FINAL

ENVIRONMENTAL ASSESSMENT
FOR
KENNEDY SPACE CENTER
SHORELINE PROTECTION PROJECT

AUGUST 2015

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FINAL

August 2015

ENVIRONMENTAL ASSESSMENT FOR KSC SHORELINE PROTECTION PROJECT JOHN F. KENNEDY SPACE CENTER, FLORIDA

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InoMedic HEALTH APPLICATIONS

EXECUTIVE SUMMARY

This Environmental Assessment (EA) has been prepared in compliance with the National Environmental Policy Act (NEPA) of 1969, as amended (42 U.S.C. §§ 4321-4370d) and according to the Procedures of Implementation of NEPA for the National Aeronautics and Space Administration (NASA) (Title 14, Code of Federal Regulations [CFR], part 1216 subparts 1216.1 and 1216.3), and the Council on Environmental Quality (CEQ) NEPA implementing regulations (40 CFR Parts 1500 to 1508). In support of the NASA overall mission and requirements of 10 U.S.C. 2273 - Policy Regarding Assured Access to Space, Kennedy Space Center (KSC) has identified the need for shoreline protection to safeguard critical launch infrastructure assets in danger of being compromised or destroyed as a result of severe shoreline erosion. Crucial threatened and endangered wildlife species habitat is also at risk from shoreline retreat. Potential environmental consequences associated with location and use of sand source(s), and placement of sand fill and vegetation to create new dune or reinforce the existing dune and beach are evaluated in this EA.

Purpose and Need

NASA KSC is responsible for its real property assets and infrastructure in support of the Agency mission of human spaceflight and continued exploration of space. The purpose of the proposed action is to reduce shoreline erosion, thereby protecting both critical launch infrastructure and valuable threatened and endangered species habitat along the KSC coastline from storm wave and sea level rise damage.

The proposed action is needed to ensure the continued ability of NASA to accomplish its mission at KSC. Prior studies have suggested that the volume of sediment contained in a dune or bluff above the 100-year storm tide still water level (SWL) is a descriptor of the dune's resistance to storm-induced erosion (Hallermeier and Rhodes 1988). The Federal Emergency Management Agency (FEMA) has recommended that a minimum frontal dune reservoir of between 51 and 104 cubic meters (m^3)/meter (m) [540 and 1100 cubic feet (ft^3)/foot (ft)] alongshore, above the 100-year SWL, is required to prevent dune removal during a 100-year storm event (FEMA 2000). A value of at least 29 m^3/m (310 ft^3/ft) is associated with a 25-year storm event. The existing beach profile in the KSC proposed project area exhibits approximately 15 m^3/m (160 ft^3/ft) on average, which is less than one-quarter of the minimum FEMA recommendation for the 100-year flood protection.

The four alternative actions identified for evaluation in this EA include various amounts and locations of sand fill placement and subsequent dune vegetation planting. Each alternative seeks to establish an increased dune elevation and sand volume within the dune/beach barrier system for purposes of erosion control and flood prevention.

Proposed Action and Alternatives

The following project alternatives are being evaluated for purposes of reducing flooding and long-term loss of land along the KSC ocean shoreline due to impacts of beach erosion. Four alternatives and the No Action alternative were identified and carried forward for further evaluation.

Alternative One, the locally preferred alternative, would establish a new secondary dune immediately inland of the existing dune, and allow the existing dune and beach to serve as an erosion buffer. Alternative Two would reestablish the historical condition existing 10 to 20 years ago, and employ beach renourishment to maintain that condition. In Alternative Three, the dune would be reinforced at its current eroded location and beach renourishment employed to maintain that location. Alternative Four, a hybrid approach to utilize partial restoration of the primary dune and beach as a near-term strategy, would also establish a secondary inland dune as a long-term strategy. Alternative One would use sand from upland sources. Alternatives Two, Three, and Four would use offshore sand sources at Canaveral Shoals I or II. Details for each Alternative are found in Section 2 of this EA.

Under the No Action Alternative, the KSC beach would be left in its current state, the Canaveral Shoals I and II offshore sand sources would not be utilized, and the lease with Bureau of Ocean and Energy Management (BOEM) would not be required. Similarly upland borrow areas would not be used for dune repair or construction. Nature would be allowed to take its course and storms would potentially continue to erode the beach and further threaten or destroy KSC infrastructure and critical coastal habitat. The historical progression of dune and beach erosion along the northern 7.4 kilometers (km) [4.6 miles (mi)] of the KSC shoreline documented over the past decades, combined with the continuation or possible acceleration of sea level rise, strongly indicates that the beach and dune would continue to degrade in the absence of intervening actions. In the No Action Alternative, overtopping and breach of the primary dune are likely to occur in the near future, which would result in large-scale inundation, habitat alteration, and land loss along the coastal strand. The landward marching shoreline would degrade habitat quality and create rubble from the remaining sections of the KSC railroad and asphalt roadway. Other sections of the KSC coastline would experience connections of the ocean to existing marshes.

Environmental Consequences

An extensive discussion of impacts, including cumulative impacts, is provided in Chapter 4. Classifications of environmental impacts were pre-determined, and the resources were evaluated in terms of these classifications:

- none (no impacts expected)
- minimal (impacts are not expected to be measurable, or are too small to cause any discernable degradation of the environment)

- moderate (impacts would be measureable, but not substantial, because the impacted system is capable of absorbing the change, or the impacts could be managed through conservation measures and/or mitigation)
- major (impacts would individually or cumulatively be substantial)
- beneficial (impacts would be positive in nature)

The following environmental resource areas are analyzed in detail:

- Air Quality
- Climate Change
- Bathymetry
- Geology and Geomorphology
- Physical Oceanography and Coastal Processes
- Water Resources
- Noise
- Hazardous Materials and Waste Management
- Vegetation
- Wildlife
- Protected Species
- Essential Fish Habitat (EFH)
- Land Use
- Infrastructure
- Transportation
- Cultural Resources
- Socioeconomics

Impacts to air quality from construction and dredging equipment would be minimal and of short duration. Potential emissions of any criteria pollutants are not expected to exceed national ambient air quality standards. Greenhouse gas emissions during the construction phase would be considered minimal. Under the No Action Alternative, carbon dioxide (CO_2) would be released to the atmosphere during maintenance and emergency repair activities, but would also be considered minimal.

All four action alternatives reduce the susceptibility of KSC infrastructure to sea level rise; if the proposed project is not implemented, infrastructure would remain at greater risk of damage. Alternatives Two through Four would cause short-term minimal impacts to nearshore bathymetry from input of eroded sand into longshore and cross transport systems, and removal of sand from the offshore borrow areas.

No impacts are expected to tides, waves, currents, or cross-shore transport from any of the proposed action alternatives or the No Action Alternative. Temporary minimal changes to longshore sediment transport in areas where the quantity of sediment is under capacity would occur with Alternatives Two through Four.

Compaction and displacement of sediment and soils during construction would result in moderate impacts to the near surface geology and geomorphology of the KSC beach. The same impacts would be expected during maintenance and emergency repair measures needed if the project is not implemented.

Temporary moderate impacts to water quality would occur due to elevated turbidity and nutrient loads in surface waters west of the primary dune from Alternatives One and Four; and increased turbidity and decreased dissolved oxygen in the marine water column with Alternatives Two through Four. The No Action Alternative would result in major impacts to surface water and groundwater quality from saltwater intrusion. Restoration of floodplain and flood hazard areas would enhance their beneficial qualities including protection against further erosion and flooding. Not implementing the Shoreline Protection project would result in major impacts due to loss of valuable floodplain and wetland areas. These areas in turn provide a buffer between the ocean and KSC infrastructure to the west.

Moderate and temporary impacts due to noise are expected from construction, dredging, and sand placement activities. Marine mammals may experience temporary increased noise levels from vessel activities during dredging.

Compliance with hazardous material and waste management regulations and adherence to guidelines established by NASA would result in minimal impacts from construction activities related to the Proposed Action. Wastes generated would be properly containerized, stored, labeled, manifested, shipped, and disposed of in full regulatory compliance. The No Action Alternative would have potential moderate adverse impacts from shoreline retreat reducing the distance between hazardous material storage areas and rising waters.

Existing vegetation in the project area would be covered by sand with the implementation of all four action alternatives. However former areas of bare sand, railroad, and newly constructed or reinforced dunes would be planted with native vegetation, resulting in an overall long-term benefit to the habitat. Construction of a secondary dune as proposed in Alternatives One and Four would have moderate impacts on wetlands in the Shoreline Protection project boundary. Major impacts to dune, coastal strand, and wetland vegetation would result from continued erosion and sea level rise under the No Action Alternative.

Wildlife, including threatened and endangered species, would be moderately affected by the proposed action alternatives, however long-term impacts would be beneficial. Loss of habitat under the No Action Alternative would result in moderate changes to wildlife. Right whales and manatees could be minimally impacted from the use of hopper dredges and temporary pipelines while sea turtles could be moderately impacted. Placement of sand on the beach and use of offshore dredging vessels and equipment would have a moderate impact on marine turtles.

For EFH, Alternative One would have no impacts. Alternatives Two through Four would cause temporary minimal disturbance to penaeid shrimp EFH. Some direct mortality of shrimp could occur but the primary impact would be from degradation of communities that serve as a food source for large juvenile and adult shrimp. Migratory fish could suffer minimal impacts from direct mortality and increased turbidity.

Land use would not change from implementation of the Shoreline Protection project, and there would be no impacts to existing infrastructure. The No Action Alternative would result in major impacts to structures, utilities, the shoreline itself, and its associated uses. The No Action Alternative would result in major impacts to transportation with the eventual degradation or loss of Phillips Parkway.

The burial of existing historic areas which would occur under Alternatives One, Three, and Four would have no impact to these cultural resources because they are already covered with sand. Alternative Two would not be expected to impact any cultural or archaeological resources. The No Action Alternative would result in major impacts as the shoreline on which these historic areas are positioned would be subject to increased rates of erosion.

The construction phase of the Shoreline Protection project would provide jobs for the local workforce and benefit the local economy. The Sandy Dune repair project performed in 2013/14 was valued at over 2.5 million dollars. The Shoreline Protection project would ensure longer term utilization of existing KSC facilities and associated employment opportunities. No adverse impacts to human health or the environment related to environmental justice are expected to occur with any of the project alternatives.

ABBREVIATIONS

45^{th} SW	45^{th} Space Wing
ac	acre
Al	aluminum
AWAC	Acoustic Wave and Current Profiler
B10	10% biodiesel mixture
BBCS	Bureau of Beaches and Coastal Systems
BCSPP	Brevard County Federal Shore Protection Project
BMAPs	Basin Management Action Plans
BMPs	Best Management Practices
BO	Biological Opinion
BOEM	Bureau of Ocean Energy Management
C	Centigrade
Ca	calcium
CASI	Climate Adaptation Science Investigation
CO	carbon monoxide
CO_2	carbon dioxide
CCAFS	Cape Canaveral Air Force Station
CEM	Coastal Engineering Manual
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
Cl	chloride
cm	centimeter
CNS	Canaveral National Seashore
CS-I	Canaveral Shoals I
CS-II	Canaveral Shoals II
cy	cubic yard
CZMA	Coastal Zone Management Act
dB	decibels
dBA	A-weighted sound pressure level
dBC	decibels related to the carrier
DNL	day/night sound level
DO	dissolved oxygen
DOI	Department of Interior
DOS	Department of State
DOT	Department of Transportation
D_p	peak wave direction
DQM	Dredging Quality Management
DVT	Dune Vulnerability Team
EA	Environmental Assessment
ECS	Environmental Control System
EFH	Essential Fishery Habitat
EPA	Environmental Protection Agency
ERD	Environmental Resources Document

EO	Executive Order
F	Fahrenheit
FAA	Federal Aviation Administration
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection
FDHR	Florida Division of Historical Resources
Fe	iron
FEMA	Federal Emergency Management Agency
FWC	Florida Fish and Wildlife Conservation Commission
FMP	Fishery Management Plan
ft	feet
GCMs	Global Climate Models
GN_2	gaseous nitrogen
GPS	global positioning system
h	horizontal
ha	hectares
HAPC	Habitat Areas of Particular Concern
HCl	Hydrogen Chloride
HDPE	High Density Polyethylene
hp	horsepower
HQ	headquarters
hr	hour
H_s	wave height
IHA	InoMedic Health Applications, Inc.
IM	interim measure
IMO	International Maritime Organization
in	inches
IPCC	Intergovernmental Panel on Climate Change
IRL	Indian River Lagoon
ISS	International Space Station
K	potassium
KCA	Kennedy Customer Agreement
km	kilometer
KNPR	Kennedy NASA Procedural Requirement
KSC	Kennedy Space Center
kV	kilovolt
LC	Launch Complex
LiDAR	Light Detection and Ranging
LOC	Locations of Concern
m	meter
m^3	cubic meters
Mcy	Million cubic yards
Mg	magnesium
MHW	mean high water
mi	mile
MINWR	Merritt Island National Wildlife Refuge

