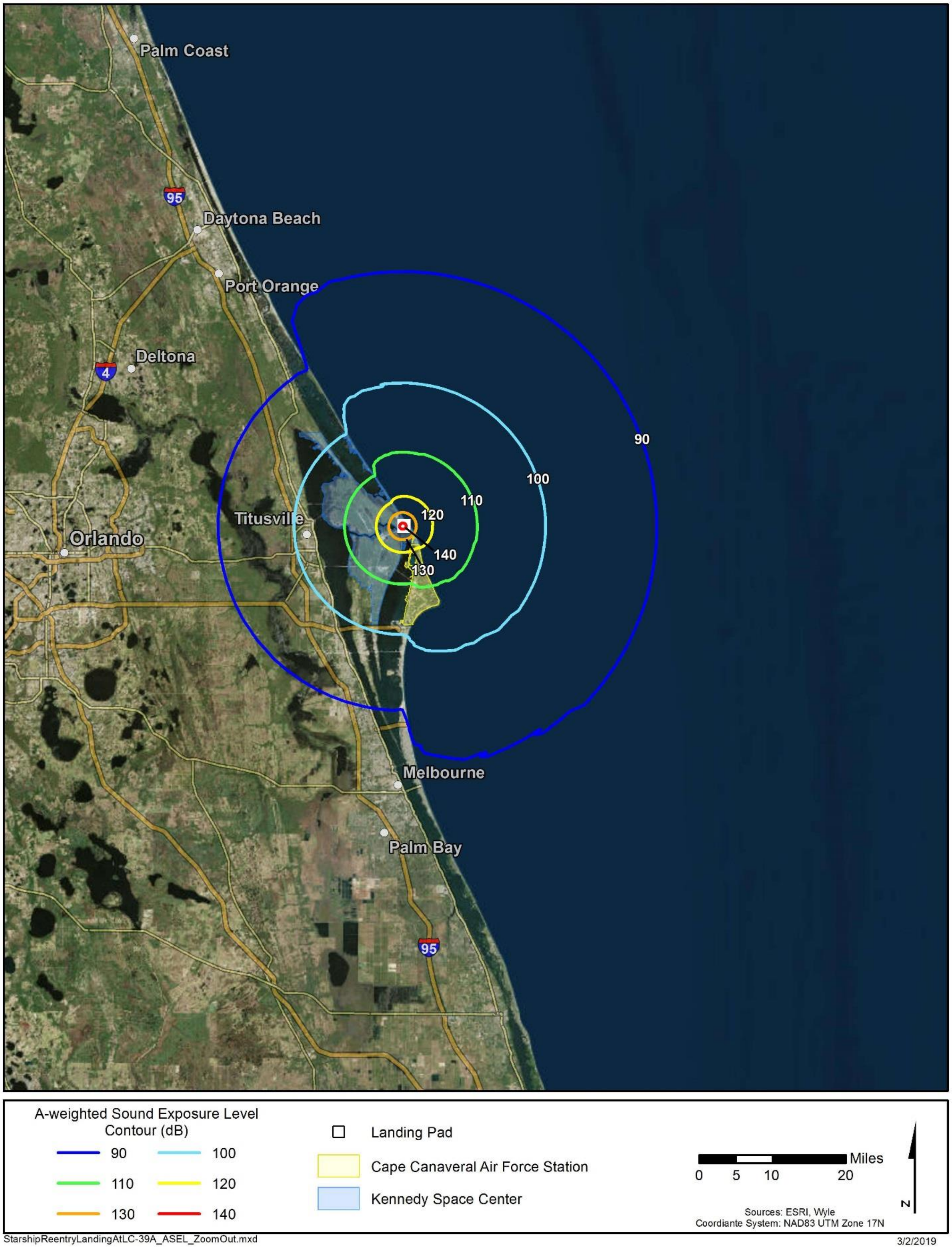

Figure 18. Starship Landing at LC-39A: Sound Exposure Levels

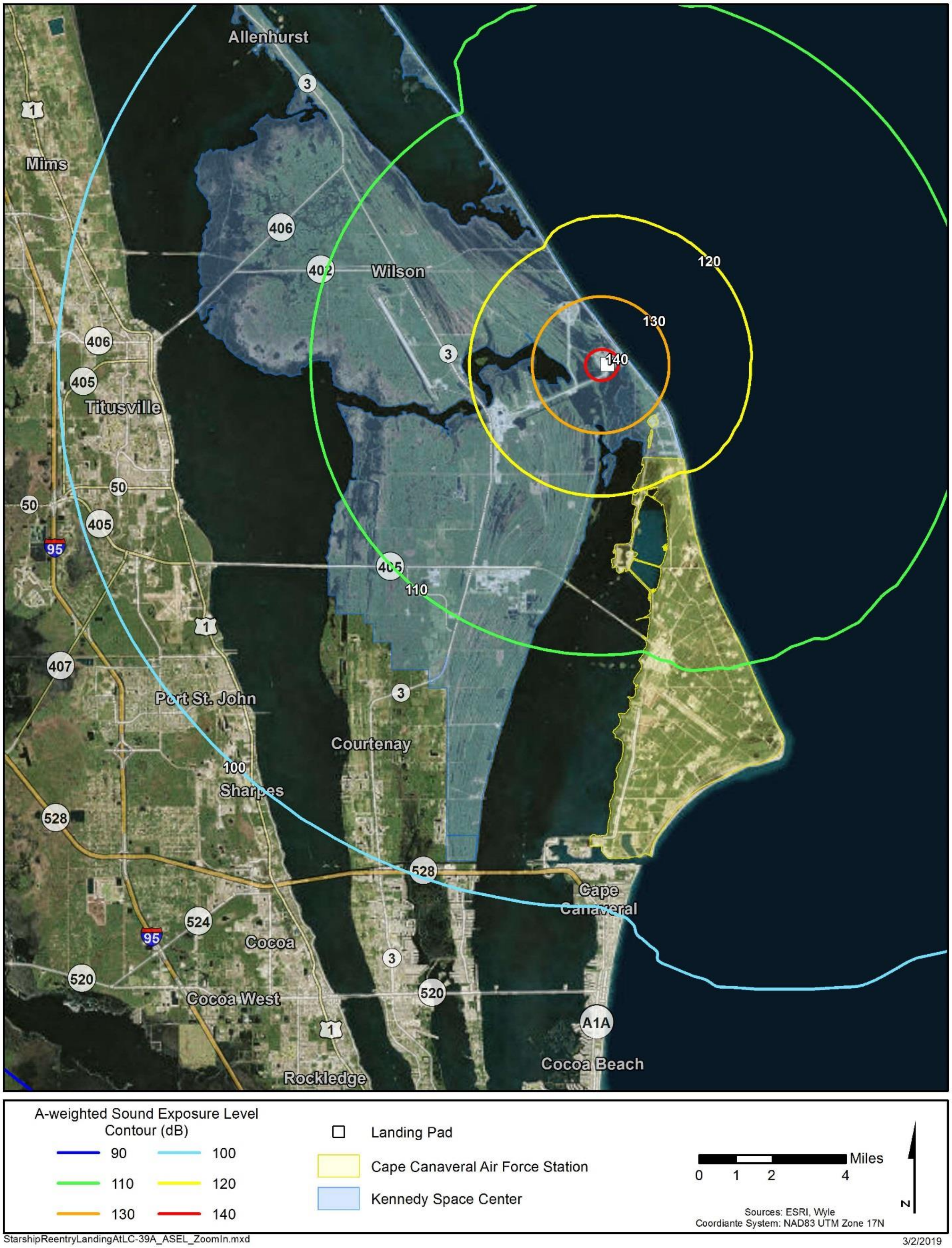

Figure 19. Starship Landing at LC-39A: Sound Exposure Levels (Zoomed in)

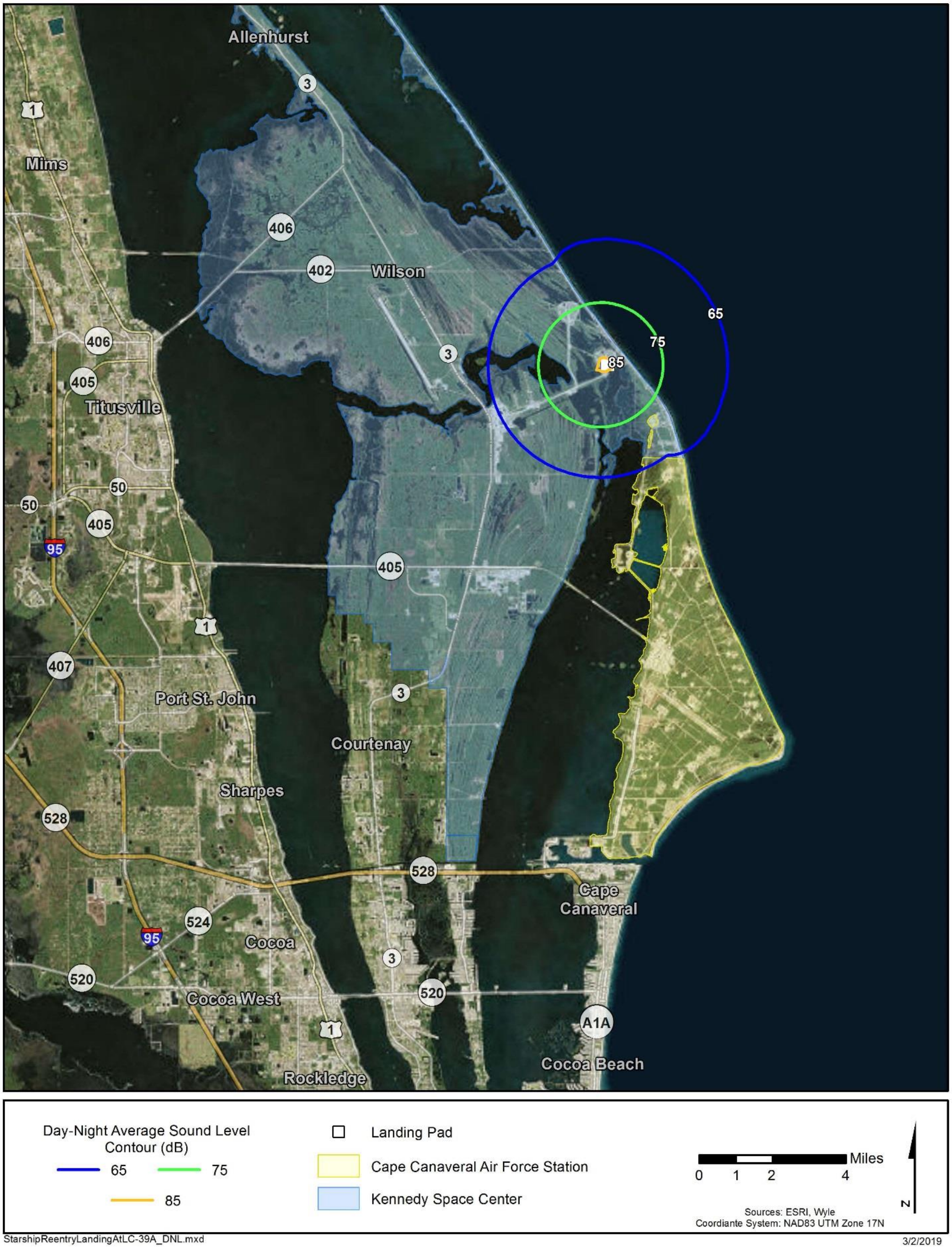

Figure 20. Starship Landing at LC-39A: Day-Night Average Sound Levels

Figure 21. Starship Landing at LZ-1: Day-Night Average Sound Levels

6.2 Super Heavy Booster Landings on a Drone Ship

RNOISE was used to estimate the L_{Amax}, and SEL contours for Super Heavy Booster landings on a drone ship. The Super Heavy Booster descent/landing trajectory was provided by SpaceX in file 'Super_Heavy_LC-39A_90_deg_azxf_LEO_Entry_Landing_80_12.ASC'. L_{Amax} contours indicate the maximum sound level at each location over the duration of the landing where engine thrust varies according to the reentry/descent thrust schedule provided.

RNOISE computations were performed as noted in Section 5.1. Ground areas were considered to be acoustically soft, and water acoustically hard. Ground effect was based on a weighted average over the propagation path. The L_{Amax} contours for the Super Heavy Booster landing on a drone ship are shown in Figure 22 with a zoomed in image of the contours shown in the inset map. Similarly, the SEL contours for the Super Heavy Booster landing on a drone ship are shown in Figure 23 (with zoomed inset map). In both figures, the drone ship location is identified in the main map legend as the landing pad. The maps also show the landing part of the trajectory and the CCAFS and KSC properties. The Super Heavy booster drone ship landings are planned to occur several hundred miles off shore, therefore noise from these events is not expected to be noticed by residents along the coast.

Figure 24 shows the estimated 65, 75, and 85 Day-Night Average Sound Level (DNL) contours for a projected 24 annual Super Heavy Booster drone ship landings (80% daytime and 20% nighttime).

The final section presents the estimated noise levels for Starship and Super Heavy Booster static fire tests conducted at LC-39A.