MLLW	Mean Lower Low Water
MMBtu	Million British thermal units
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
Mn	manganese
mph	miles per hour
mt	metric tons
N	North
Na	sodium
NAAQS	National Ambient Air Quality Standards
NASA	National Aeronautics and Space Administration
NAVD 88	North American Vertical Datum 88
NCDC	National Climatic Data Center
NDBC	National Data Buoy Center
NEPA	National Environmental Policy Act
NFA	No Further Action
NM	nautical miles
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NOx	nitrogen oxides
NPR	NASA Procedural Requirements
NR	North Reach
NRHP	National Register of Historic Places
NTU	nephelometric turbidity unit
OAI	Olsen Associates, Inc.
OCS	Outer Continental Shelf
ODMDS	Offshore Dredge Material Disposal Site
OSHA	Occupational Safety and Health Administration
OVA	Organic Vapor Analyzer
PAFB	Patrick Air Force Base
PAH	Polycyclic aromatic hydrocarbons
PAMS	Permanent Air Monitoring Station
PCB	Polychlorinated biphenyls
phi	phi unit
PM	Particulate Matter
PM-10	10-micron particulates
ppb	parts per billion
ppm	parts per million
PRL	Potential Release Location
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
RWWTF	Regional Waste Water Treatment Facility
SA	SWMU Assessment
SCTL	Soil Cleanup Target Levels
SHPO	State Historic Preservation Officer

SJRWMD	St. Johns River Water Management District
SLF	Shuttle Landing Facility
SLS	Space Launch System
SO_2	sulfur dioxide
SOP	standard operating procedure
SPL	sound pressure level
SR	state road and South Reach
SWL	Still Water Level
SWMU	Solid Waste Management Units
T_d	dominant wave period
TDS	total dissolved solids
TOC	total organic carbon
TRPH	total recoverable petroleum hydrocarbons
UF	University of Florida
UMAM	Unified Mitigation Assessment Method
USACE	United States Army Corps of Engineers
USAF	United States Air Force
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VAB	Vehicle Assembly Building
ZAP	Zone of Archaeological Potential

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1.0 Introduction, Purpose and Need

1.1 Introduction

In support of the National Aeronautics and Space Administration (NASA) overall mission and requirements of 10 U.S.C. 2273 - Policy Regarding Assured Access to Space, Kennedy Space Center (KSC) has identified the need for shoreline protection to safeguard critical launch infrastructure assets in danger of being compromised or destroyed as a result of severe shoreline erosion. Crucial threatened and endangered wildlife species habitat is also at risk from shoreline retreat. This Environmental Assessment (EA) evaluates the potential environmental consequences of actions associated with the location and use of sand source(s), the placement of sand fill, and planting vegetation to create new dune or reinforce the existing dune.

As a federal agency, NASA is required to consider environmental consequences resulting from NASA actions on federal property. This is based on several regulatory mandates including the National Environmental Policy Act (NEPA) of 1969, as amended (42 U.S.C. 4321, et seq.), the Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA (40 CFR parts 1500-1508), Procedures for Implementing NEPA (14 CFR part 1216 subpart 1216.3), and NASA policy and procedures (NASA NPR 8580.1 – Implementing the National Environmental Policy Act). As NASA is considering a plan to restore and protect the KSC shoreline, this EA is necessary to support NASA's compliance with NEPA, 40 CFR 1500-1508, and related federal and state environmental regulations.

The Florida State Clearinghouse coordinated a review of the Draft EA pursuant to Presidential Executive Order 12372; Section 403.061(42), Florida Statutes; the Coastal Zone Management Act, 16 U.S.C. SS1451-1464, as amended; and NEPA, 42 U.S.C SS 4321-4347, as amended. The Clearinghouse letter dated August 12, 2015, and comments the State received from the Florida Fish and Wildlife Conservation Commission (FWC), Florida Department of Environmental Protection (FDEP), and the Florida Department of State (DOS) are provided in Appendix H.

Chapter 1 of this EA describes the background, the purpose of, and need for the Proposed Action. A description of the Proposed Action and Alternatives, including the No Action Alternative, is provided in Chapter 2. Chapter 3 describes the existing conditions of specified environmental resources that could be affected by implementation of the Proposed Action and alternatives. Chapter 4 addresses how those resources might be affected by implementation of the Proposed Action and alternatives, and Chapter 5 summarizes general mitigation actions that were considered at this phase in project planning.

1.2 Federal Agency Involvement

Three federal agencies are directly involved in the EA for this proposed action: NASA, Bureau of Ocean Energy Management (BOEM), and the U.S. Fish and Wildlife Service at Merritt Island National Wildlife Refuge (USFWS/MINWR). Federal agencies, including U.S. Army Corps of Engineers (USACE), USFWS, and National Oceanic and Atmospheric Administration (NOAA), will also be involved through permitting and related consultations.

1.2.1 Role of NASA

As the landowner, NASA KSC is responsible for its real property assets and infrastructure in support of the Agency mission of human spaceflight, and continued exploration of space. NASA's KSC is the only United States launch complex utilized for human spaceflight. NASA is also responsible for managing other areas on KSC for space-related industry, development, and operations. KSC provides oversight for current commercial space and technology development related uses, and will be responsible for establishing and coordinating activities outlined in the proposed action. NASA is the lead agency for the proposed action and is responsible for ensuring overall compliance with applicable environmental statutes, including NEPA.

1.2.2 Role of BOEM

BOEM is a cooperating agency for the KSC Shoreline Protection project. Authorization from BOEM is required for use of an offshore borrow area located in federal waters to supply sand resources for beach restoration and enhance storm damage protection.

1.2.3 Role of USFWS

The USFWS is also a cooperating agency for the KSC Shoreline Protection project. USFWS is a U.S. Department of Interior (DOI) agency having management responsibilities for land potentially affected by the activities evaluated in this EA. NASA coordinates all land uses and activities that may have impacts on this agency's responsibilities and missions.

An interagency agreement was executed between NASA, KSC, and USFWS for use and management of KSC property referred to as the Merritt Island National Wildlife Refuge (KCA-1649). MINWR manages the acreage of KSC not specifically used for spaceflight related operations, including the proposed Shoreline Protection project area.

1.3 Purpose and Need for Action

The purpose of the proposed action is to reduce shoreline erosion, protect critical launch infrastructure, and protect valuable threatened and endangered species habitat along the KSC coastline from storm wave and sea level rise damage. The most active hurricane season in KSC's history was 2004 with marshes, shoreline, and dunes being affected, at least temporarily, due to storm surge and beach erosion. Additionally, damages to facilities exceeded $100M (NASA 2004). Hurricane Sandy, the largest hurricane to ever form in the Atlantic basin, developed from a tropical wave in the western Caribbean Sea on 22 October 2012, quickly strengthened and was upgraded to Tropical Storm status within six hours. As this late season storm merged with a cold front approaching the east coast of the United States, it intensified into a super storm with a cloud cover nearly 3,218 kilometers (km) (2,000 miles [mi]) across, resulting in the weather forecasters dubbing it "Frankenstorm". The tidal effects from the full moon magnified the storm's already large waves causing record-breaking storm surges along the coast from Florida to Maine. Sandy was one of the costliest storms in history with a total price tag of nearly $70 billion dollars, only surpassed by Hurricane Katrina. Beach erosion along the Brevard County coastline was estimated to cost over $25 million, impacting many shoreline nourishment projects.

The proposed action is needed to ensure the continued ability of NASA to accomplish its mission at KSC. Prior studies have suggested that the volume of sediment contained in a dune or bluff above the 100-year storm tide still water level (SWL) is a descriptor of the dune's resistance to storm-induced erosion (Hallermeier and Rhodes 1988). The Zone V designation is given to areas along coasts subject to inundation by the 1-percent-annual-chance flood event with additional hazards associated with storm-induced waves. For purposes of V-zone mapping and protection of habitable development within the coastal zone, the Federal Emergency Management Agency (FEMA) has recommended that a minimum frontal dune reservoir of between 51 and 104 cubic meters ($m^{3)}$/meter (m) [540 and 1100 cubic foot ($ft^{3)}$/foot (ft)] alongshore, above the 100-year SWL, is required to prevent dune loss during a 100-year storm event (FEMA 2000) as shown in Table 1-1. These are empirical guidelines that reflect very wide variation in field data and refer to only the front half of the dune. The existing beach profile in the KSC project area exhibits between 7 and 32 m^3/m (75 and 340 ft^3/ft), which is far less than the minimum FEMA recommendation.

The four alternative actions identified for evaluation in this EA include various amounts and locations of sand fill placement and subsequent dune planting. Volumes of sand needed for these alternatives range from 321,400 to 2,142,400 m^3 [420,000 to 2,800,000 cubic yards (cy)]. Each alternative seeks to establish an increased dune elevation and sand volume within the dune/beach barrier system for purposes of erosion control and flood prevention.

Table 1-1. FEMA minimum frontal dune reservoir recommendations for 100-year and 25-year storm events as compared to the current (2013) KSC conditions.

100-year storm event	25-year storm event	Current KSC condition
51 -104 m^3/m (540-1100 ft^3/ft)	29 m^3/m (310 ft^3/ft)	7 to 32 m^3/m, (typically <15 m^3/m) (75 - 340 ft^3/ft)

The purpose of BOEM's proposed action is to consider NASA's request for the use of OCS sand resources in renourishing the KSC shoreline.

1.4 Background and Location

During the past few years, the beach and coastal dunes at KSC have eroded significantly enough to change the coastline contour, which increasingly threatens KSC infrastructure and the critical role of KSC within NASA's mission (Coastal Planning and Engineering 2011). Coastal dunes protect the landward infrastructure, including Launch Complexes (LC) 39A and 39B, critical utility transmission lines, and federally protected wildlife species habitat from the impact of waves and inundation. They also provide a physical buffer between launch infrastructure and sea turtle nesting areas, affording some shielding of facility lighting that may cause turtle disorientation. Reports on sea turtle nesting and disorientations on KSC/MINWR (IHA 2011, 2012) describe the effects of natural beach profile variation, loss of primary dune and associated vegetation, and facility lighting on turtle disorientation.

A comparison of historical maps, aerial photographs, and topographic survey data indicates a fairly consistent trend in shoreline change along the KSC coastline over the past 137 years. This proposed project focuses on the northern 7.6 km (4.7 mi) of the 10 km (6.2 mi) KSC ocean shoreline (Figure 1-1) between the KSC north boundary/Eagle 4 and the False Cape.

This reach, particularly the 4.2 km (2.65 mi) of shoreline between LC 39A and LC 39B (V-070 to V-084), features low upland elevations, very narrow and low dunes, and chronically high shoreline erosion rates of between 0.9 and 1.8 m (3 and 6 ft) per year (Figures 1-2, 1-3, and 1-4). Figure 1-4 depicts the maximum dune elevation and the total sediment volume above +2.1 m North American Vertical Datum (NAVD) (+7 ft) within 67 m (220 ft) landward of the mean high water shoreline in existing conditions as of September 2014, pursuant to the post-Hurricane Sandy dune repairs in early 2014. The +2.1 m (+7 ft) elevation approximately corresponds to the 25-year storm surge level and the natural beach berm elevation; and the 67 m (220 ft) distance includes the landward limits of the 2014 dune repairs. Lower dune heights and volumes south of V-089 are associated with the lower-energy, accreting nature of the shoreline area along and south of False Cape, and do not otherwise indicate shoreline vulnerability.

The dune along the shoreline between LC 39A and LC 39B is chronically eroded, frequently overwashed by high tides and waves, and is prone to breaching as evidenced by the average rate of shoreline erosion along the toe of the dune from 1999 to 2014 (Figures 1-3 and 1-4). Breaching and/or loss of the dune results in wide scale flooding of the uplands between the shore and the launch pads as described in the No Action alternative below.

Figure 1-1. KSC Shoreline Protection project location.

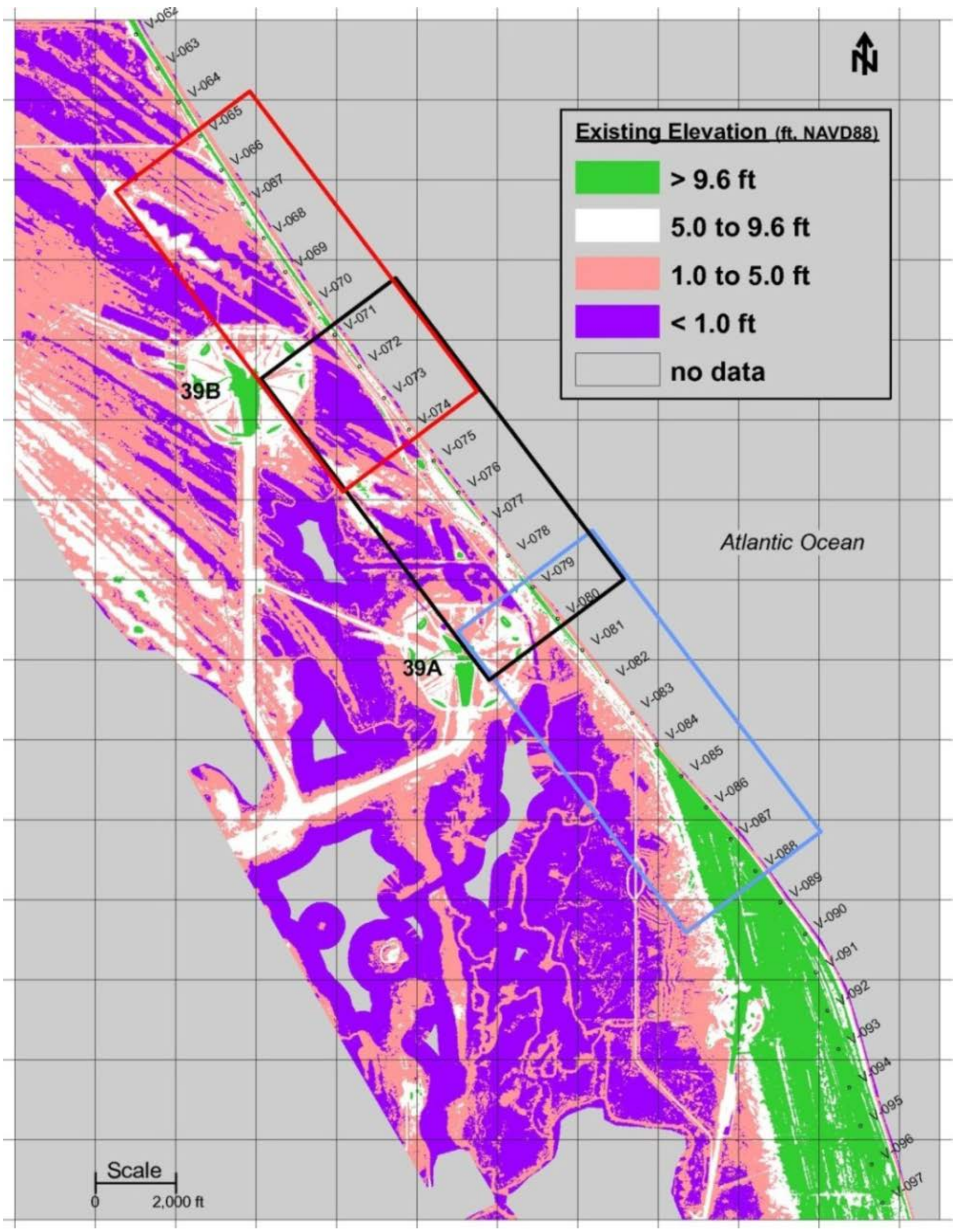


Figure 1-2. Upland land elevations along the KSC shoreline (from 2007 Light Detection and Ranging [LiDAR] survey). Much of the interior is below mean high water (MHW) elevation, approximately +0.3 m (1 ft) (purple), and below +1.5 m (5 ft) elevation (pink), and is separated from the ocean by a narrow ridge greater than +1.5 m (5 ft) (white). Lands higher than the approximate 100-year storm elevation, +2.9 m (9.6 ft) (green), include the ocean dune ridge that diminishes in height and width between LC 39A and LC 39B. Details are found in Appendix A.

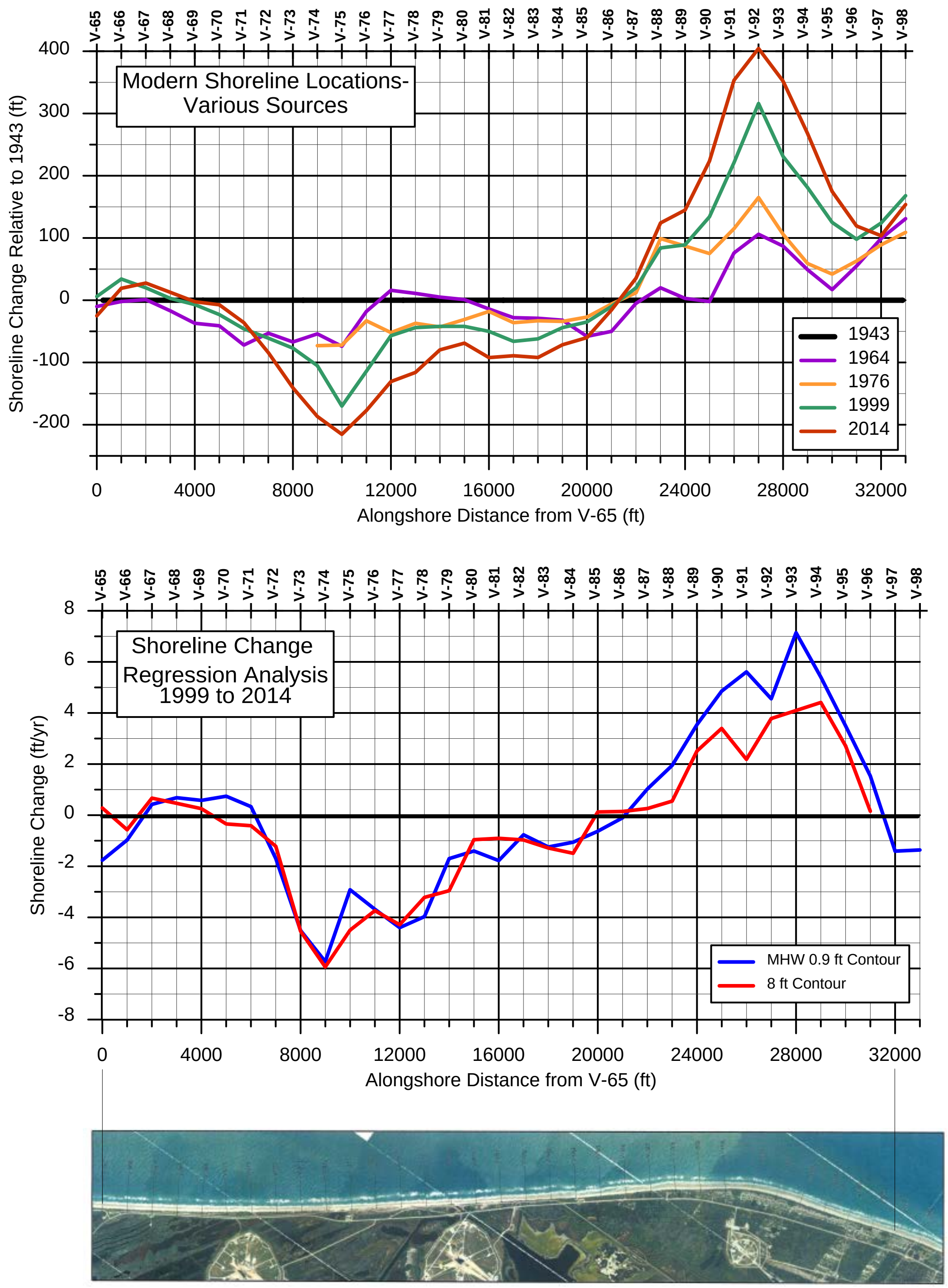


Figure 1-3. Recent and historical changes in shoreline location on KSC. Upper - Approximate high water shoreline locations in 1999-2014 relative to 1943. Lower - Average annual change in MHW shoreline and dune face location (+0.3 m [0.9 ft] and +2.4 m [8 ft] NAVD 88, respectively) from Fall 1999 through September 2014, based upon regression analysis of surveys in 1999, 2007, 2009, 2011, and 2014. Negative values indicate erosion; positive values indicate accretion.

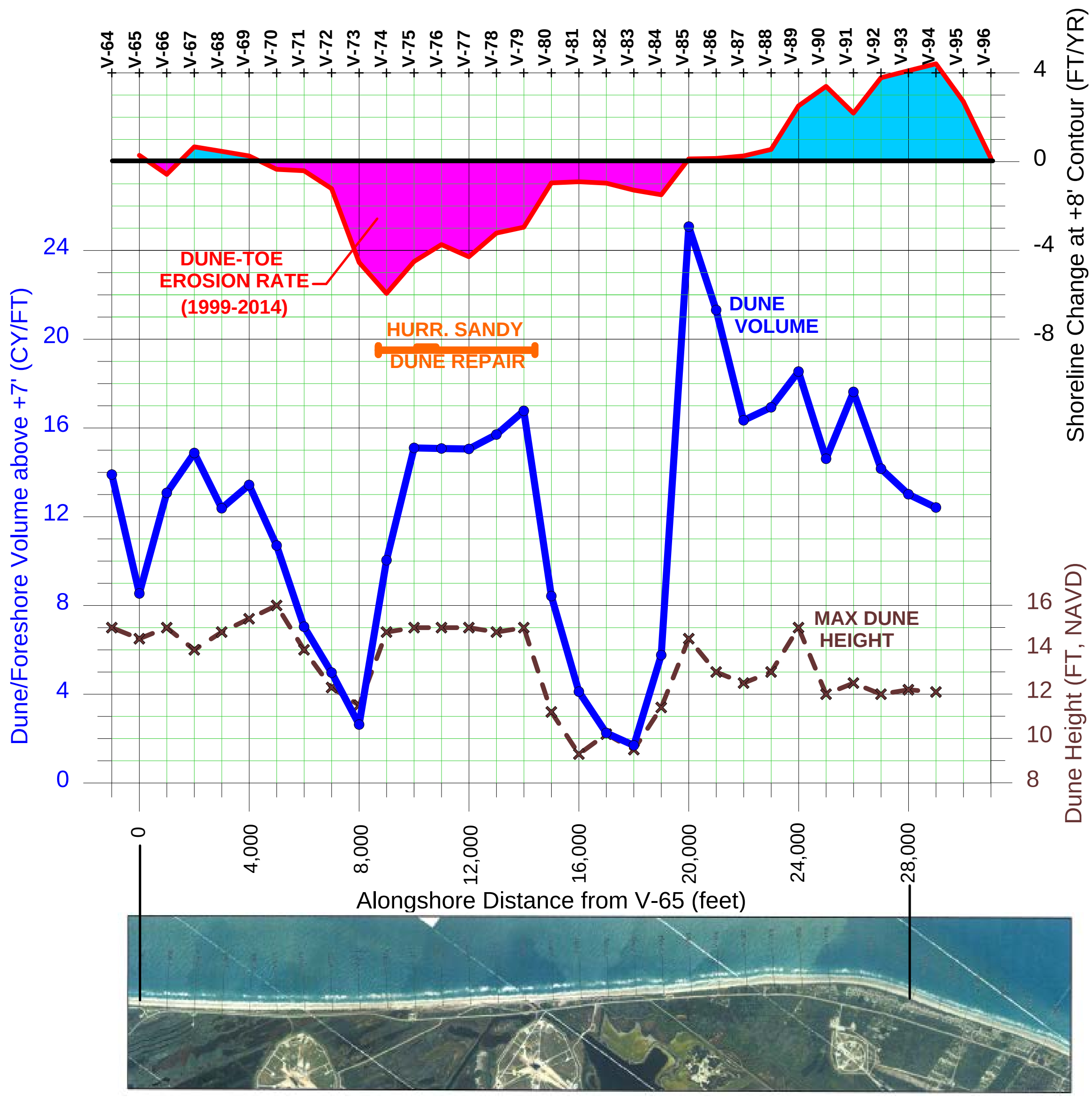


Figure 1-4. Existing dune/foreshore sand volume above +2.1 m (7 ft) NAVD (blue), and maximum dune height (brown), within 67 m (220 ft) landward of the mean high water shoreline. The values include conditions measured in September 2014, pursuant to the post-Hurricane Sandy dune repairs in spring 2014. The 67 m distance includes the landward limit of the dune repairs above +2.1 m NAVD. The average annual rate of dune erosion, measured along the +2.4 m (8 ft) NAVD contour (red-erosion, blue-accretion), from 1999 through September 2014.