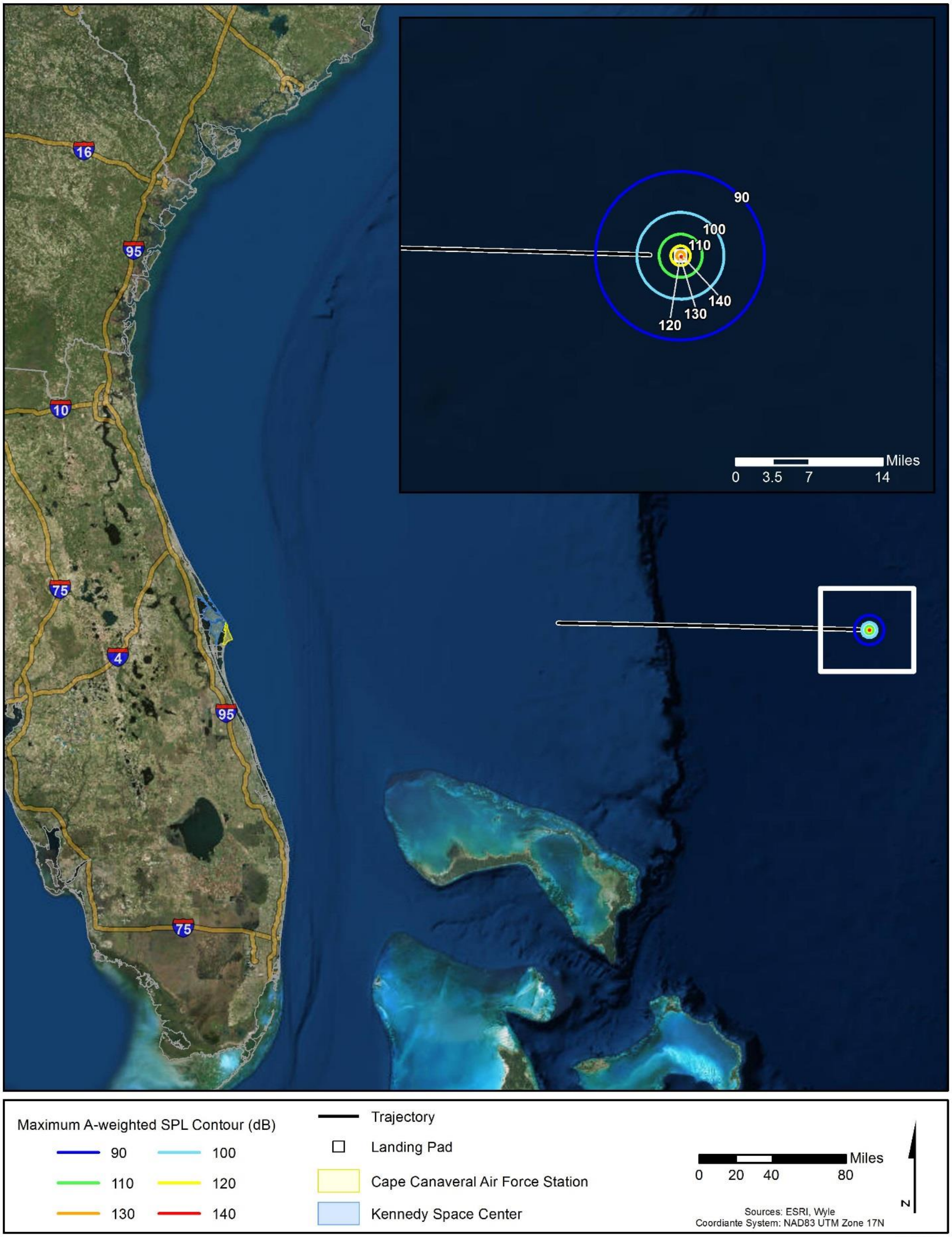

Figure 22. Super Heavy Booster Landing on Drone Ship: Maximum A-Weighted Sound Levels

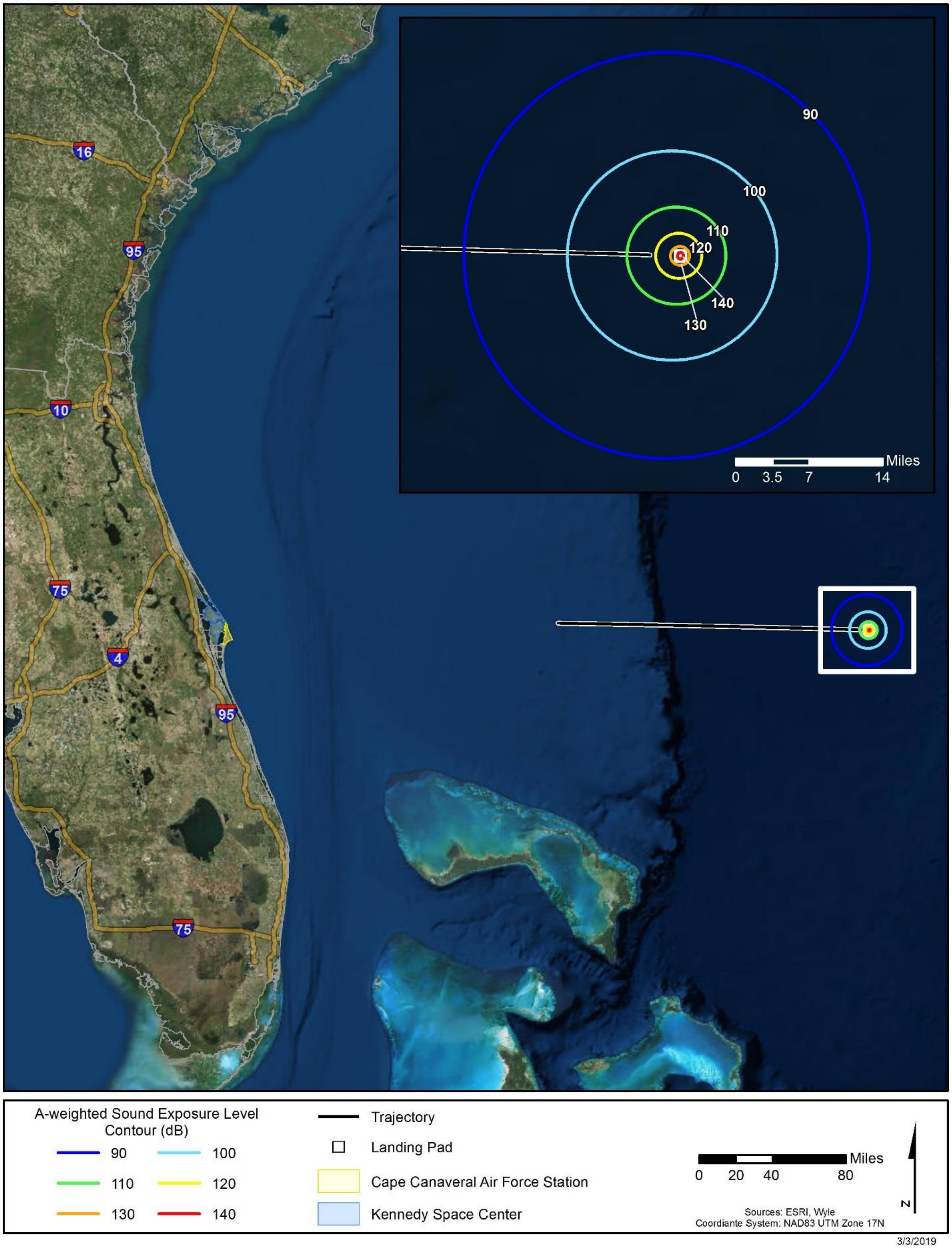

Figure 23. Super Heavy Booster Landing on Drone Ship: Sound Exposure Levels

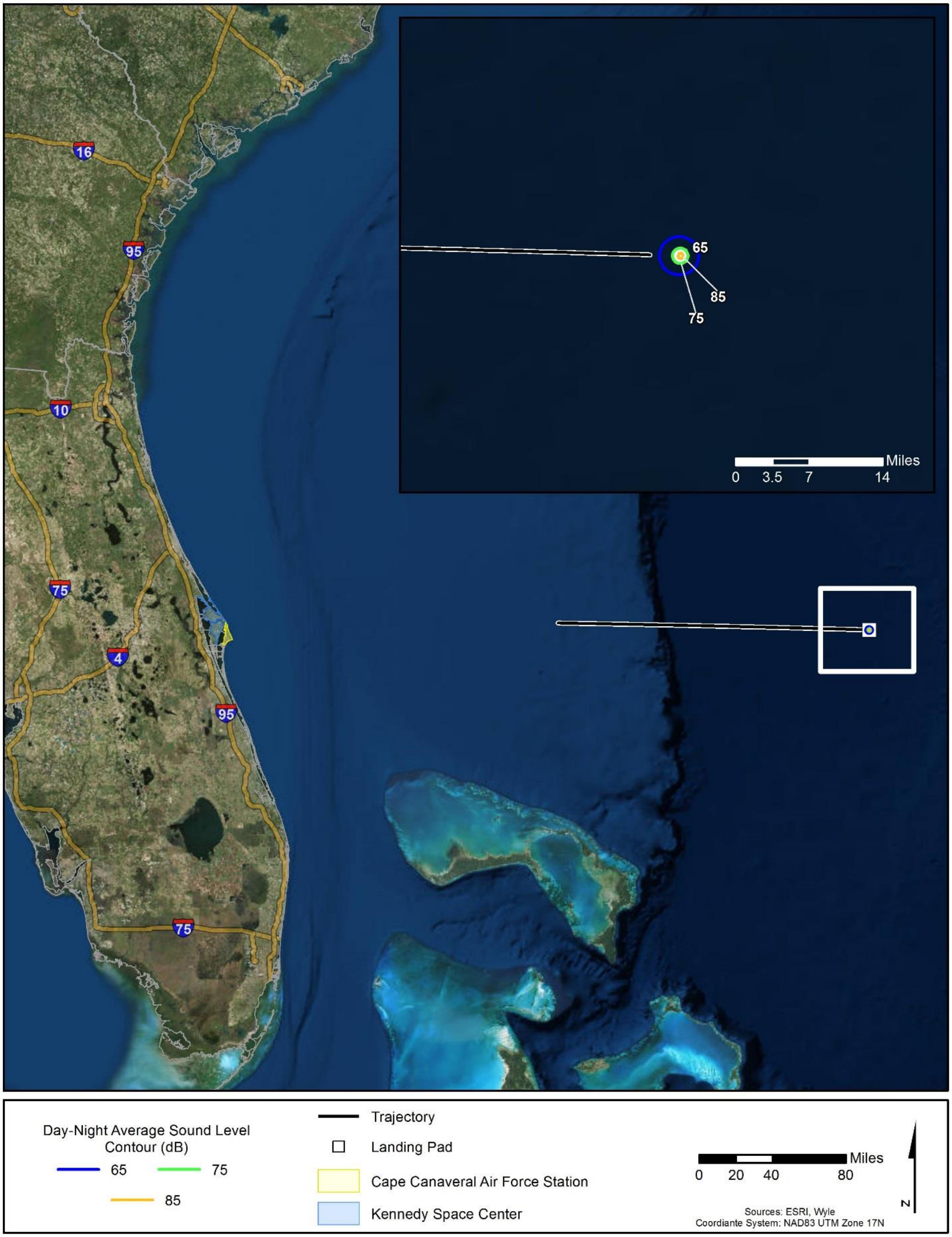

Figure 24. Super Heavy Booster Landing on Drone Ship: Day-Night Average Sound Levels

7 Static Fire Test Noise Levels

7.1 Starship Static Tests at LC-39A

Starship static fire tests are planned to occur at LC-39A where all 7 engines (170 metric tons of thrust per engine) are fired for 15 seconds. Figures 25 and 26 show the estimated L_{Amax} contours and Figures 27 and 28 show the estimated SEL contours for the Starship static fire test at LC-39A. The L_{Amax} and SEL contours (90 dB and above) are entirely contained within the CCAFS and KSC properties. During tests, Maximum A-weighted sound levels above 70 dB may be noticed by residents of Merritt Island. Figure 29 shows the estimated 65, 75, and 85 Day-Night Average Sound Level (DNL) contours for a projected 24 annual Starship static fire tests at LC-39A (90% daytime and 10% nighttime).