There have been significant hurricane and non-hurricane storm events over the last 10 to 15 years which resulted in overwash and severe erosion of the dunes and beach. In 1999, Hurricane Floyd impacted the east coast, causing over 15 m (50 ft) of shoreline retreat at KSC between LC 39A and B (Figure 1-5). This shoreline loss has not been recovered.

Figure 1-5. Coastline loss resulting from Hurricane Floyd as indicated by shoreline locations shown in March 1999 and May 2000.

In 2005, small scale emergency funds supported a dune restoration project to repair damage to the back side of the eroded primary dune caused by Hurricanes Charley, Frances, and Jeanne, and other storms during the 2004-2005 hurricane seasons (Figure 1-6). In 2008, another restoration project was implemented to repair damage from a 2007 non-hurricane storm event and the 2008 Tropical Storm Fay (Figure 1-7).

The U.S. Geological Survey (USGS) developed a model during the Phase 1 Coastal Vulnerability Study (Plant 2009) and predicted that the KSC railroad would be eroded by the year 2026, and could be breached earlier. This did indeed happen in 2012 when Hurricane Sandy passed alongshore of KSC in October 2012. Detailed historical shoreline change information is found in Appendix A. KSC infrastructure and protected species habitat will continue to be at high risk for storm damage from future dune breach and overwash events. In 2008, as part of an ongoing research effort at KSC, a Dune Vulnerability Team (DVT) was created with participants from NASA, USGS, University of Florida (UF), InoMedic Health Applications (IHA), Coastal Planning and Engineering, Inc., and the U.S. Air Force.

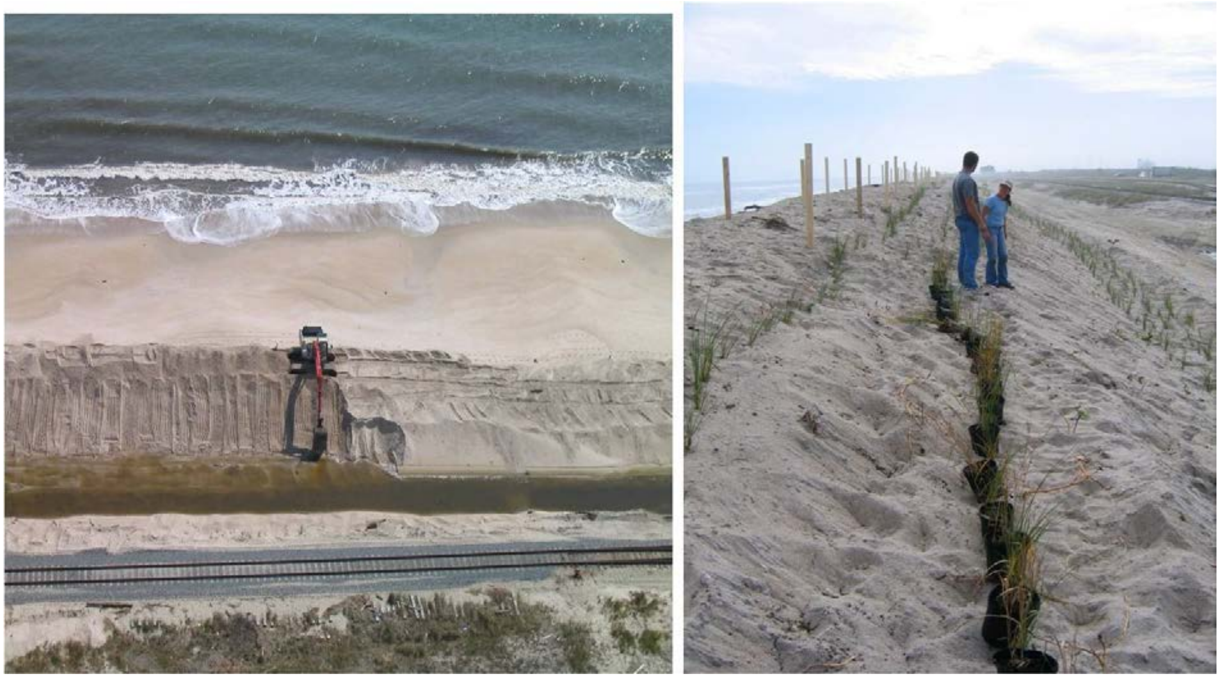


Figure 1-6. Emergency hurricane recovery-funded dune restoration in 2005.

Figure 1-7. Overwash from Tropical Storm Fay and the resulting 2008 restoration project.

The DVT worked to quantify recent changes in dune vulnerability from overwash and erosion, determine causes of these changes, and predict future changes related to erosion and storms. They described the changing high water mark of the KSC shoreline from 1994 to 2007 (Figure 1-8).

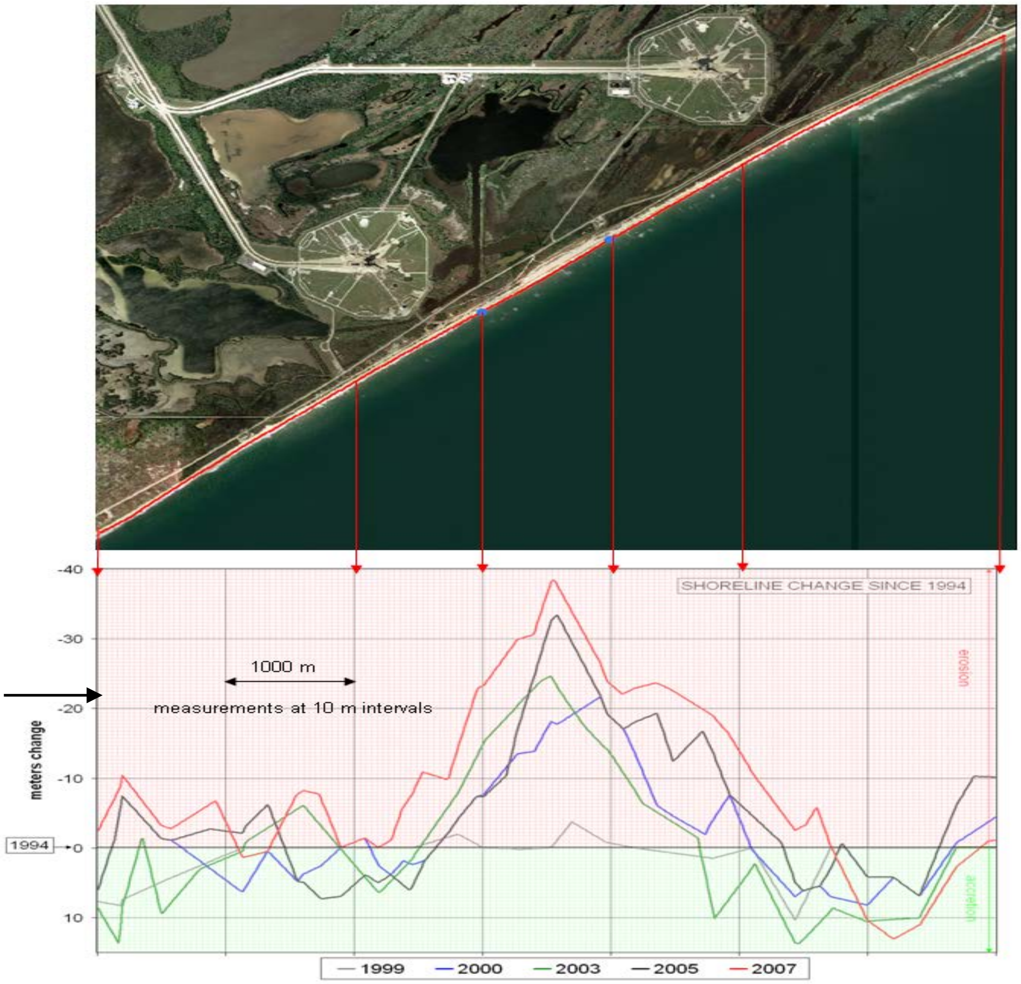


Figure 1-8. KSC shoreline change from 1994 to 2007.

Waves and surge from the offshore passage of Hurricane Sandy in late October 2012 caused over 15 m (50 ft) of shoreline and dune recession along the northern 6.5 km (4 mi) of the KSC shoreline (Figure 1-9). The dune was overwashed and completely breached in several locations. In response, emergency dune repairs were constructed in early 2014 along the most severely damaged section of shoreline.

Figure 1-9. KSC beach after Hurricane Sandy breached areas of the critically eroding dunes on KSC. The ballast of the railroad is shown on the left near LC 39A and the breached primary dune and railroad overwash are evident on the right, near LC 39B.

Approximately 81,000 m^3 (105,900 cy) of sand from an existing upland stockpile on Titan Road at Cape Canaveral Air Force Station (CCAFS) were placed to reconstruct a dune between 2.65 km and 4.4 km (8,700 and 14,400 ft) south of KSC's northern security area boundary. The dune was constructed landward of the existing (eroded) dune, approximately 50 m (165 ft) upland of the mean high water shoreline. Approximately 1.8 km (5800 ft) of existing railroad and bedding damaged by the storm were removed from the shorefront along the dune area; and portions of the dune were constructed atop the location of the former railroad. The location and a typical cross-section profile of the Hurricane Sandy dune repair are illustrated in Figure 1-10. A history of KSC shoreline change through 2014, including the effects of Hurricane Sandy is provided in Figure 1-11 with additional details available in Appendix A.

A sand source study was performed in 2013 to support options for alternatives in this EA. That study is found in Appendix C and includes the descriptions and locations of the upland and offshore sources summarized in Section 3.1.6 of this EA.

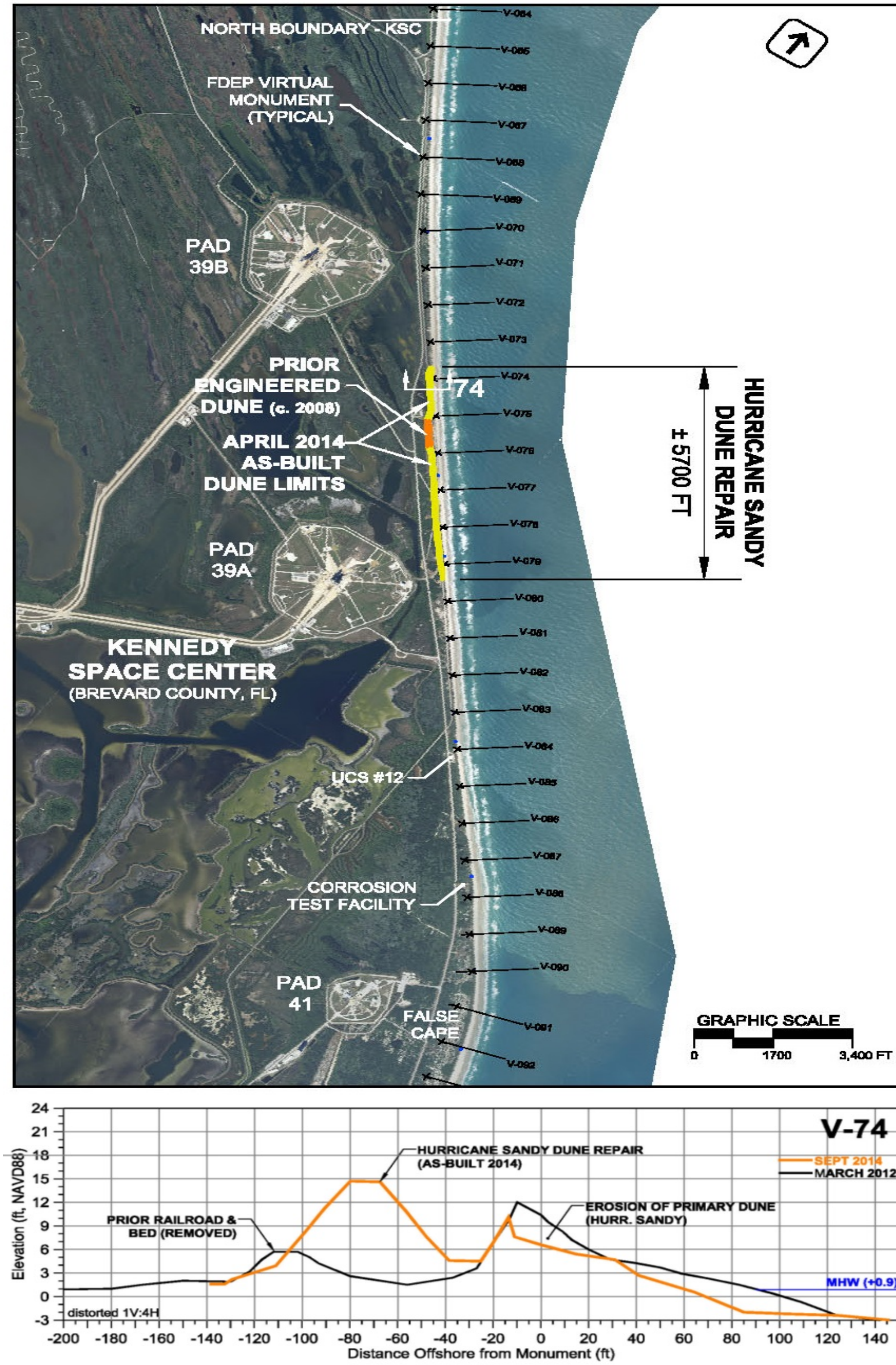


Figure 1-10. Location and typical section of post-Hurricane Sandy dune repairs.

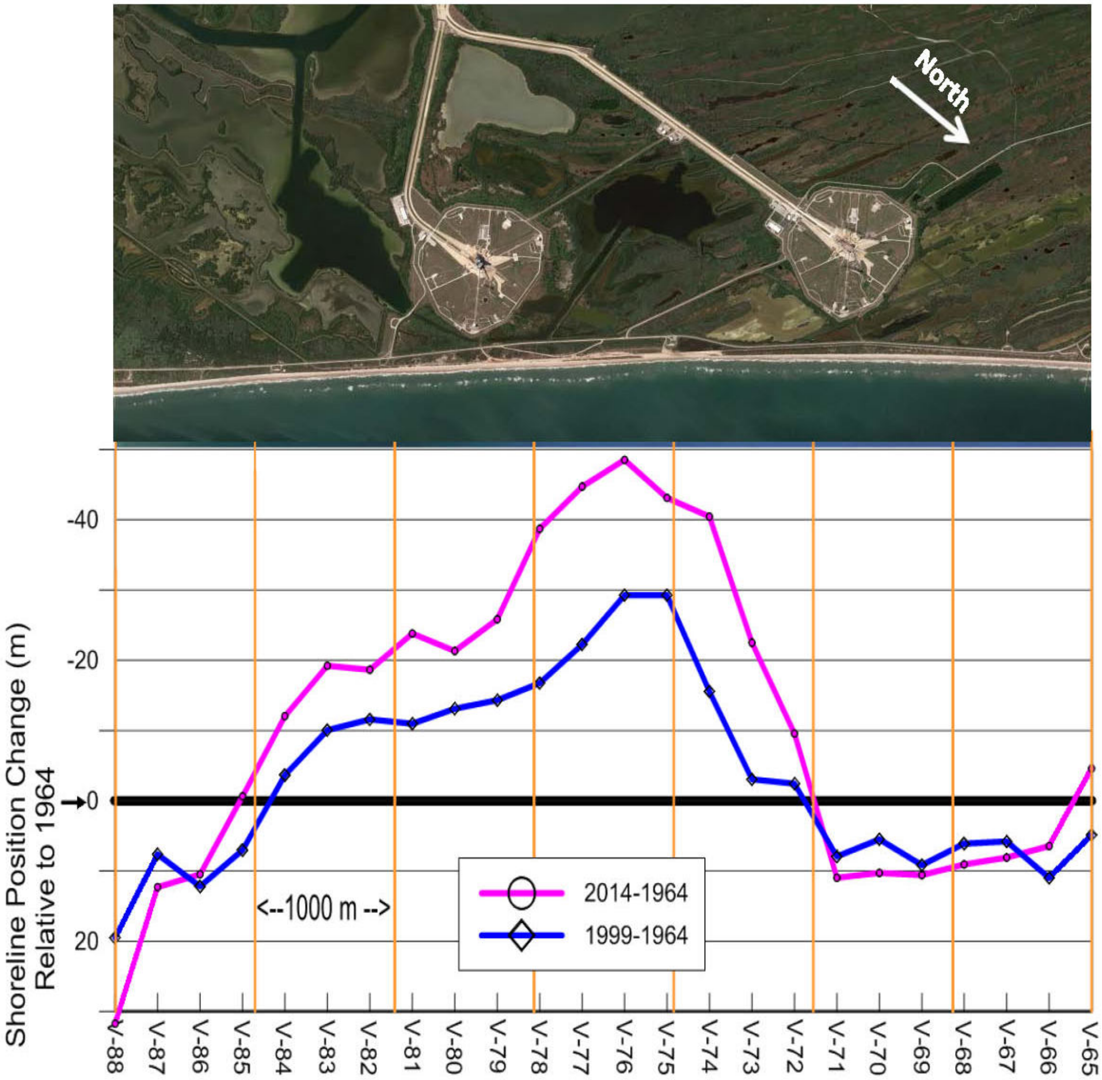


Figure 1-11. Change in the mean high water shoreline location along KSC from 1964 to 2014.

1.5 Scope of the Environmental Assessment

This EA evaluates the potential site specific environmental consequences associated with the alternatives considered for the Proposed Action to provide sand based protection to the KSC shoreline, and the No Action Alternative. This EA was produced using available information to the maximum extent possible. All applicable environmental data necessary were collected to describe current environmental conditions and potential impacts to the environment. The following resources were identified for analysis in this EA: Air Quality, Climate Change, Bathymetry, Geology and Geomorphology, Physical Oceanography and Coastal Processes, Sand Sources, Water Resources, Noise, Hazardous Materials and Waste Management, Biological and Cultural Resources, Land Use, Infrastructure, Transportation, and Socioeconomics.

Pursuant to 40 CFR 1506 and 43 CFR 46, the existing analyses and review of other documents are incorporated by reference where applicable. These include, among others, NEPA documents prepared by the USACE, BOEM, and U.S. Air Force (USAF) that evaluate the extraction of sediments from the Canaveral Shoals II (CS-II) offshore sand borrow area located within the Action area of this EA (USACE 1996; MMS 2005, 2009; USAF 2012; BOEM 2012, 2013).

2.0 Description of Proposed Alternatives

The following project alternatives are being evaluated for purposes of reducing flooding and long-term loss of land along the KSC ocean shoreline due to impacts of beach erosion. Four alternatives and the No Action Alternative were identified and carried forward for further evaluation. Several other alternatives, described in Section 2.6, were deemed impractical to implement, environmentally adverse, or unable to meet project objectives. Each of the action alternatives address all or part of the northern 7.6 km (4.7 mi) of the KSC 10 km (6.2 mi) ocean shoreline between FDEP virtual monument locations V-065.3 (KSC/Canaveral National Seashore (CNS) North Boundary at Eagle 4) and V-089 (False Cape). The shoreline boundaries of the project alternatives (Figure 2-1) described below were selected to reinforce and/or restore the beach and dune system to protect against dune breaching, interior flooding, land loss, and damage to KSC assets specifically based upon the existing dune/shoreline conditions and historical erosion rates summarized in Figures 1-3, 1-4, and Appendix A. Existing conditions of the four reaches along the project area shoreline are illustrated in Figure 2-2, and each of the project alternatives are subsequently depicted in Figures 2-3 to 2-6. These reaches approximately correspond to monument ranges A) V065.3-V071, B) V071-V079, C) V079-V084, and D) V084-089.

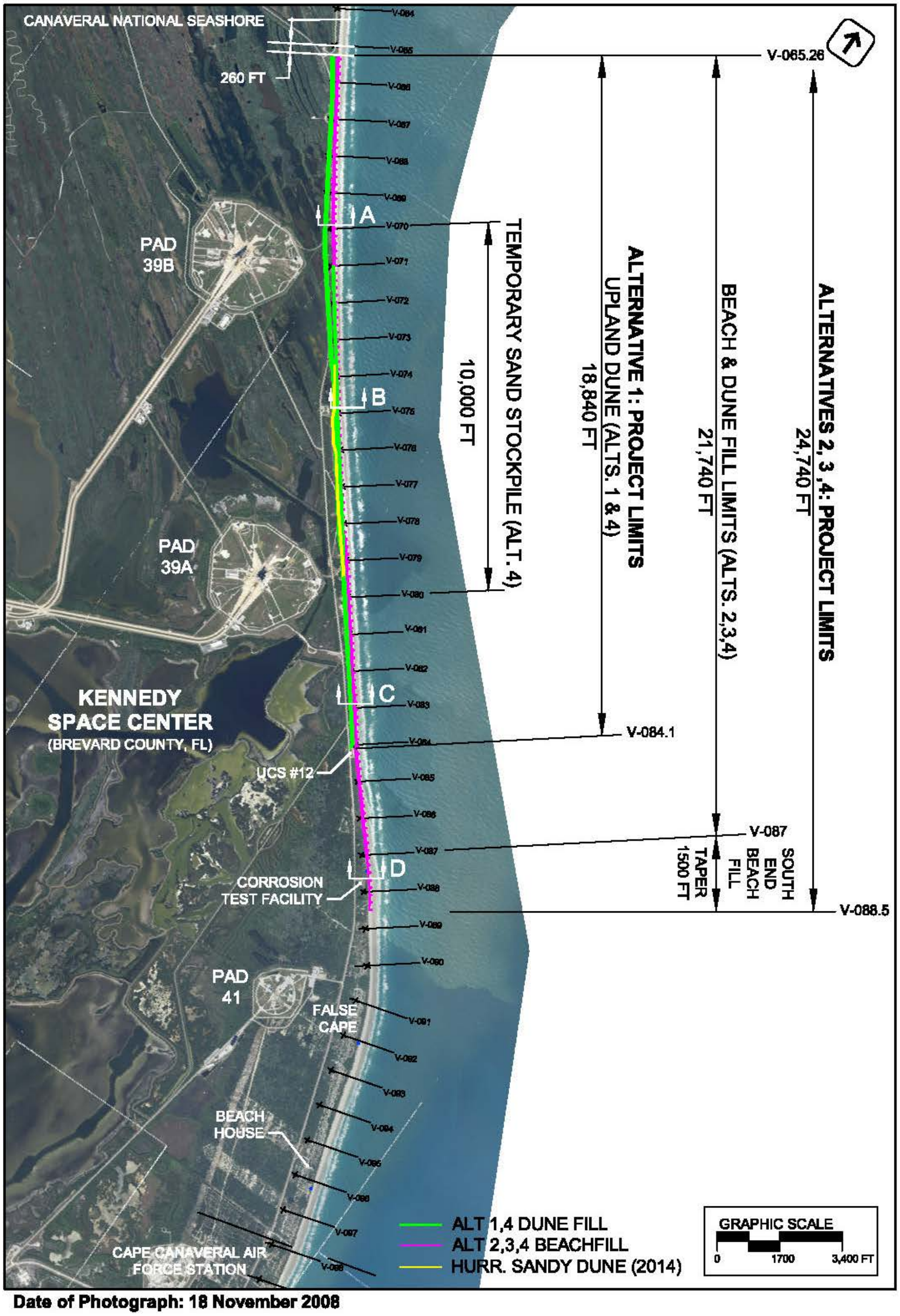


Figure 2-1. Shoreline Project area limits for Alternatives One, Two, Three, and Four.