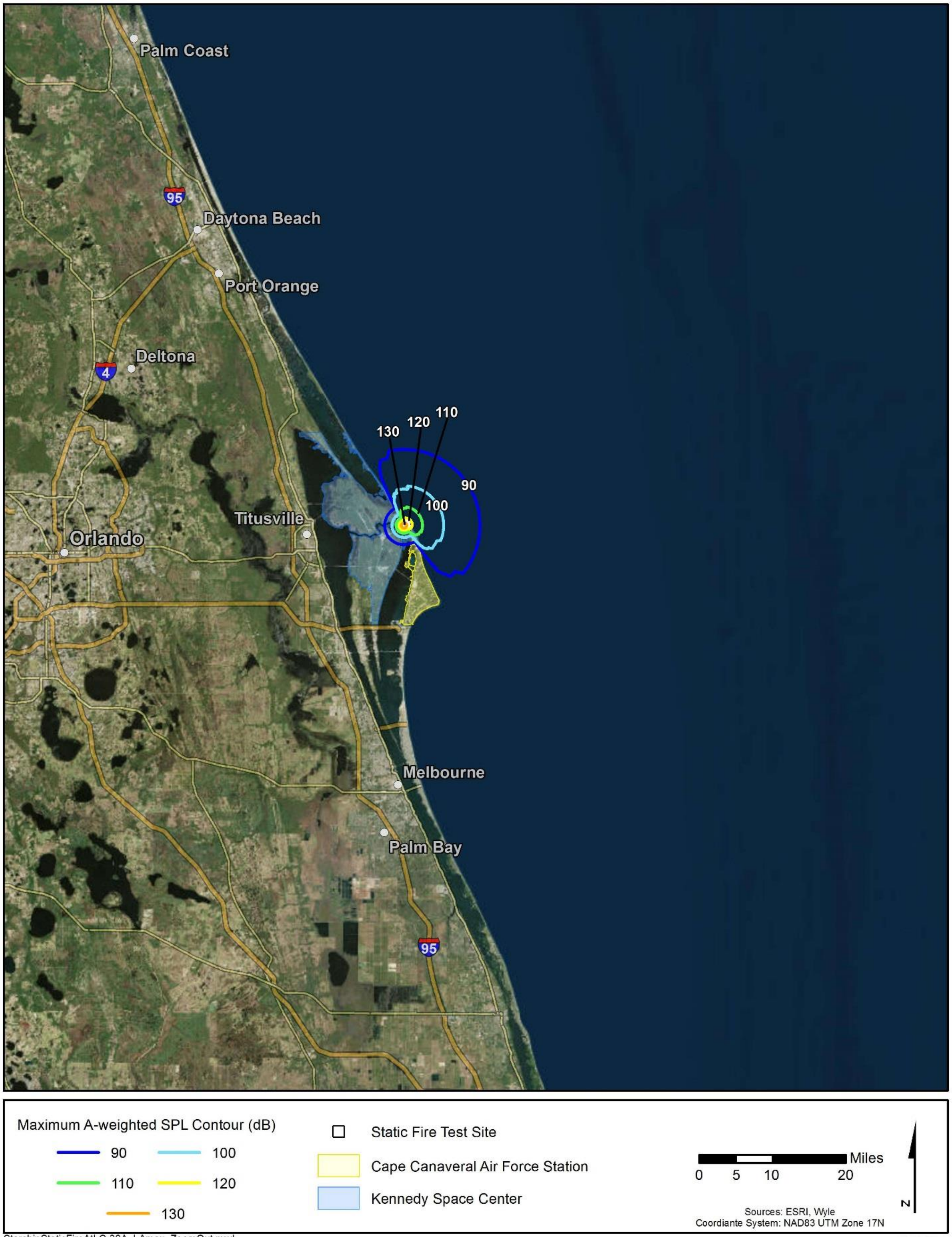

Figure 25. Starship Static Fire Test at LC-39A: Maximum A-Weighted Sound Levels

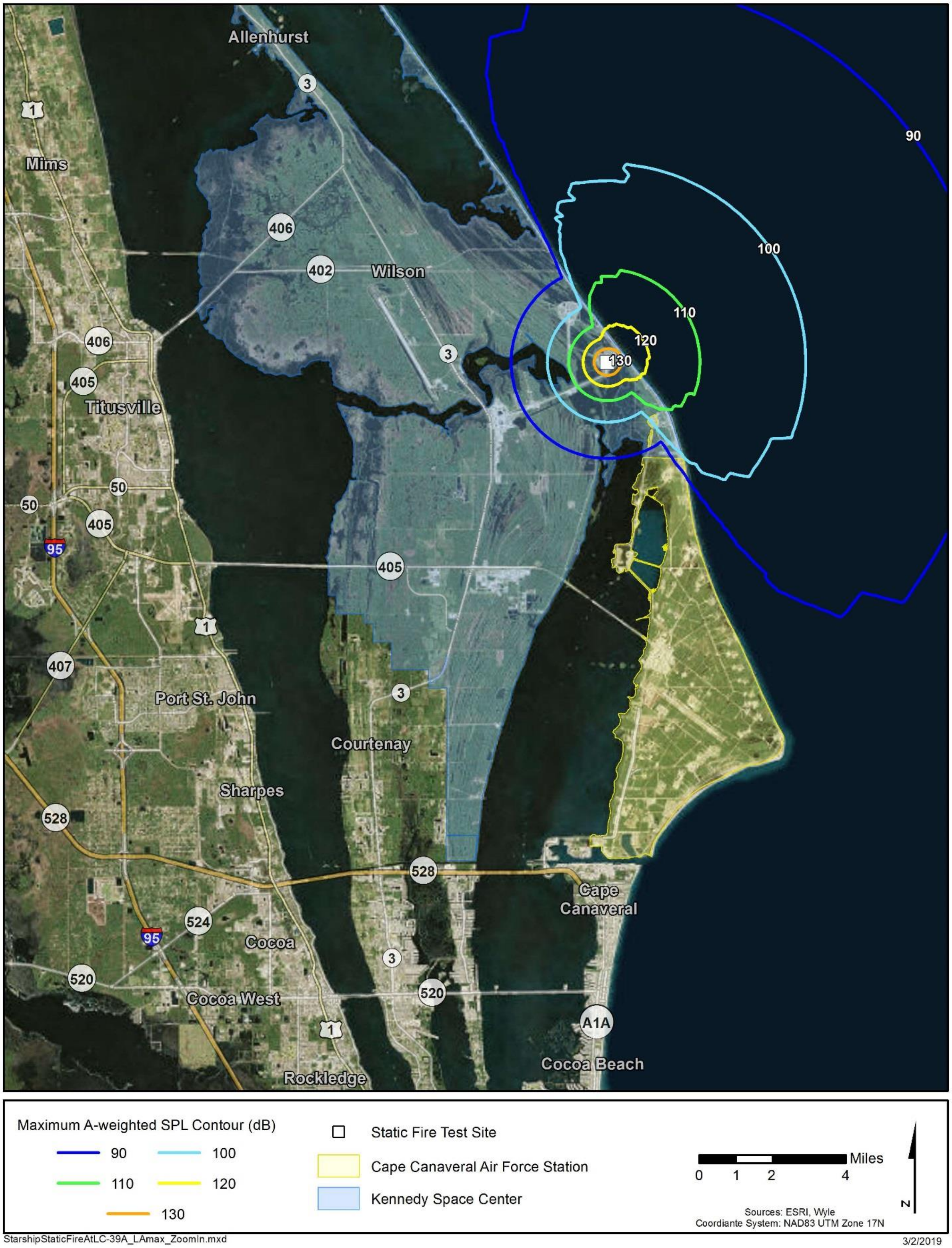

Figure 26. Starship Static Fire Test at LC-39A: Maximum A-Weighted Sound Levels (Zoomed in)

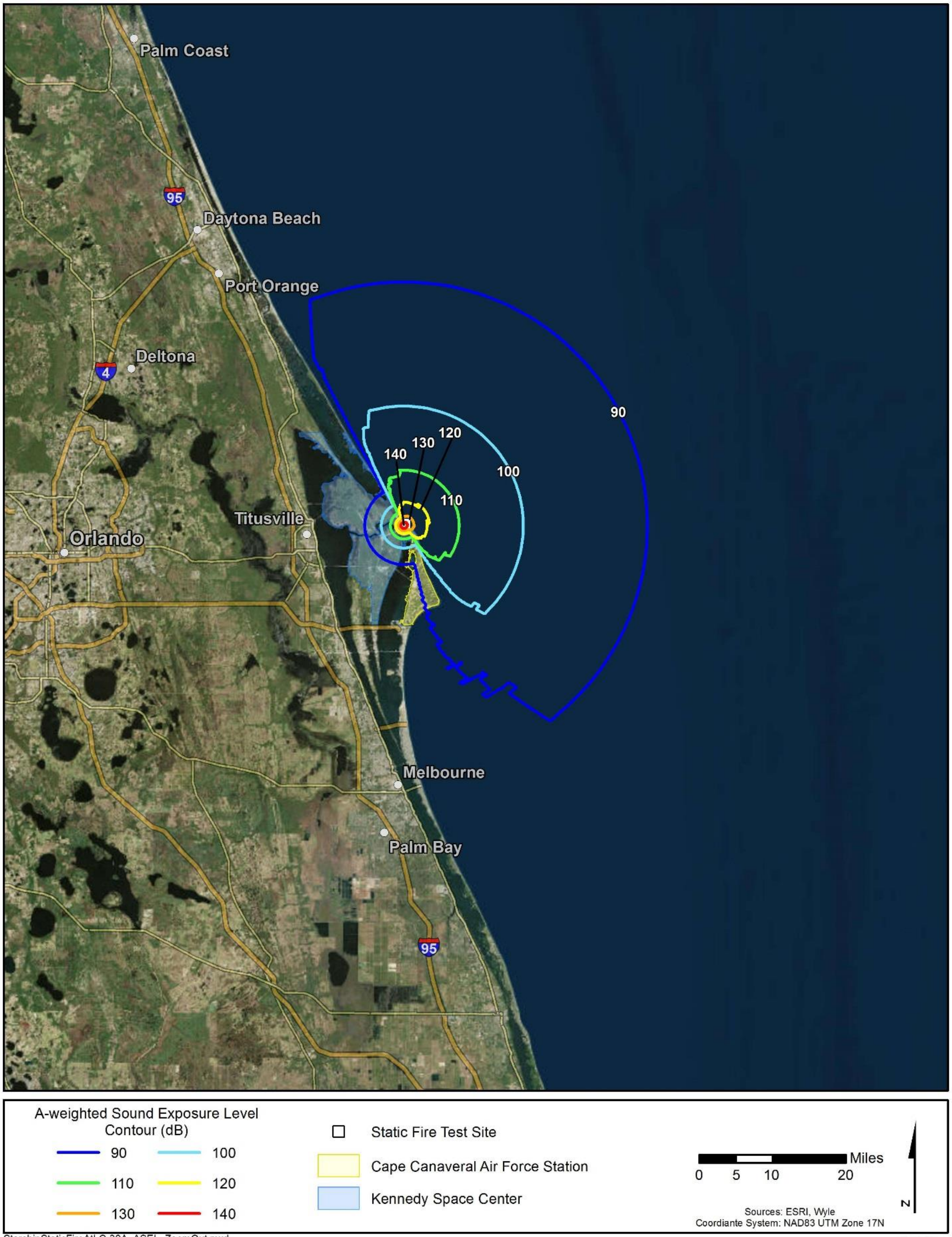

Figure 27. Starship Static Fire Test at LC-39A: Sound Exposure Levels

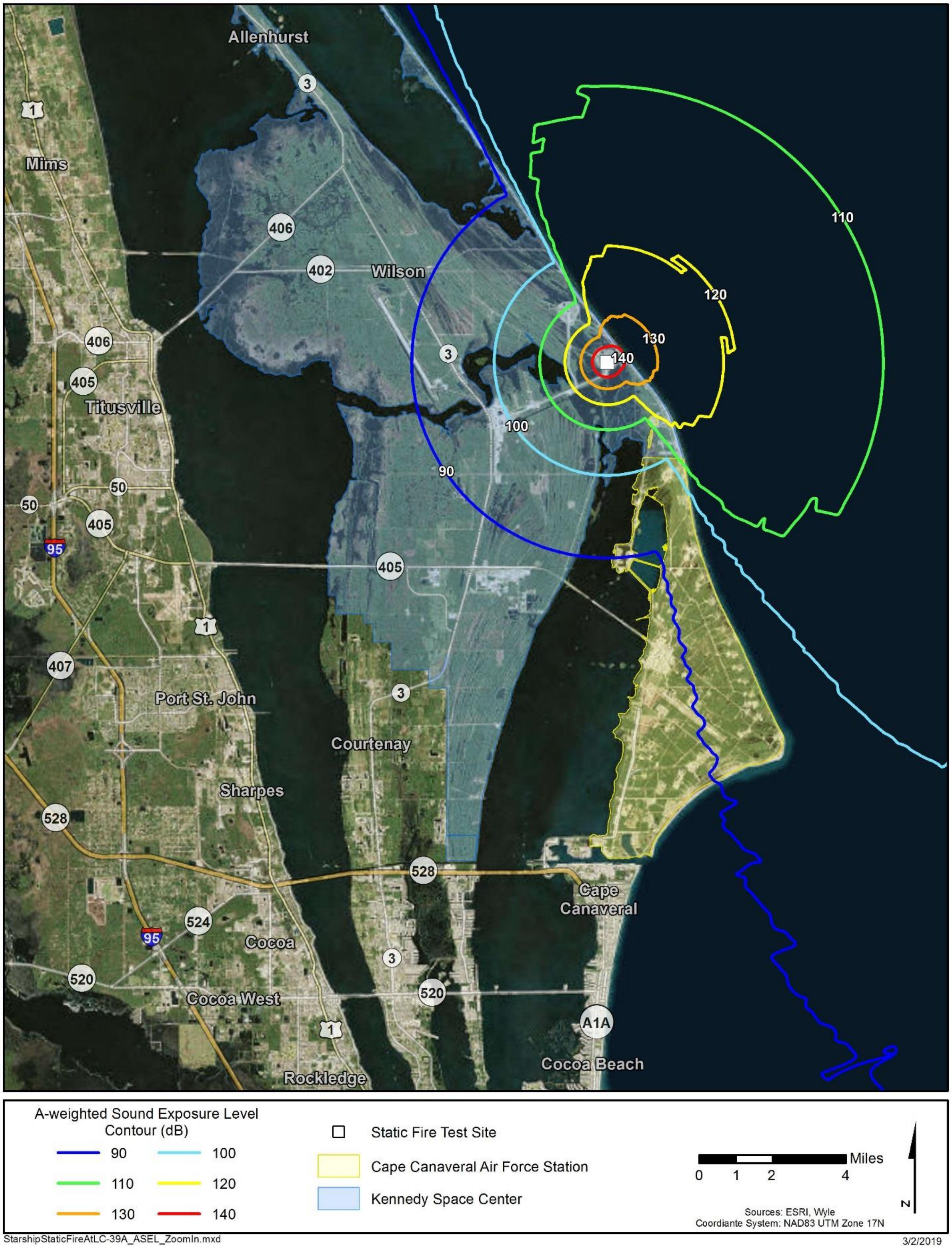

Figure 28. Starship Static Fire Test at LC-39A: Sound Exposure Levels (Zoomed in)