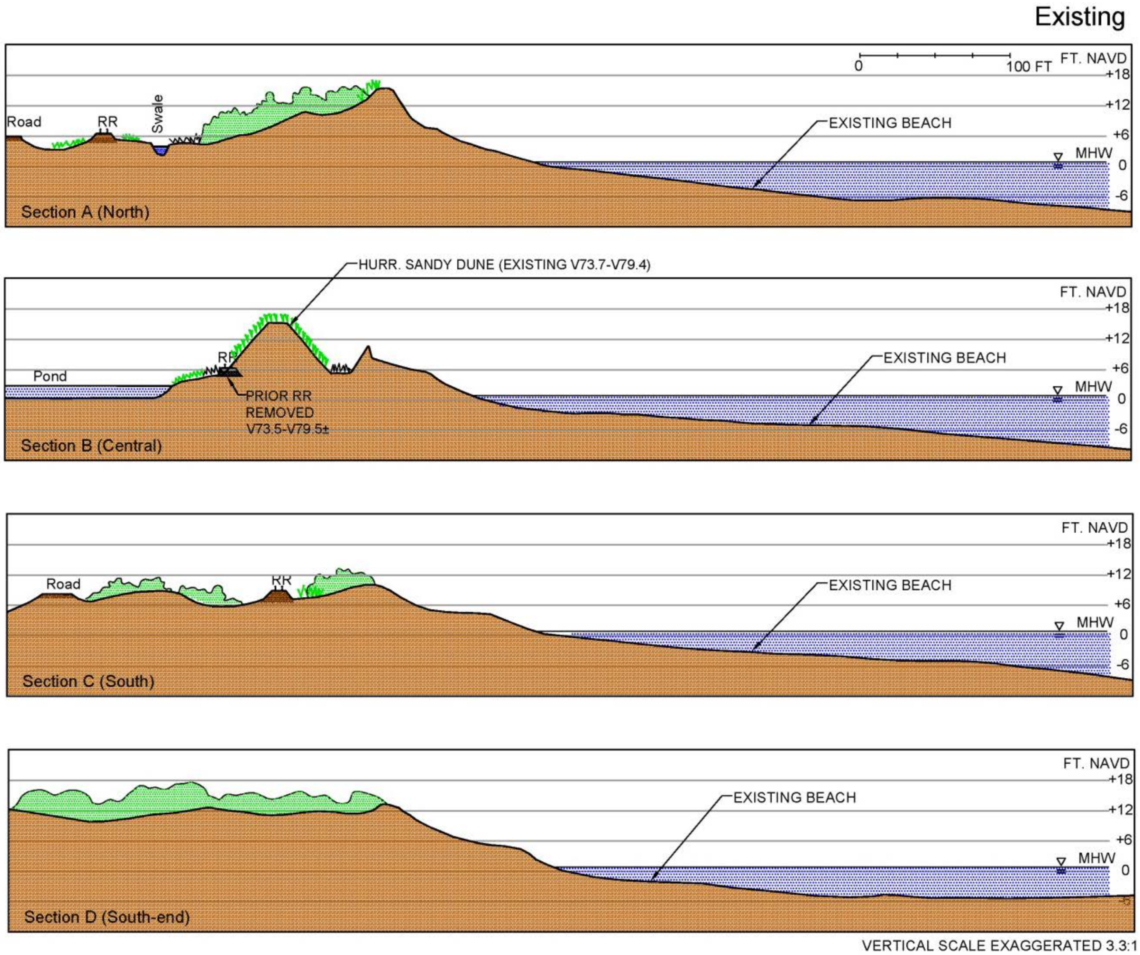


Figure 2-2. Typical existing beach and dune conditions along the northern 7.3 km (4.5 mi) of the KSC ocean shoreline.

Alternative One, the locally preferred alternative, establishes a new secondary dune immediately inland of the existing dune/shoreface, and allows the existing dune and beach to continue to serve as an erosion buffer. Alternative Two reestablishes the historical condition that existed approximately 10 to 15 years ago (1999-2004), and employs beach renourishment to maintain that condition. In Alternative Three, the dune is reinforced at its current eroded location and beach renourishment is employed to maintain that location. Alternative Four is a hybrid approach that utilizes partial restoration of the primary dune and beach as a near-term strategy, and establishes a secondary inland dune as a long-term strategy.

2.1 Alternative One: Inland Dune

Project Alternative One is the locally preferred alternative and involves 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 between monuments V-065.3 and V-084 (Figure 2-1). This alternative involves placing beach-compatible sand along or behind the landward side of the existing dune to create a substantial and continuous inland sand dune. Salt-tolerant vegetation would be planted along the dune crest and side slopes to further stabilize the constructed dune (Figure 2-3). Minimal sand fill would be placed on the beach.

The proposed limits of Alternative One (V-065.3 to V-084.1) reflect the following observations. Over the last 15 years, the MHW shoreline and dune toe have exhibited marginal stability to severe erosion between V-065 and V-085 (Figure 1-3). Hurricane Sandy eroded the dune toe along this entire reach, including erosion of between 15 and 20 ft along the northern end of this reach from V-066 to V-070, as illustrated by shoreline changes from 2011 to 2014 (Appendix A, Figure A-4). The existing elevation and dune volume from V-065 to V-085, ranging from 2 to 16 cy/ft (5 to 40 m3/m), are substantially less than the frontal dune reservoir recommendations for 25-yr and 100-yr storm events per Table 1-1. South of V-084.1, the dune and shoreline exhibits significant volume, vegetation, and historical accretion. Rational physical boundaries for this alternative are accordingly presented by the northern end of the KSC shoreline near V-065.3 and the existing vegetation and UCS #12 camera pad near V-084.1.

In areas where the existing primary dune is extensively degraded (e.g. between monuments V-071 and V-079), sand fill and vegetation would be used to both augment the existing primary dune and construct the secondary inland dune. Where there is little or no existing primary dune, frequent overwash, and narrow dune strand (e.g. between monuments V-073.8 and V-078.5), the primary and secondary dune would be constructed as a single unit atop and behind the existing dune line. Along that area where dune repairs were constructed after Hurricane Sandy (approximately between V073.7 and V079.4), this alternative would augment the height and width of the existing dune by placing sand fill along the constructed dune's crest and landward or seaward side, and replacing the vegetation by additional dune planting. The enlargement of the existing constructed dune would be planned and constructed to maximize the benefit of augmentation (as opposed to constructing an entirely new dune) while minimizing the impacts to the established upland dune (Figure 2-3).

Alternative One represents a managed retreat strategy by establishing shore protection landward of the existing dune and beach berm. It seeks to minimize impacts to the existing beach and dune and to reduce requirements for periodic beach/dune renourishment (maintenance) of the project area. Unavoidable project impacts would occur from initial dune construction in back-beach habitats. Alternative One would be located principally within the uplands but might impact some wetland habitats. The dimensions and locations of the dune feature would be determined so as to maximize the volume of placed sand (relative to the existing dune volumes) while minimizing the spatial impact to existing dune, back-dune, and wetland habitats. The inland dune must also avoid the existing asphalt roadway that parallels the shoreline. This would require constructing the dune along and over the top of the existing rail line. The rail line is abandoned and no longer functional since a 1.6 km (1 mi) section was removed in 2013 after Hurricane Sandy breached it in 2012. Where the railbed remains, the steel rails, wood ties, and gravel that comprise the bed would be either removed prior to dune construction as part of the project, or buried by the sand fill. Approximately 3430 m (11,200 ft) of remaining shorefront railbed would be removed or buried by Alternative One, beyond that already removed during the post-Hurricane Sandy dune repairs in 2014. This includes about 2300 m (7,500 ft) from V065.9 to V073.4, and 1130 m (3,700 ft) from V079.7 to V083.4.

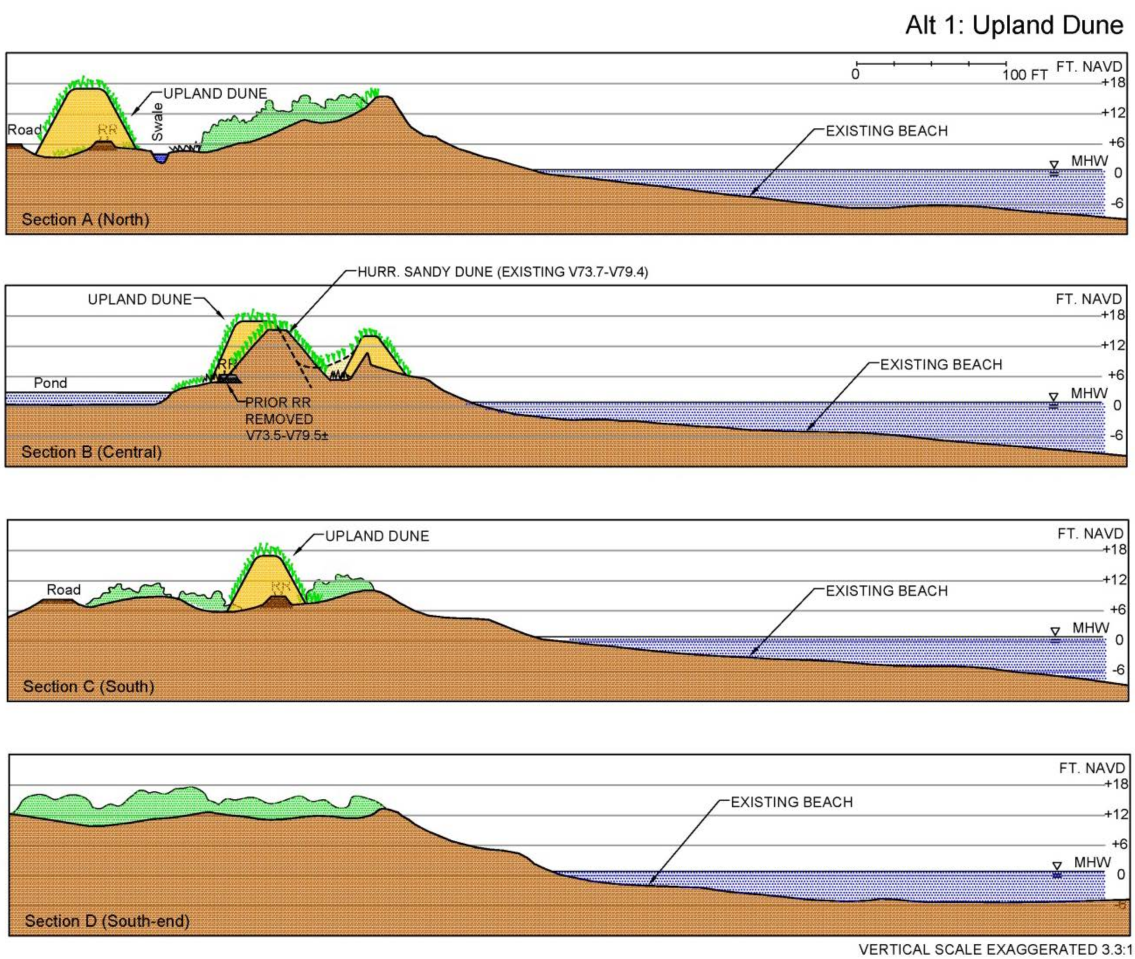


Figure 2-3. Alternative One: Inland Dune.

In the northern project area, the dune would be located between an existing swale (wetland) and the asphalt roadway. In the central area, the dune would be located immediately behind the primary dune crest. In the south area, it would be located behind the existing dune and mostly centered along the eastern railbed between stands of existing vegetation.

Up to approximately 321,000 m^3 (420,000 cy) of sand would be required to construct this alternative, and subsequent native plant installation would also be needed. This equates to about 55 m^3/m (22 cy/ft) of sand on average, locally varying between about 35 and 58 m^3/m (14 and 30 cy/ft). These values reflect a constructed dune with crest elevation of about +5.2 m (+17 ft) NAVD 88, variable top width of 4.6 to 7.6 m (15 to 25 ft) and side slopes of approximately 1(v):1.7(h) to 1(v):2.5(h). Dune vegetation requirements are estimated to be on the order of 756,000 plant units at 45 centimeters (cm) [18 inches (in)] nominal spacing. Installed plant spacing would vary between approximately 38 and 76 cm (15 and 30 in) to provide various levels of vegetative cover and to emulate natural dune conditions.

The fill sand would be trucked to the site from one or more upland sand sources that contain sediment compatible with the existing beach and dune sediments. The specific sources of sand fill would be determined prior to construction and would include commercial upland quarries and/or other sites of excavation that are available. The sand would be placed and graded by mechanical excavators, payloaders and bulldozers. Truck access lanes would be located along existing roadways and/or coincident with the footprint of the constructed dune work in order to minimize damage to existing habitats from truck access and construction activity. The plant material would originate from nurseries and, as practicable, existing plants that would be otherwise impacted by the inland dune construction would be relocated. Plants would be installed with standard nursery requirements, including water and/or absorbent gel and mild fertilizer at the root ball (typical for all alternatives). During planting, straw may be placed on the constructed dune to temporarily stabilize the sand feature while the vegetation takes root.

Long-term maintenance (sand replacement) may be required in areas where the existing primary dune is augmented. Otherwise, the constructed secondary dune, to be placed well landward of the primary dune, is intended to be beyond the extent of typical storm impacts and annual erosion for at least one or two decades (barring very severe hurricane overwash) and therefore, should not require frequent maintenance. Inspection, irrigation, and replacement of planted vegetation would be required until the plants are established.

2.2 Alternative Two: Restore Beach and Dunes

Project Alternative Two involves sand placement for beach nourishment to restore the dune and beach to a condition that existed approximately 10 to 15 years ago (Figure 2-4). The two goals of this alternative are to restore beach width lost to erosion and to reinforce the height and width of the primary dune, principally along its crest and seaward face. This would ensure protection from storm waves and flooding, while also serving to shield nesting and hatching sea turtles from artificial lighting at nearby facilities. The affected project area includes the northern 7.1 km (4.4 mi) of the KSC shoreline, between monuments V-065.3 and V-088.5 (Figure 2-1). Of this total area, dune and beach nourishment would occur along the northern 6.6 km (4.1 mi) from V-065.3 (north KSC boundary) to V-087 (north of the Corrosion Test Facility) (Figure 2-4, Sections A, B, and C). The remaining 460 m (1500 ft) includes sections V-087 to V-088.5 along False Cape and would be constructed as a long tapered transition into the existing dune using beach renourishment with minor augmentation of the existing dune toe (Figure 2-4, Section D).

Alternative Two is an aggressive beach restoration strategy that seeks to reinforce and restore the beach/dune system on its ocean side, i.e., mostly seaward of the existing dune and vegetation line. This approach minimizes impact to existing dune and upland habitats, but because the installed fill is fully exposed to the sea, it is subject to higher erosion rates and requires dedicated future renourishment to ensure shoreline longevity.

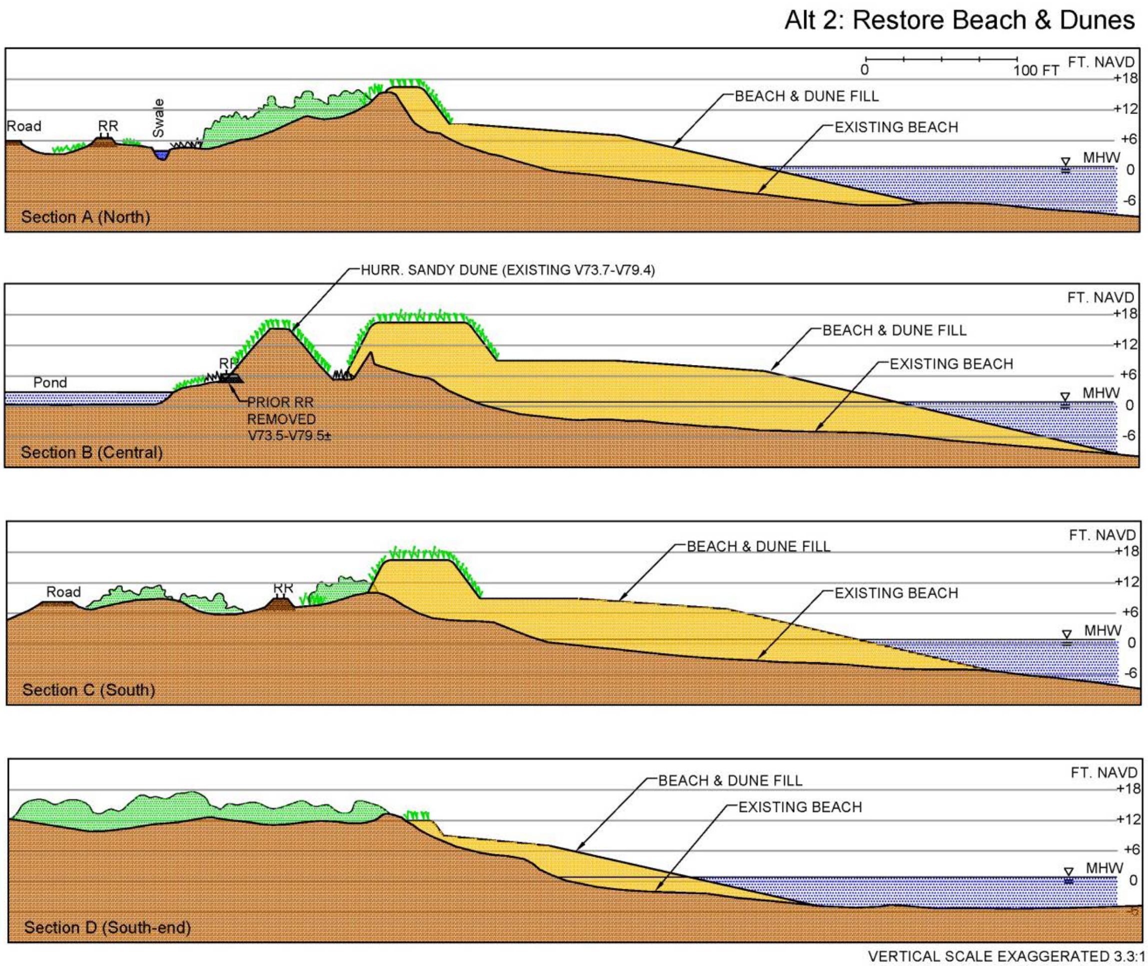


Figure 2-4. Alternative Two: Restore Beach and Dunes.

Sand fill would be placed along the existing beach, dune crest, and seaward face north of V-087, to provide a consistent dune height of about +5.0 m (16.5 ft NAVD) north of V-087 and a dune width and location approximately equivalent to that which existed circa 1995. A dune height of about +5.0 m (16.5 ft) is similar to that which presently exists at the KSC/CNS boundary at Eagle 4. The beach berm would be widened and elevated to similarly restore historical conditions, along with additional sand fill placement to allow for initial fill equilibration and six to ten years of advance renourishment. The constructed dune improvements would be planted with native salt-tolerant dune vegetation immediately after construction.

On the order of up to 2,140,000 m^3 (2,800,000 cy) of beach fill sand would be required to initially construct Alternative Two. This includes an average fill volume of about 316 m^3/m (124 cy/ft) along the principal project area (V-065.3 to V-087), plus south end taper. This is consistent with recommendations for a typical moderate to significant fill density for initial construction of a substantial beach restoration project on Florida's east coast. Planting would require on the order of 814,000 plant units at nominal spacing of approximately 46 cm (18 in).

Project dimensions would vary alongshore as a function of existing conditions and the local historical erosion rate. Nominal dune dimensions would include a dune crest of approximately +5.0 m (16.5 ft) elevation, width of 6.1 to 18 m (20 to 60 ft), seaward slope of about 1(v):2.5(h) and landward slope of about 1(v):1.7(h). Nominal beach fill dimensions would include a berm elevation of about +2.7 m (9 ft) and a total width of about 30.5 to 55 m (100 to 180 ft), of which the seaward 30.50 m (100 ft) berm width would gently slope from +2.7 to 2.1 m (9 to 7 ft) elevation, sloping 1(v):15(h) to the seabed. This sloping berm configuration reflects a turtle friendly design, introduced and used to construct Brevard County beach nourishment projects since 2002, which reduces overtopping, ponding, escarpments, and lighting impacts across the berm.

Along the southern 0.9 km (3,000 ft) of the project area, the fill would include dune-toe reinforcement of about 4.9 m (16 ft) width at elevation +3.7 m (+12 ft), sloping at about 1(v):2.5(h) to an approximately 21 m (70 ft) wide berm sloping from about +2.7 to +2.1 m (+9 to +7 ft), to the seabed at 1(v):15(h).

The source of the beach-compatible sand fill would be the existing Canaveral Shoals II (CS-II) offshore borrow area in federal waters, or alternately, the Canaveral Shoals I (CS-I) offshore borrow area in State of Florida waters (if use of the CS-II site is not available). More details regarding the borrow areas are found in Appendix C. As of May 2014 following the most recent offshore dredging activities, the CS-II site contains approximately 15,884,000 m^3 (20.76 million cubic yards [Mcy]) of sediment and CS-I contains approximately 12,242,000 m^3 (16.0 Mcy) of sediment within their respective permitted boundaries. The sand would be excavated by hydraulic hopper dredge, pumped to the project area via temporary pipeline, and then spread and graded by payloaders and bulldozers. Up to 2,370,000 m^3 (3,100,000 cy) of excavation at the borrow area may be required to construct the 2,140,000 m^3 (2,800,000 cy) beach fill. This dredge volume estimate includes a 10-11% allowance for handling and placement losses between the borrow site and placement area. This is a conservative allowance given the coarse nature and low overfill ratios of the borrow area sediments (1.00 for CS-II and 1.00-1.02 for CSI-I (Appendix C). One or more hopper dredges would carry the excavated sand in 1,500 to 3,000 m^3 (2,000 to 4,000 cy) loads, moor to one of several submerged pipelines temporarily placed between the nearshore and the beach with the aid of temporary anchors or tender vessels, and pump the sand load to the beach through the pipelines via a seawater slurry. After spreading and grading, the beach would be tilled above the wave zone to reduce compaction and to facilitate marine turtle nesting activity. Between four and six access paths would be established over the dune, between the beach and the existing upland roadway, for construction vehicle access. These paths would be established every 1524 m (5000 ft) alongshore, preferentially in areas where existing natural resources are minimal, and the paths would be revegetated after construction. Dune plant material would consist of native species provided from nurseries.

The schedule for Alternative Two would be driven by constraints of the sea turtle nesting season (May – October). Initial project construction would require 30 days for mobilization, a minimum of 165 days for sand placement, plus 30 to 75 days for dune vegetation installation. Staging of some equipment on the beach would be required prior to November 1. Sand fill placement would be limited to the period November 1 to April 30, and vegetation installation would occur in April through July thereafter. Construction of a project of this size in one season (i.e., 2.1 million m^3 [2.8 Mcy] in less than 180 days) is challenging and dependent upon favorable seas. If equipment mobilization can occur in October, the schedule would require net sand placement of over 11,850 m^3 (15,500 cy) per day, every day, including weather and mechanical downtime. This would require one large hopper dredge 3060^+ m^3 (4000^+ cy), or two medium dredges, 1530^+ m^3 (2000^+ cy) each, and probably some combination thereof.

After construction, the placed sand would initially equilibrate to a natural barred profile extending to depths of between -3 and -5 m (-10 and -16 ft) NAVD 88. The post-project loss rate of sand from the project area is preliminarily anticipated to be on the order of 99,392 m^3 (130,000 cy) per year. Periodic renourishment of the project would be required at intervals of between 6 and 10 years, likely comprising between 596,000 m^3 (780,000 cy) and 994,000 m^3 (1,300,000 cy) per event, depending upon the renourishment frequency and the severity of storm erosion between events. Interim renourishment may be required after severe storm erosion. Periodic renourishment would seek to more or less restore the initial project construction template, adjusted to reflect the project performance observed through prior physical monitoring. Future project renourishment would be constructed by hopper dredge, using offshore sand sources, between November 1 and April 30, as outlined above.

2.3 Alternative Three: Reinforce Dune Plus Beach Fill

Project Alternative Three includes beach fill with significant impact to the existing dune. The primary dune would be reconstructed or reinforced with sand and vegetation. Sand would be placed on the beach to provide a wide berm, restoring it to a less eroded condition. This would protect and reinforce the dune at its present location, avoiding advancement toward the sea by sand placement atop the existing dune (Figure 2-5). The affected project area includes the northern 7.1 km (4.4 mi) of the KSC shoreline, between monuments V-065.3 and V-088.5 (Figure 2-1). Of this total area, full dune and beach nourishment would be implemented along the northern 6.6 km (4.1 mi) from V-065.3 to V-087 (Figure 2-5, Sections A, B, and C). The remaining 460 m (1500 ft) from V-087 to V-088.5 would be constructed as a long taper using beach renourishment with minor augmentation of the existing dune toe (Figure 2-5, Section D). This tapered section would serve to help integrate the newly renovated areas into the natural system.