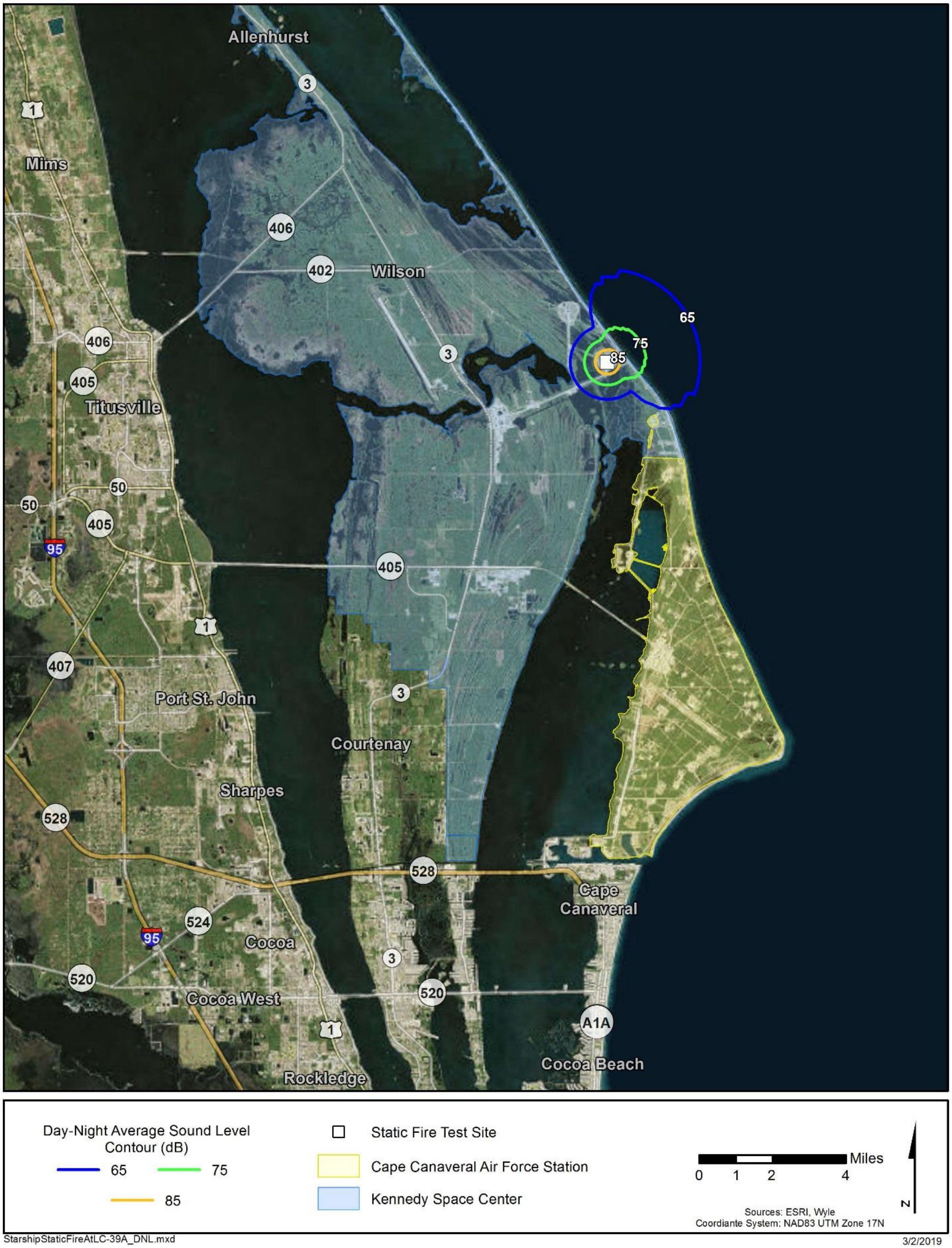

Figure 29. Starship Static Fire Test at LC-39A: Day-Night Average Sound Levels

7.2 Super Heavy Booster Static Tests at LC-39A

Super Heavy Booster static fire tests are planned to occur at LC-39A where all 31 engines (170 metric tons of thrust per engine) are fired for 15 seconds. Figures 30 and 31 show the estimated L_{Amax} contours and Figures 32 and 33 show the estimated SEL contours for the Super Heavy Booster static fire test at LC-39A. The L_{Amax} and SEL contours (90 dB and above) are entirely contained within the CCAFS and KSC properties. During tests, maximum A-weighted sound levels above 70 dB are likely to be noticed by residents of Merritt Island and possibly by residents of Titusville. Figure 34 shows the estimated 65, 75, 85, and 95 Day-Night Average Sound Level (DNL) contours for a projected 24 annual Super Heavy Booster static fire tests at LC-39A (90% daytime and 10% nighttime).

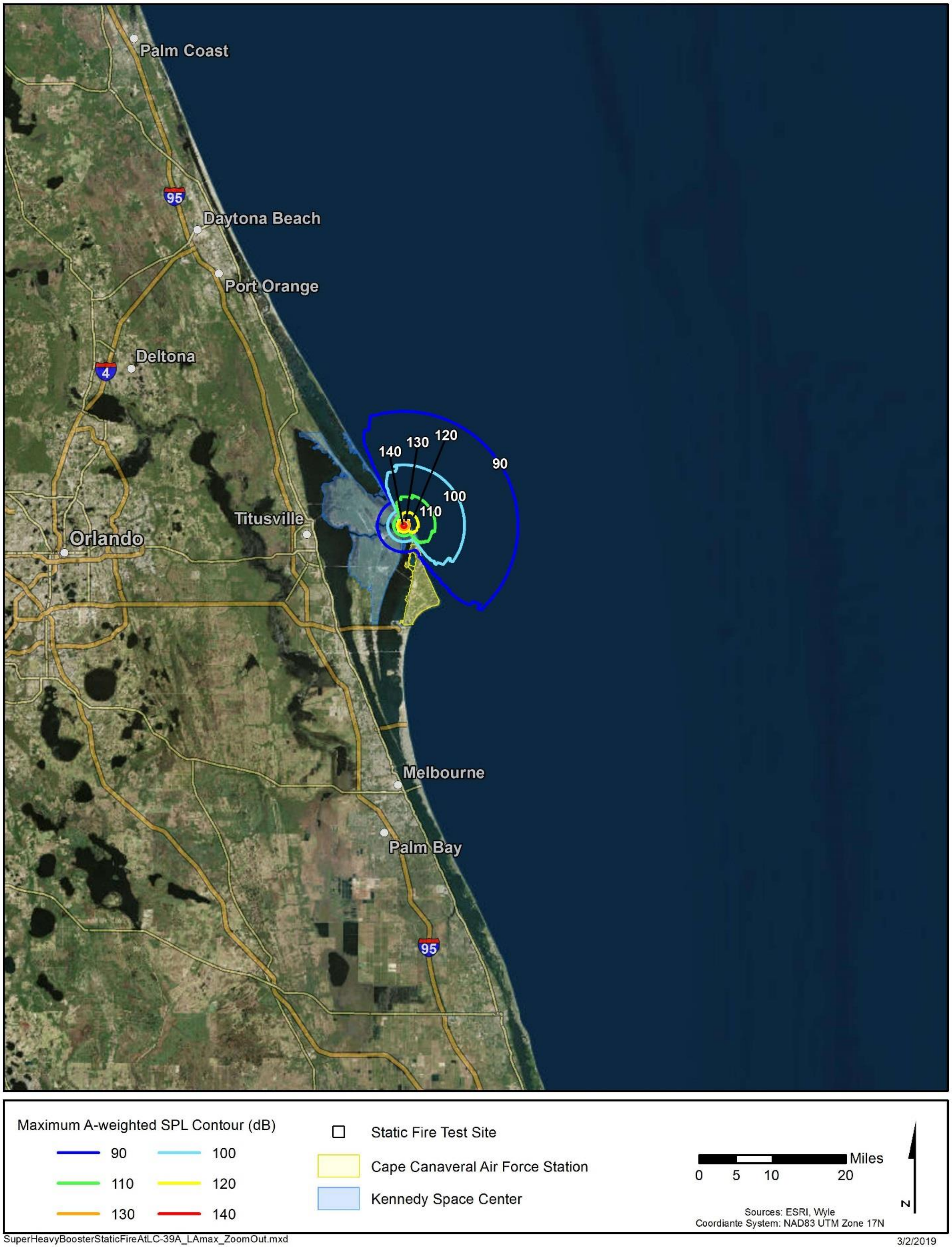

Figure 30. Super Heavy Booster Static Fire Test at LC-39A: Maximum A-Weighted Sound Levels

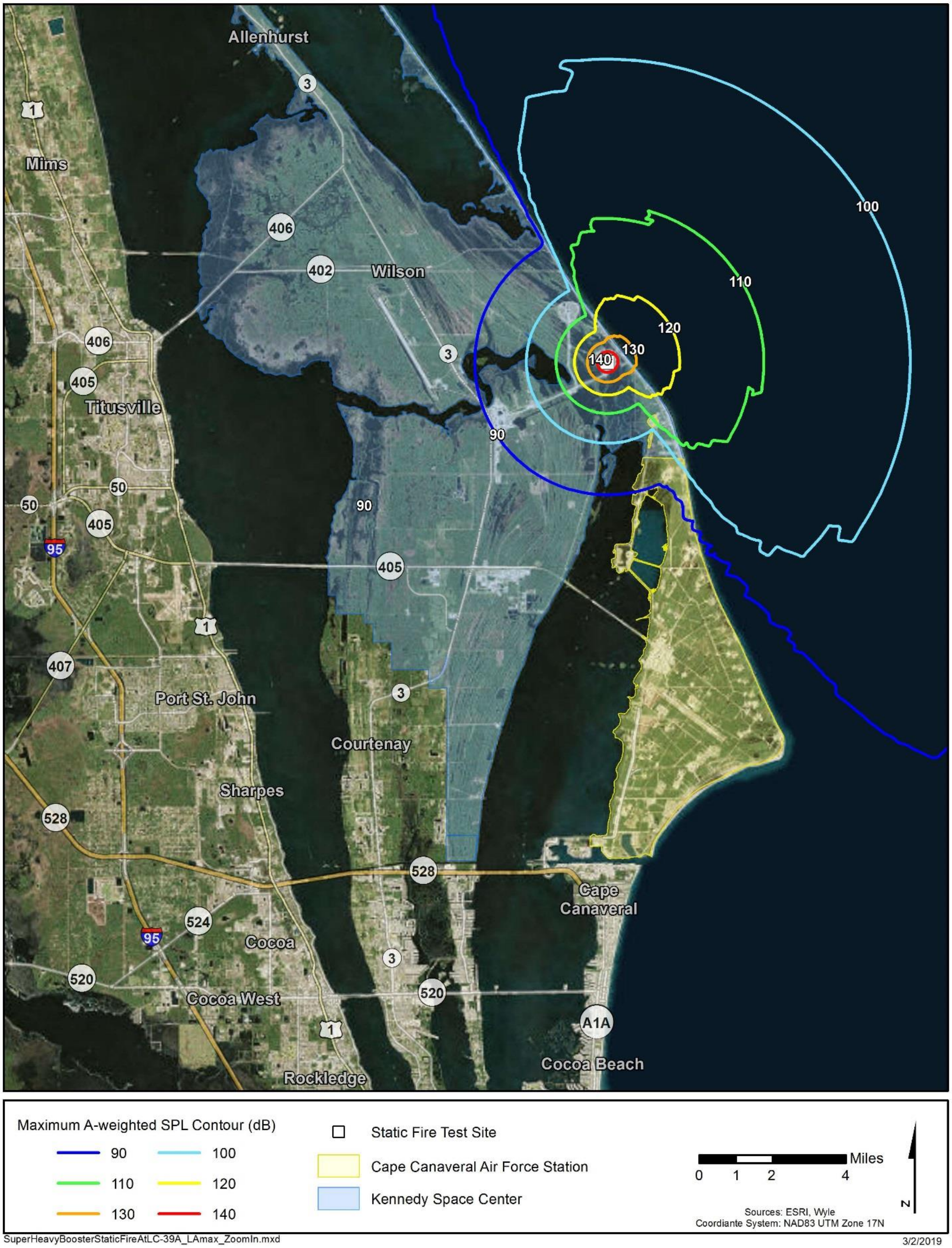

Figure 31. Super Heavy Booster Static Fire Test at LC-39A: Maximum A-Weighted Sound Levels (Zoomed in)

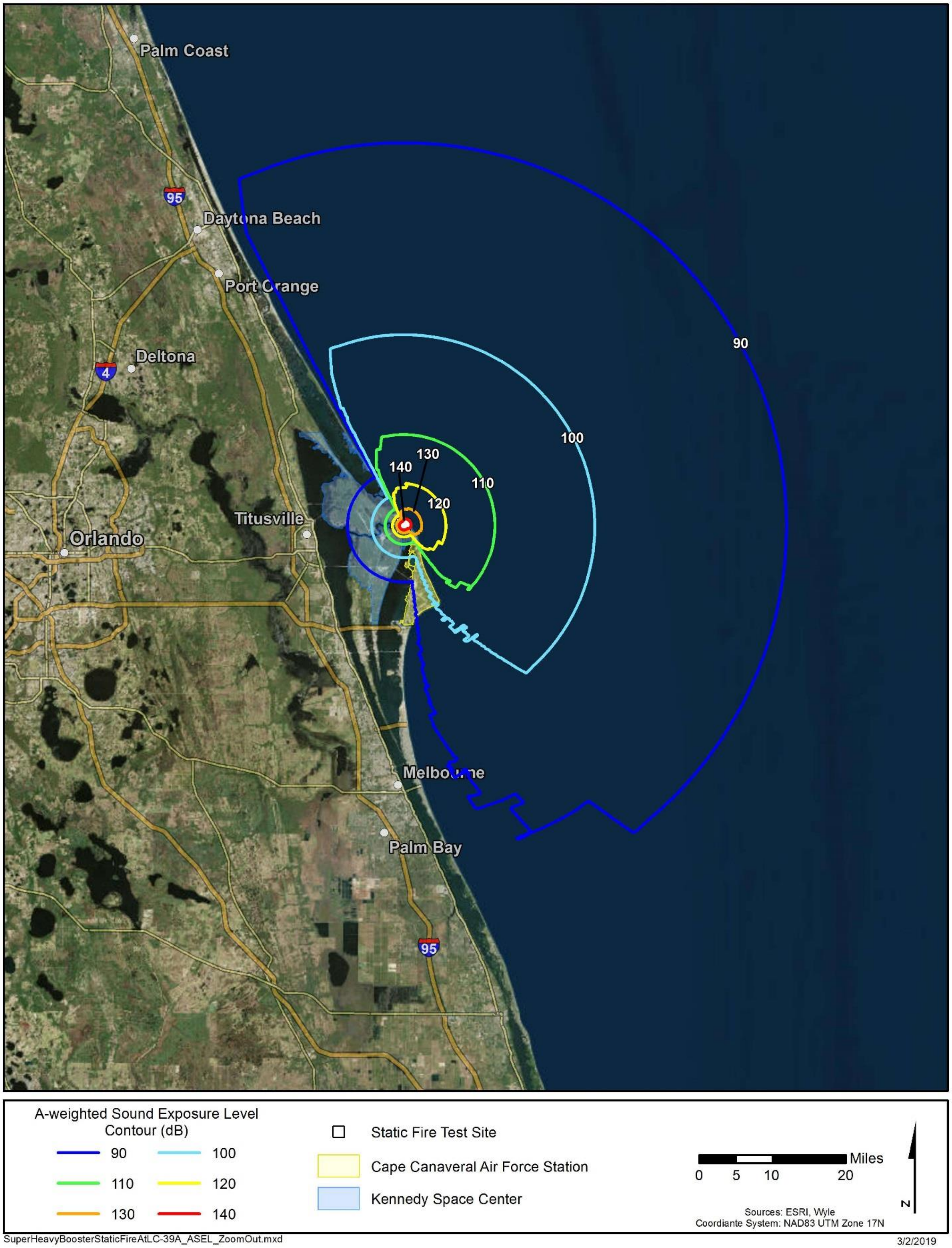

Figure 32. Super Heavy Booster Static Fire Test at LC-39A: Sound Exposure Levels

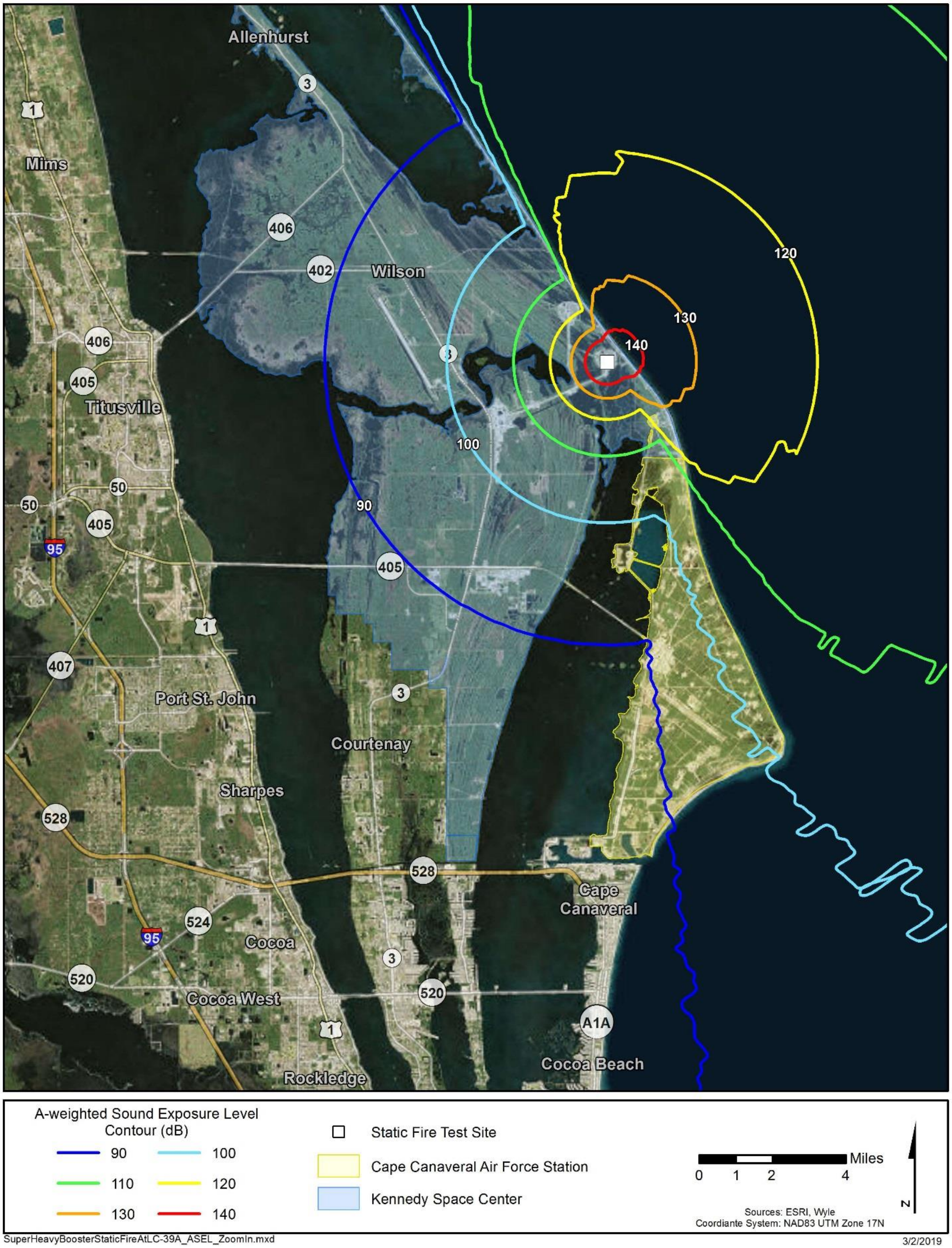

Figure 33. Super Heavy Booster Static Fire Test at LC-39A: Sound Exposure Levels (Zoomed in)

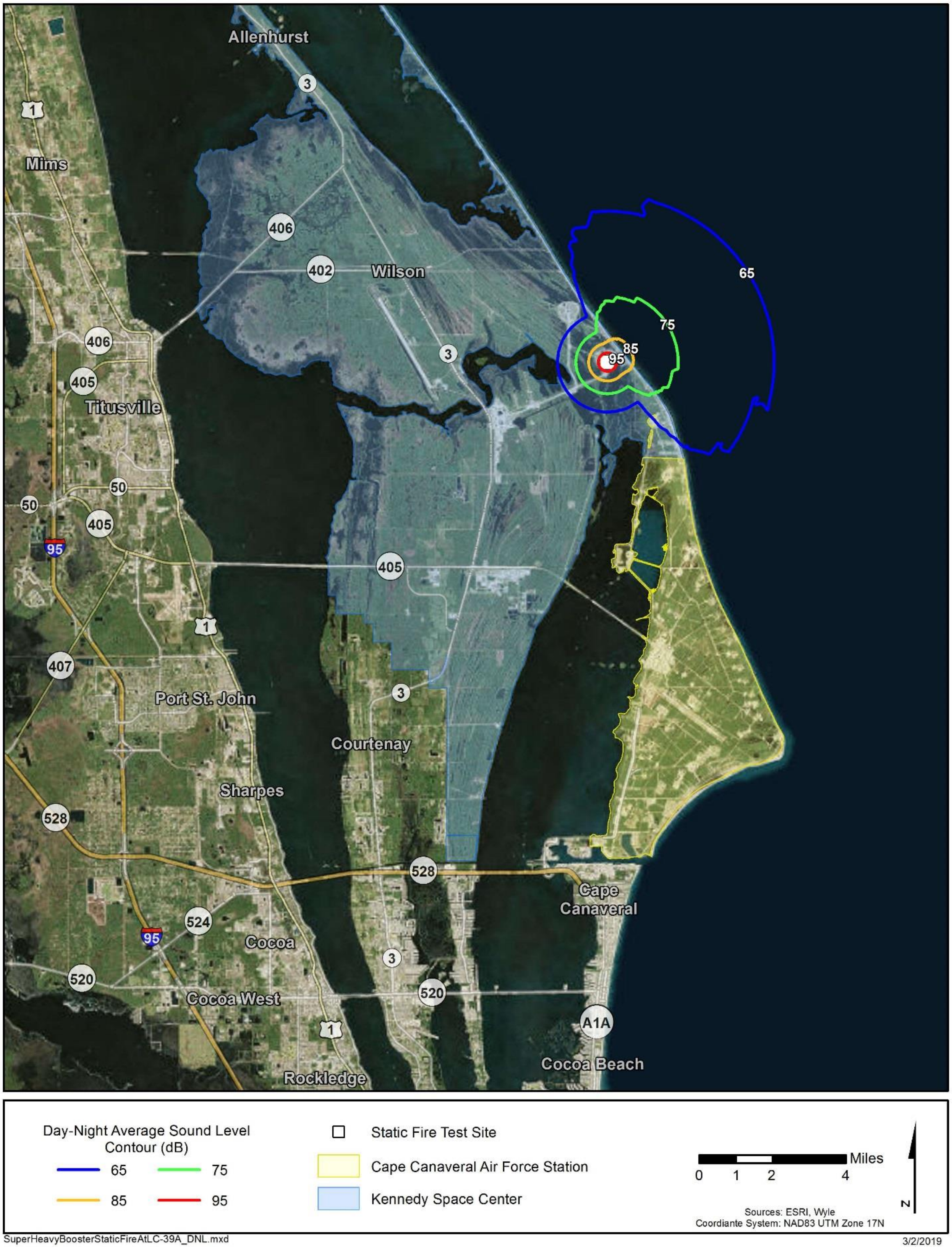

Figure 34. Super Heavy Booster Static Fire Test at LC-39A: Day-Night Average Sound Levels

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Sierra Engineering & Software, Inc.

ANALYSIS REPORT

NUMBER: 2019-001b

DATE: 18 June 2019

SUBJECT: Exhaust Plume Calculations for SpaceX Raptor Booster Engine

NO. OF APPEN. 0

PREPARED FOR: Katy Smith, SpaceX **(W.O. 6017)**

DISTRIBUTION:

1.0 SUMMARY

Calculations were performed to estimate the far-field exhaust constituents of the SpaceX Raptor liquid oxygen-liquid methane (LOX-LCH4) booster rocket engine firing under sea-level conditions. Although the exit-plane exhaust is fuel-rich and contains high concentrations of carbon monoxide (CO), subsequent entrainment of ambient air results in nearly complete conversion of the CO into carbon dioxide (CO_2). A small amount of thermal nitrous oxides (NOx) is formed, all as NO. The CO and NO emissions are predicted to be less than 0.024 lb_m/s each, per engine under nominal power (100%) operation. No soot is predicted to be generated by this engine cycle. The CO and NO emission rates for the Super Heavy has been estimated to be no more 0.788 lb_m/s each. The predicted sea-level CO and NO emission rate for the Starship upper stage are estimated to be no more than 0.168 lb_m/s each.

2.0 ENGINE DESCRIPTION

The subject engine is the baseline booster engine for the SpaceX Super Heavy launch vehicle. The baseline Super Heavy stage includes 31 Raptor engines. The propellants are liquid oxygen (LOX) and liquid methane (LCH4). The subject engine uses a closed power cycle with a 34.34:1 regeneratively-cooled thrust chamber nozzle. As a simplification needed to address the problem with the existing axisymmetric analysis tools, the computational nozzle exit plane. Characteristic dimensions of the thrust chamber nozzle are included in Table 1.

The nominal operating condition for the Raptor engine is an injector face stagnation pressure (Pc) of 3669.5 psia and a somewhat fuel-rich engine O/F mixture ratio (MR) of 3.60. The current analysis was performed for the 100% nominal engine operating pressure (Pc=3669.5 psia) and an engine MR of 3.60.

Table 1: Raptor Nozzle Characteristics

Throat Radius (in)	4.362
Downstream radius of curvature (in)	1.309
Tangency angle (deg)	32.0
Nozzle lip exit angle (deg)	6.0
Nozzle exit diameter (in)	51.226
Nozzle throat to exit length (in)	60.06

3.0 ANALYSIS APPROACH

A series of simulations were required to estimate the emissions from the Raptor engine. The PERCORP analysis model[1] was used to estimate the O/F mixture ratio variations that exist within the Raptor thrust chamber. The VIPER parabolized Navier-Stokes model[2] was used to kinetically expand the thrust chamber exhaust to the nozzle exit plane. The VIPER results were used to assess the validity of the PERCORP solution, correlating engine thrust, mass flow rate and specific impulse (ISP) to test results. PERCORP input parameters were adjusted until there was good agreement between the VIPER performance predictions and the test results. The SPF code[3] was used to predict the flow structure of the free exhaust plume and the entrainment of ambient air. VIPER solution was used as the starting condition for the SPF. Though the SPF code can handle detailed chemical kinetics within the plume evolving flow field, the strong barrel shock downstream of the nozzle exit produces numerical convergence problems with the version of SPF used. The present SPF simulations were performed without chemical kinetics. The results were air entrainment and gas temperature profiles. The SPF and VIPER results were used as inputs for one-dimensional kinetic modelling of the plume flow field. The kinetic model in the TDK code[4] was used to model chemical reactions within the evolving plume flow field.

TDK modelling of the plume flow field included chemical mechanism that address a) the oxidation of CO to CO_2, b) the complex oxidation of hydrocarbons to H_2O and CO_2, and c) the thermal generation of NOx in a mixture of air and combustion products. Table 2 includes the chemical reactions and rates used in the TDK simulation.

Table 2: Kinetic Reactions Included in One Dimensional Chemistry Simulations*

	A	N	B
H + H + m = H2 + m†	6.4E17	1.0	0.0
H + OH + m = H2O + m	8.4E21	2.0	0.0
O + O + m = O2 + m	1.9E13	0.0	-1.79
CO + O + m = CO2 + m	1.0E14	0.0	0.0
O + H + m = OH + m	3.62E18	1.0	0.0
CH4 + m = CH3 + H + m	1.259E17	0	88.4
HCO + m = CO + H + m	5.012E14	0	19.0
C2H3 + m = C2H2 + H + m	7.943E14	0	31.5
N+NO = N2+O	2.700E13	0	0.355
N+O2 = NO+O	9.000E9	-1.0	6.5
N+OH = NO+H	3.360E13	0	0.385
HO2+NO = NO2+OH	2.110E12	0	-0.480
NO2+O = NO+O2	3.900E12	0	-0.240
NO2+H = NO+OH	1.320E14	0	0.360
O2 + H = O + OH	2.2E14	0.0	16.8
H2 + O = H + OH	1.8E10	-1.	8.9
H2 + OH = H2O + H	2.2E13	0.0	5.15
OH + OH = H2O + O	6.3E12	0.0	1.09
CO + OH = CO2 + H	1.5E7	-1.3	-.765
CO + O = CO2	2.5E6	0.0	3.18
CO2 + O = CO + O2	1.7E13	0.0	52.7
CH4+ OH = CH3 + H2O	3.162E13	0	6.0
H + CH4 = CH3 + H2	6.310E14	0	15.1
O + CH4 = CH3 + OH	3.981E14	0	14.0
CH3 + O = CH2O + H	1.259E14	0	2.0
CH3 + OH = CH2O + H2	3.981E12	0	0
C2H2 + OH = C2H + H2O	6.310E12	0	7.0
H + CH2O = HCO + H2	3.162E14	0	10.5
O + CH2O = HCO + OH	1.995E13	0	3.1

* TDK reaction format is k=AT**(-N)*EXP(-1000B/RT) [cc-Kcal-K-mole-s]

† m is any molecule for a third body reaction

Table 2: Kinetic Reactions Included in One Dimensional Chemistry Simulations (ctd)

	A	N	B
OH + CH2O = HCO + H2O	7.943E12	0	0.2
H + HCO = CO + H2	1.995E14	0	0
OH + HCO = CO + H2O	1.000E14	0	0
H + C2H2 = C2H + H2	1.995E14	0	19.0
O + C2H2 = CH2 + CO	5.012E13	0	3.7
C2H + O2 = HCO + CO	1.000E13	0	7.0
CH2 + O2 = HCO + OH	1.000E14	0	3.7
H + C2H4 = C2H3 + H2	1.000E14	0	8.5
C2H2 + H = C2H3	5.500E12	0	2.39
H + C3H6 = C2H4 + CH3	3.981E12	0	0

4.0 ANALYSIS RESULTS

The PERCORP modelling of the Raptor thrust chamber included 1.2% of the total engine flow (13.89 lb/s) as film coolant. Fuel-rich gas, used fuel film coolant, is injected through three slots located in the converging section of the thrust chamber. The PERCORP code is not currently capable of treating three discreet injection slots; however, since the slots are all within just a 0.71-inch axial length, the total film cooling effect on the exhaust plume can be reasonably approximated using just a single. The PERCORP solution for the nominal 349. 6 lbf-s/lb_m engine specific impulse includes a 2.3% core mixing loss, yielding a characteristic velocity (C*) efficiency of 98.6%. The PERCORP results included initial boundary conditions for the VIPER nozzle flow field simulation. The predicted thrust chamber nozzle exit species mass fractions from VIPER are listed in Table 3.

The SPF modelling stepped to 100 nozzle exit radii (Rexit = 25.613 inches, 2.134 ft). Predicted plume contours for temperature and mass fractions of N_2 and CO are presented in Figure 1 through Figure 3. Since there plume entrainment and mixing field is simulated for chemically frozen flow, the N_2 contours are representative of the air entrainment, while the CO contour indicates a key product of incomplete combustion.

Table 3: Thrust Chamber Nozzle Exit Species Mass Fraction from VIPER Simulation

Species	Mass Fraction
CO2	0.39950
H2O	0.41333
CO	0.12071
O2	0.054752
H2	0.007462
OH	0.0035882
O	5.3558E-04
CH4	7.286E-05
H	5.207E-05

Figure 1: Plume Temperature Contours (degrees K)
R is radius normalized by Rexit, X is axial distance from nozzle exit normalized by Rexit

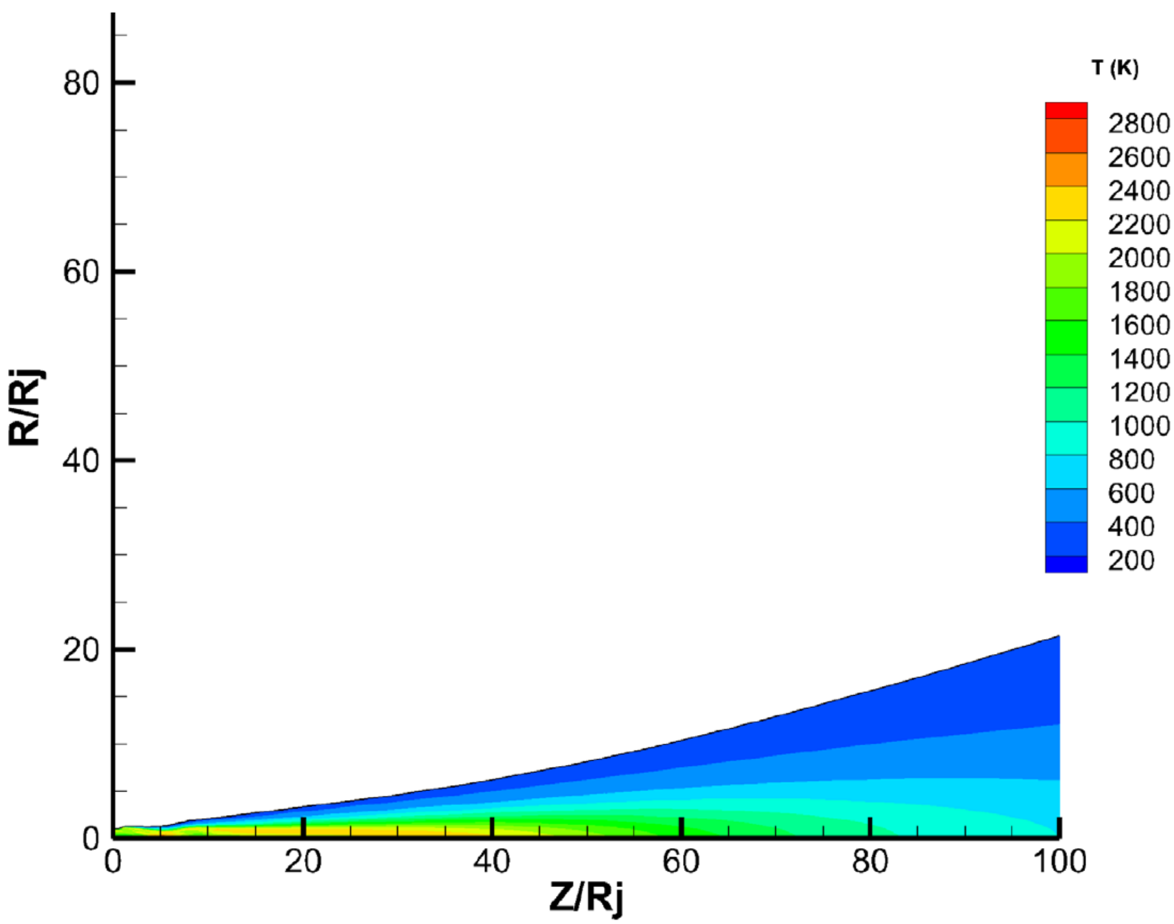


Figure 2: Plume N_2 Mass Fraction Contours
R is radius normalized by Rexit, X is axial distance from nozzle exit normalized by Rexit

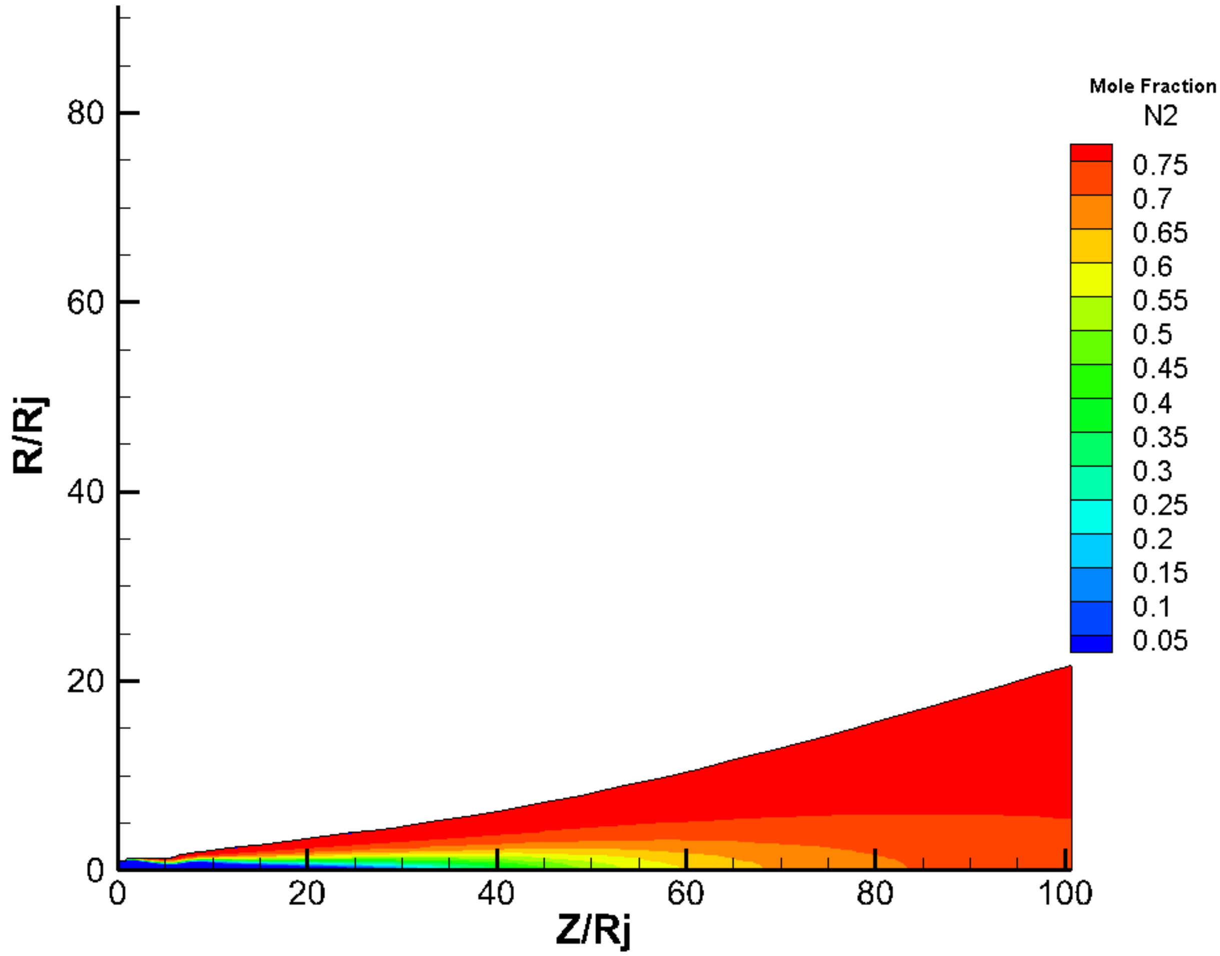
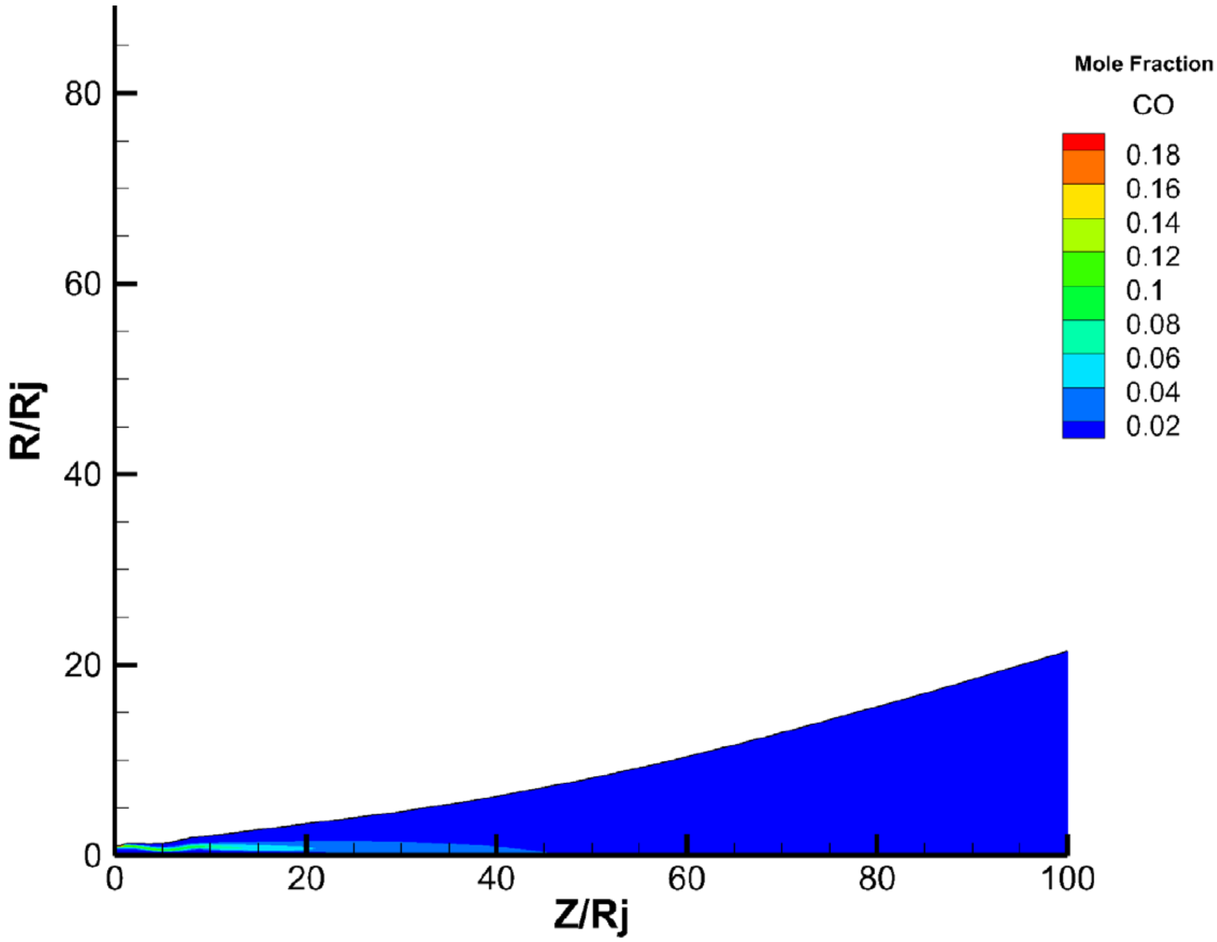


Figure 3: Plume CO Mass Fraction
R is radius normalized by Rexit, X is axial distance from nozzle exit normalized by Rexit



The reactive plume was defined to include all flow that had a CO concentration greater than 1,000 ppm. Integration of the SPF data indicates that 23,079 lb/s air is entrained by the end of the simulation (Figure 4). It is estimated that the 215 foot entrainment end point is reached 179 msec after the plume flow exits the nozzle.

The subsequent TDK simulation of the plume chemistry required an approximate fit of the air entrainment rate. The SPF air entrainment profile was fit to an "availability profile" for the TDK simulations, whereby ambient air is mixed into the plume flow. Figure 5 shows that the approximate TDK air addition agrees well with the entrainment rate predicted by SPF.

Figure 4: Axial Air Entrainment Estimates from SPF.

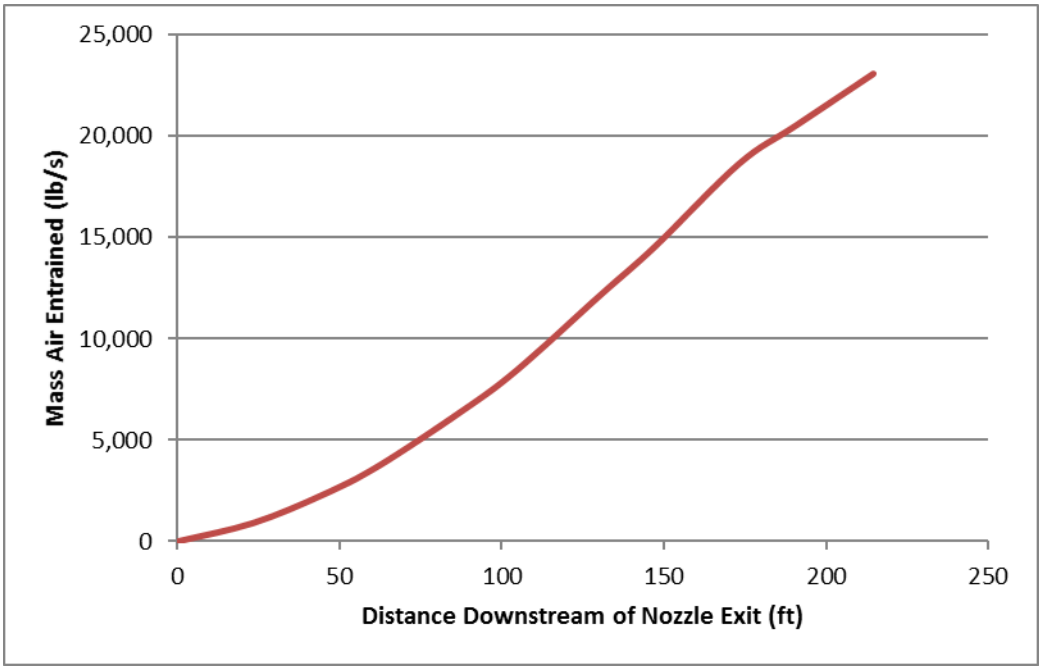
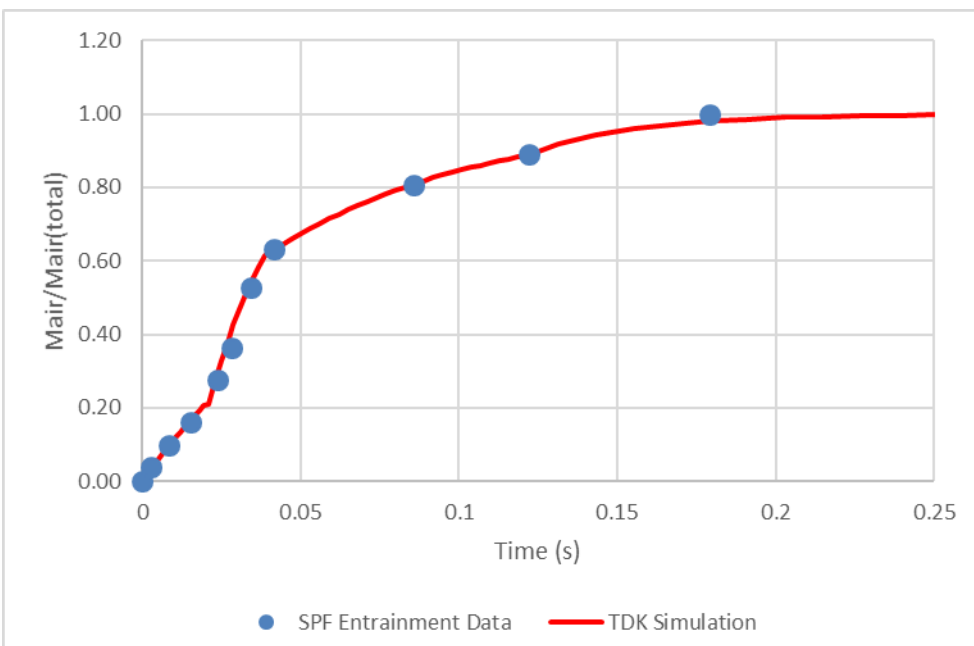
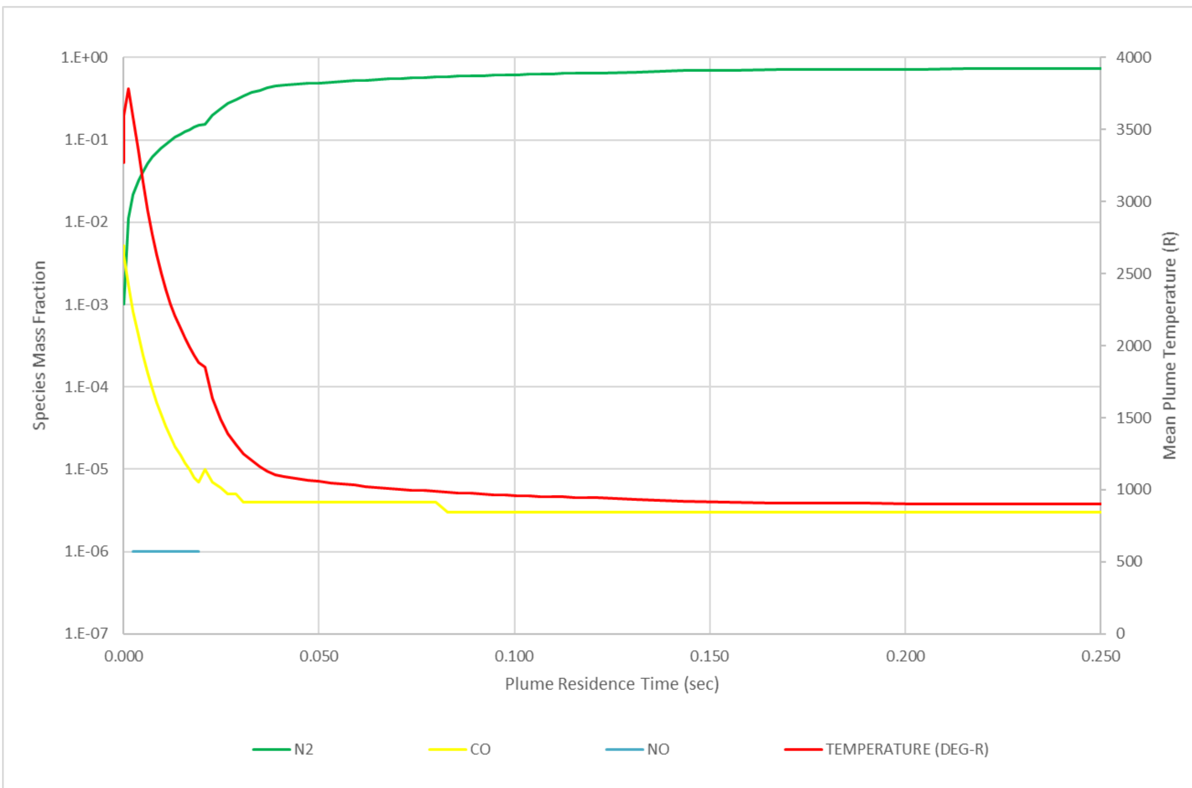


Figure 5: Approximate Air Entrainment Profile used in TDK Simulations



The one-dimensional kinetics modeling of the after-burning characteristics of the exhaust plume was performed assuming a piecemeal constant pressure (13.3-14.7 psia) and entrainment of ambient temperature air. The small concentration of unburnt methane is rapidly oxidized, surviving less than 1 msec. The model predicted that nearly complete CO oxidation occurs, with concentrations reduced to 3 ppm within 100 msec. The plume exit concentration is approximately 1 ppm. There is no significant thermal NO formation, with just 1 ppm formed during the early part of the entrainment process. The NO mass fraction at the end of the 215 ft long plume entrainment is less than 1 ppm. Given the total mixed plume mass flow rate of 24,227 lb/s, this corresponds to CO and NO mass flow rates of no more than 0.024 lb/s for each. Figure 6 shows the predicted temperature and pollutant species mass fraction profiles. The pollutant flow rates were calculated in terms of lb_m generated per second of steady engine operation.

Figure 6: Predicted Profile of Bulk Plume Temperature and Species Mass Fraction



Due to the complexity of how the 31 engines are integrated into the base of the Super Heavy vehicle, there is not a simplified method to directly predict the air entrainment and exhaust burnout chemistry for the installed engines. An extensive computational fluid dynamics (CFD) analysis would likely be needed to fully address the entrainment process. However, engineering judgement can be used bound the problem. The outermost 24 engines will entrain air like the single engine for the outboard portion of their flow (about 50%), but the inboard portion of the flow will interact with the exhaust from the inner engines, delaying the time and distance before the plume flow field interacts with ambient air. The centermost 7 engines will likely entrain rocket exhaust plume for a significant amount of time before air entrainment begins. The effluent from the rocket nozzle exhaust only contains significant amounts of CO as an unburned combustion product, and there is no propellant nitrogen included in the rocket nozzle exhaust. It is likely that the hot interior CO will oxidize as soon as air is available (entrained) and the only NO is formed as a result of the small time window when the exhaust is hot and there is air introduced into the plume. With this description of the global flow field generated by the Super Heavy, it is likely that the exhaust plume length is 3-4 times longer than predicted for a single engine (645-860 ft), but that the CO and NO emission for the Super Heavy are no more than 31 times the single engine level (0.744 lb_m/s for each).

The same Raptor engine is used on the upper stage Starship. Starship uses a cluster of 7-engines (6 around 1). Using the same logic as above, the plume flow field for the Starship configuration should be 2-3 times longer than predicted for a single stand-alone engine (430-645 ft), with total CO and NO emission rate no more than 0.168 lb_m/s each.

5.0 REFERENCES

[1] *Performance Correlation Program (PERCORP 2006) Reference and User's Manual, Version 2.0*, Sierra Engineering Inc., Carson City, NV, June 2009

[2] *Viscous Interaction Performance Evaluation Routine For Two-Phase Nozzle Flows With Finite Rate Chemistry, VIPER 4.5*, Software and Engineering Associates, Carson City, NV, 2018

[3] Taylor, M.W. and Pergament, H.S.; *Standardized Plume Flowfield Model SPF-III, Version 4.2 Program User's Manual*, PST TR-51, Propulsion Science and Technology, Inc. East Windsor, NJ, June 2000

[4] Nickerson, G. R., Dunn, S.S., Coats, D.E. and Berker, D.R.; *Two-Dimensional Kinetics (TDK) Nozzle Performance Computer Program User's Manual*, Software and Engineering Associates, Carson City, NV, Jan 1999

APPENDIX B. FWS 2016 Biological Opinion USFWS Log No. 04EF1000-2016-F-0083

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.

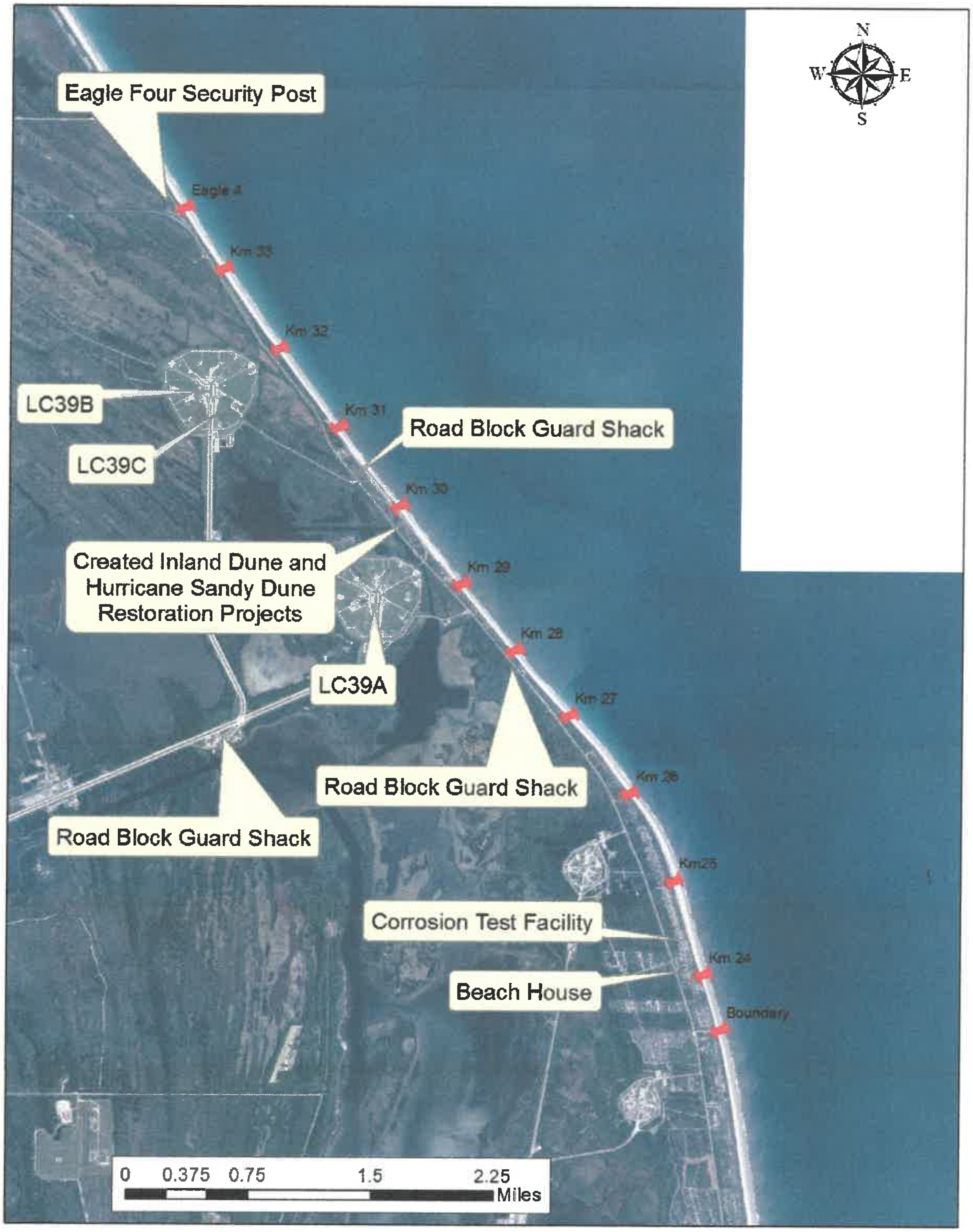


Figure 1. Facilities with light sources near the KSC beaches, dune restoration site and nesting beach kilometer locations

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).

<u>Hawksbill Sea Turtle</u>

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.

<u>Green Sea Turtle</u>

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).

<u>Leatherback Sea Turtle</u>

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).

<u>Hawksbill Sea Turtle</u>

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.

<u>Green Sea Turtle</u>

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).

<u>Leatherback Sea Turtle</u>

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).

Kemp's Ridley Sea Turtle

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. National Marine Fisheries Service 2016 Consultation Letter

UNITED STATES DEPARTMENT OF COMMERCE
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F/SER31: NMB

AUG 08 2016

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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.

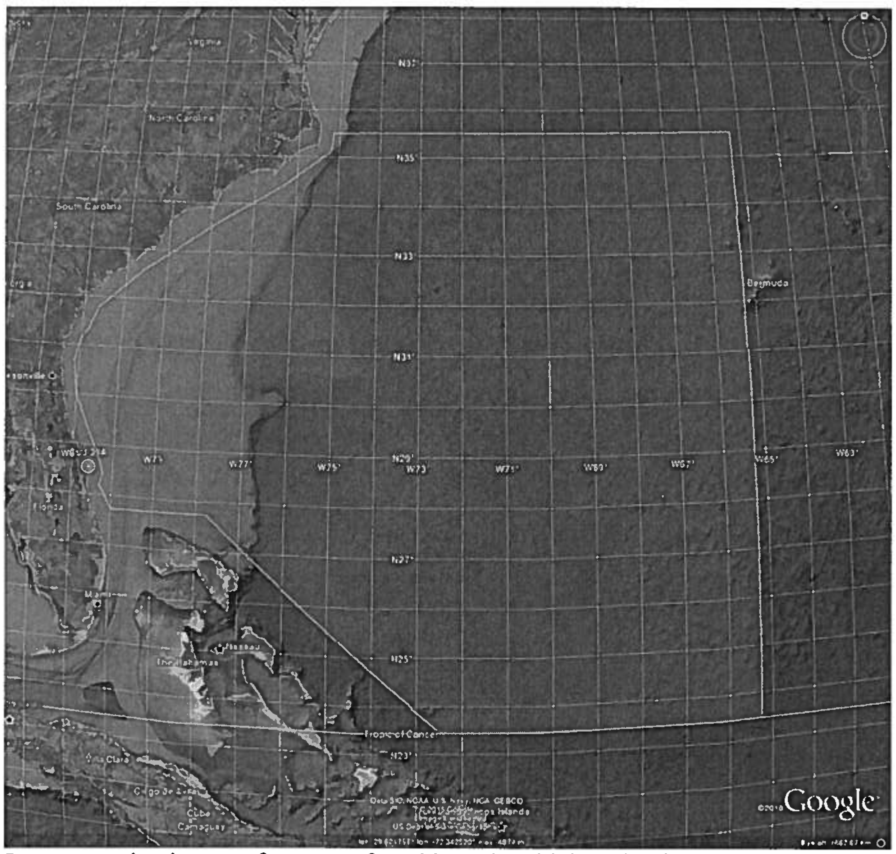
Applicant(s)	**SER Number**	**Project Type(s)**
National Aeronautics and Space Administration (NASA) and Federal Aviation Administration	SER-2016-17894	Waterborne landings of spacecraft

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

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
263 13th Avenue South
St. Petersburg, Florida 33701-5505
http://sero.nmfs.noaa.gov

Nov, 21, 2018 F/SER31:DMB
SER-2018-19649

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

Dear Mr. Czelusniak:

This letter responds to your request for re-initiation of 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)
Federal Aviation Administration (FAA), National Aeronautics and space Administration (NASA), and the U.S. Air Force (USAF)	SER-2018-19649	Waterborne landings of spacecraft

Consultation History
We completed consultation on the proposed action on August 8, 2016 (Public Consultation Tracking System [PCTS] identifier number SER-2016-17894). In that consultation, we determined the proposed action was not likely to adversely affect (NLAA) green sea turtle (North Atlantic and South Atlantic distinct population segments [DPSs]), Kemp's ridley sea turtle, leatherback sea turtle, loggerhead sea turtle (Northwest Atlantic DPS), loggerhead sea turtle designated critical habitat (Units LOGG-N-1 through LOGG-N-19, LOGG-S-1, and LOGG-S-2), hawksbill sea turtle, smalltooth sawfish (U.S. DPS), Gulf sturgeon, shortnose sturgeon, Atlantic sturgeon (Carolina and South Atlantic DPSs), North Atlantic right whale, North Atlantic right whale designated critical habitat (Unit 2), blue whale, fin whale, humpback whale, sei whale, and sperm whale.

On October 19, 2018, we received your letter requesting re-initiation of consultation due to our recent listing of the giant manta ray and the oceanic whitetip shark as threatened under the ESA (83 FR 2916 and 83 FR 4153, respectively). We re-initiated consultation on October 19, 2018.

Project Location

Address	Latitude/Longitude*	Water body
Kennedy Space Center (KSC) and Cape Canaveral Air Force Station (CCAFS) , Brevard County, Florida	28.608402ºN, 80.604201ºW (North American Datum 1983) Coordinates provided are for launch pad 39A. Other launch pads at the KSC and CCAFS may be used.	Atlantic Ocean
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

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 Figures 1 and 2 below. 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.

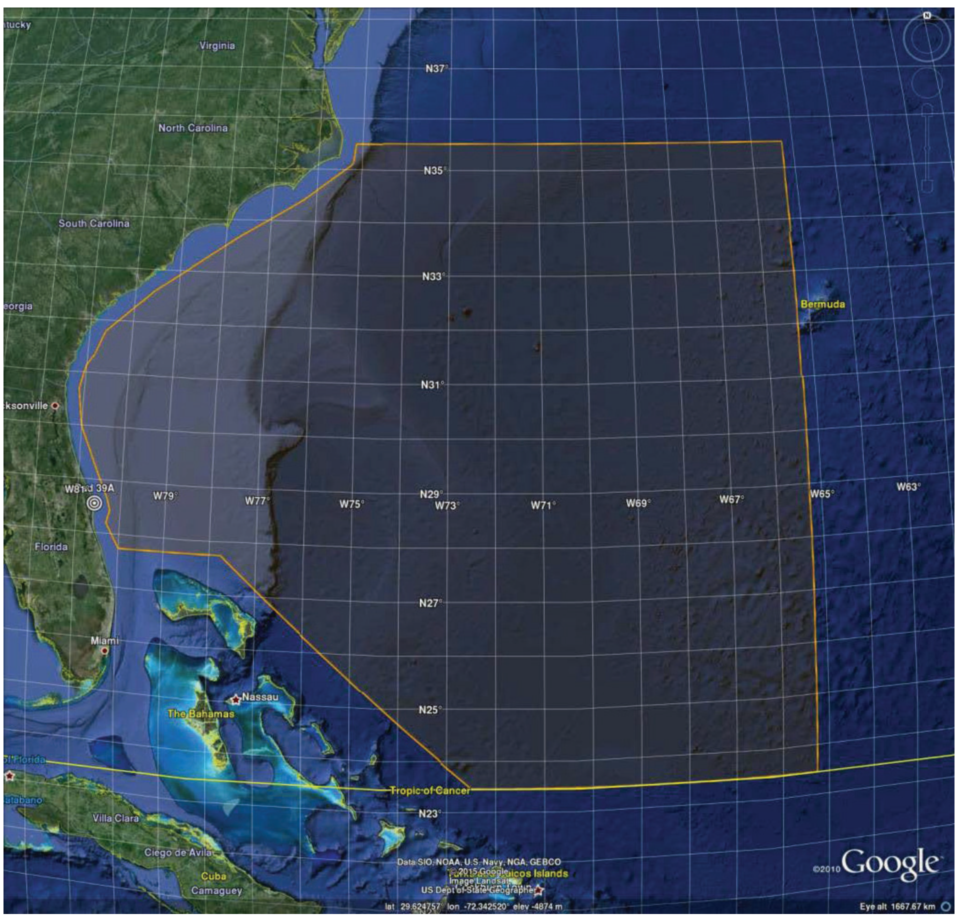


Figure 1. Representative image of action area in the Atlantic Ocean (Image provided by NASA)

Figure 2. Representative image of action area in the Gulf of Mexico (Image provided by NASA)

Existing Site Conditions
Please refer to PCTS identifier number SER-2016-17894 for existing site conditions. The applicants have not identified any changes to the existing site conditions.

Project Description
Please refer to PCTS identifier number SER-2016-17894 for the existing project description. The applicants are not proposing any changes to the existing project description.

Construction Conditions
Please refer to PCTS identifier number SER-2016-17894 for construction conditions, including Education and Observation, Reporting, Vessel Traffic and Construction Equipment, and Hazardous Materials Emergency Response. The applicants are not proposing any changes to the existing construction 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
Fish			
Scalloped hammerhead shark (Central Atlantic [CA] and Southwest Atlantic [SWA] DPS)	T	--	NLAA
Giant manta ray	T	NLAA	NLAA
Oceanic whitetip shark	T	NLAA	NLAA
Marine Mammals			
Bryde's whale	E (Proposed)	--	NLAA
E = endangered; T = threatened; NLAA = may affect, not likely to adversely affect			

Please refer to PCTS identifier number SER-2016-17894 for the previous effect determinations for species occurring within the action areas. There are no changes to these determinations.

Critical Habitat
The action area is located in North Atlantic right whale critical habitat (Unit 2) and loggerhead sea turtle critical habitat (Units Logg-N-1 through Logg-N-19, Logg-S-1, and Logg-S-2). Please refer to the PCTS identifier number SER-2016-17894 for the previous effect determinations for these critical habitat units.

Because the action area in the Gulf of Mexico starts a minimum of 5 nautical miles offshore, the project is also located within the boundary of Gulf sturgeon critical habitat (Unit 14 – Suwannee Sound). The following primary constituent elements (PCEs) are present in Unit 14:

(1) Abundant prey items within estuarine and marine habitats and substrates for juvenile, subadult, and adult life stages;
(2) Water quality, including temperature, salinity, pH, hardness, turbidity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages;
(3) Sediment quality, including texture and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages; and
(4) Safe and unobstructed migratory pathways necessary for passage within and between riverine, estuarine, and marine habitats (e.g., a river unobstructed by any permanent structure, or a dammed river that still allows for passage).

We believe only the water quality PCE of Gulf sturgeon critical habitat (Unit 14 – Suwannee Sound) may be affected by the proposed action.

Analysis of Potential Routes of Effects to Species
Scalloped hammerhead shark, giant manta ray, oceanic whitetip shark, and Bryde's whale may be affected by open-water landings if they were to be struck by falling materials, spacecraft, or controlled burn water landings. We believe that it is highly unlikely that these species will be struck and that the effects are discountable given the relatively small size of capsules (less than 200 ft^2) compared to the open ocean. These launches have been occurring for decades with no known interactions with these species. Further, launches will occur intermittently (approximately every few months) and the goal is to ultimately reduce and eliminate the need for open-water landings.

Scalloped hammerhead shark, giant manta ray, oceanic whitetip shark, and Bryde's whale may become entangled in the parachutes that will transport the capsule to the water surface. However, we believe the risk of entanglement is discountable. Due to their high mobility, these species will likely avoid the area immediately following a landing. Additionally, all materials will be retrieved quickly (approximately 1 hour). As stated previously, the ultimate goal is to reduce the need for open-water landings, thus reducing the need for parachutes.

Scalloped hammerhead shark, giant manta ray, oceanic whitetip shark, and Bryde's whale may be affected by any hazardous materials spilled into the Atlantic Ocean or Gulf of Mexico during the proposed action. For planned marine landings, all fuel valves will shut automatically prior to landing to retain any residual fuels. We believe any effect to these species from a hazardous materials spill is discountable. While a small fuel spill is possible, hazardous material spills are highly unlikely due to the NASA's 98-99% success rate. Further, failed missions do not necessarily occur over marine waters, and most, if not all, fuel would be consumed (e.g., during an explosion) or contained (according to the applicant's Hazardous Material Emergency Response Plan) during a failed mission.

Analysis of Potential Routes of Effect to Critical Habitat

Water quality, including temperature, salinity, pH, hardness, turbidity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages (PCE 2) of Gulf sturgeon critical habitat (Unit 14 – Suwannee Sound) may be affected by any hazardous materials spilled into Gulf of Mexico during the proposed action. We believe the effect to PCE 2 from a hazardous materials spill is discountable. While a small fuel spill is possible, hazardous material spills are highly unlikely due to the NASA's 98-99% success rate. Further, failed missions do not necessarily occur over marine waters, and most, if not all, fuel would be consumed (e.g., during an explosion) or contained (according to the applicant's Hazardous Material Emergency Response Plan) during a failed mission.

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 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 Dana Bethea, Consultation Biologist, at (727) 209-5974, or by email at Dana.Bethea@noaa.gov.

Sincerely,

David Bernhart
Assistant Regional Administrator
for Protected Resources

File: 1514-22.v

APPENDIX D. USFWS 2019 Consultation Letter

(Pending Consultation)