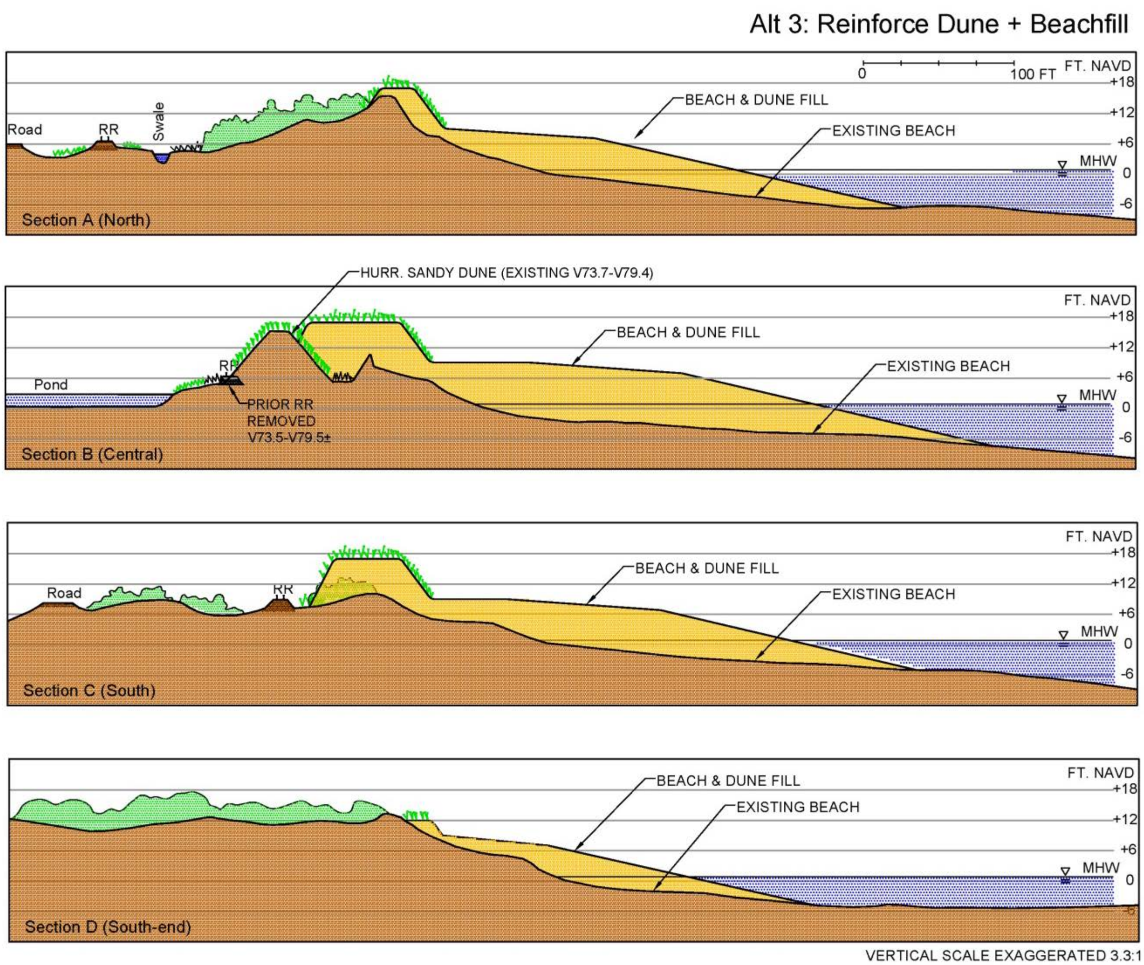


Figure 2-5**.** Alternative Three: Reinforce Dune Plus Beach Fill.

Alternative Three represents a "hold-the-line" beach restoration strategy that seeks to reinforce and restore the beach/dune system at its current, eroded location. This differs from Alternative Two which seeks to restore the dune and beach to a seaward, historical location by placing the sand fill seaward of the existing dune line. In order to establish a stable dune along the existing dune line, Alternative Three places the sand fill atop the existing dune. This approach increases the chance of project success by defending against future erosion rather than attempting to reverse or combat it. Likewise, this approach decreases, but does not eliminate, the requirement for dedicated future renourishment.

Sand fill would be placed along the existing dune crest to provide a consistent dune height of about +5.0 to +5.2 m (16.5 to 17 ft) north of V-087, with varying crest width. The dune width would be constructed to establish a fairly consistent sand volume across the entire primary dune as measured above the 25-year and 100-year still water storm surge elevations. To accomplish this, the constructed dune would be widest along those portions of the central project area (e.g., V-070 to V083) where the existing dune and beach berm is least in volume. In several locations, where the existing primary dune is very narrow, the landward edge of the constructed dune would bury portions of the swale/wetland and remaining railroad bed that are located closely behind the primary dune (e.g., from V-073 to V-074 [swale], and V-079.5 to V-083.2 [railbed]). An alternative is to shift the dune reinforcement seaward; but this "bulges" the dune into an advanced location onto the beach at these areas, rendering the dune vulnerable to erosion. This modification would transform Alternative Three to more closely resemble the approach of Alternative Two.

Seaward of the improved dune, the beach berm would be widened and elevated by sand fill to protect the dune from typical high-frequency storms and wave uprush. This would include sand fill placement to allow for initial fill equilibration and six to ten years of advance renourishment. The constructed dune improvements would be planted with native salt-tolerant dune vegetation immediately after construction.

On the order of up to 1,760,000 m^3 (2,300,000 cy) of beach fill sand would be required to initially construct Alternative Three. This equates to a fill volume of about 260 m^3/m (102 cy/ft) along the principal project area (V-065.3 to V-087), plus south end taper. These values represent a minimum typical recommended fill density for initial construction of beach restoration projects on Florida's east coast. Dune vegetation requirements are estimated to be on the order of 834,000 plant units at nominal spacing of approximately 46 cm (18 in).

Project dimensions would vary alongshore depending on existing conditions and the local historical erosion rate. Along the principal project area north of V-087, the nominal dune dimensions would include a dune crest of approximately +5.0 to +5.2 m (16.5 to 17 ft) elevation, width of 6.1 to 18 m (20 to 60 ft), seaward slopes of 1(v):2.5(h) and landward slope of

1(v):1.7(h). Nominal beach fill dimensions would include a berm elevation of +2.7 m (9 ft) and a total width of about 30.5 to 50.3 m (100 to 165 ft), of which the seaward 30.5 m (100 ft) berm width would slope from +2.7 to +2.1 m (9 to 7 ft) elevation, to the seabed at 1(v):15(h). This gently sloping berm configuration reflects a turtle friendly design introduced and used in Brevard County beach nourishment projects since 2002 that reduces overtopping, ponding, escarpments, and lighting impacts across the berm. On average, along the southern 914 m (3000 ft) of the project area, the fill would include dune-toe reinforcement of 4.9 m (16 ft) width at elevation +3.7 m (12 ft), sloping at 1(v):2.5 (h) to a 21.3 m (70 ft) wide berm sloping from about +2.7 to +2.1 m (9 to 7 ft), sloping 1(v):15(h) to the seabed.

The source of the beach-compatible sand fill would be the existing CS-II offshore borrow area in federal waters, or alternately, the CS-I offshore borrow area in State of Florida waters if use of the CS-II site was not available (Section 3.1.6). The sand would be excavated by hydraulic hopper dredge, pumped to the project area via temporary pipeline, and then spread and graded by payloaders and bulldozers. Up to 1,950,000 m^3 (2,550,000 cy) of excavation at the borrow area may be required to supply the 1,758,000 m^3 (2,300,000 cy) beach fill. One or more hopper dredges would carry the excavated sand in 1,500 to 3,000 m^3 (2,000 to 4,000 cy) loads, moor to one of several submerged pipelines temporarily placed between the nearshore and the beach with the aid of temporary anchors or tender vessels, and pump the sand load to the beach through the pipelines via a seawater slurry. After spreading and grading, the beach would be tilled above the wave zone to reduce compaction and to facilitate marine turtle nesting activity. Between four and six access paths would be established over the dune, between the beach and the existing upland roadway, for construction vehicle access. These paths would be established approximately every 1,524 m (5,000 ft) alongshore where damage to existing resources would be minimized, and the paths would be revegetated after construction. The dune plant material would consist of native species provided by nurseries.

Initial project construction would require approximately 30 days for mobilization, 150 days for sand placement, and 30 to 75 days for dune vegetation installation. Staging of some equipment on the beach would be required beginning not later than October 15. Sand fill placement would be limited to the period November 1 to April 30, outside the sea turtle nesting season, and vegetation installation would occur from April through July. Construction of a 1.8 million m^3 (2.3 Mcy) project in one season (180 days) is practical as long as winter seas are typical. Assuming initial mobilization commences October 15, net sand placement of over 9557 m^3/day (12,500 cy/day), including downtime, would be required. At this site, this is a reasonable expectation for one large hopper dredge (3,058+ m^3 [4,000+ cy]), or two medium dredges (1,529 m^3 [2,000 cy]) each. It would require regulatory allowance for some advance construction activity on the beach, such as pipeline staging, beginning as early as October 15 in order for sand placement to commence in early November.

Approximately 1,130 m (3,700 ft) of railbed could be buried by the dune fill near the south-central end of the project area. If the rail, ties, and gravel were to be removed as part of the project, then this demolition activity would have to be conducted prior to the commencement of sand dredging and placement.

After construction, the placed sand would initially equilibrate to a natural, barred profile extending to depths of between -3 and -5 m (-10 and -16 ft) NAVD 88. The post-project loss rate of sand from the project area is preliminarily anticipated to be on the order of 91,750 m^3 (120,000 cy) per year. Periodic renourishment of the project would be required at intervals of between 6 and 10 years, likely comprising between 550,480 m^3 (720,000 cy) and 917,500 m^3 (1,200,000 cy) per event, depending upon the renourishment frequency and the severity of storm erosion between events. Interim renourishment may be required after severe storm erosion. Periodic renourishment would seek to more or less restore the initial project construction template, adjusted to reflect the project performance as determined through prior physical monitoring. Project renourishment construction would be by hopper dredge, using offshore sand sources, between November 1 and April 30, as outlined above.

2.4 Alternative Four: Hybrid Approach – Inland Dune Plus Beach Fill

Project Alternative Four is a hybrid of proposed Alternatives One, Two, and Three. This action includes placement of sand to restore beach lost to erosion, reinforcement of the existing primary dune (principally along the seaward edge and face, similar to Alternative Two), and construction of a secondary dune inland of the primary dune, identical to Alternative One (Figure 2-6**)**. The inland dune would be constructed from either upland sand sources or offshore dredged sources. In the latter case, sand would be temporarily stockpiled on the beach and then mechanically rehandled to construct the inland dune. Wetland areas and critical habitat would be avoided as much as possible during construction of the secondary dune, as described for Alternative One. Salt-tolerant native vegetation would be planted along the crest and face of both the primary dune and inland dune as needed for stabilization.

The affected project area includes the northern 7.1 km (4.4 mi) of the KSC shoreline, between monuments V-065.3 and V-088.5 (Figure 2-1). Of this total area, the inland dune would be constructed along the northern 5.8 km (3.6 mi), V-065.3 to V-084.1; nourishment of the beach and primary dune would be accomplished along the northern 6.6 km (4.1 mi), V-065.3 to V-087 (Figure 2-6, Sections A, B, and C). The remaining 460 m (1500 ft), V-087 to V-088.5 would be constructed as a long taper consisting of beach renourishment with minor augmentation of the existing dune toe (Figure 2-6, Section D). Temporary stockpiling of sand on the beach for construction of the inland dune would occur along the central 3.1 km (1.9 mi) of shoreline, between monuments V-070 and V-080.

Alternative Four represents a hybrid strategy that combines managed retreat with beach renourishment. That is, it combines construction of the inland dune (identical to Alternative One) with a modest-scale beach/dune nourishment project (similar to Alternatives Two and Three). But, in contrast to the latter two alternatives, Alternative Four limits the width and placement of beach fill sand to the seaward face of the primary dune to minimize impacts to the existing dune vegetation/habitat. Alternative Four allows the inland dune to be constructed from sand dredged from an offshore borrow area (in lieu of, or in addition to, upland truck-haul sand sources). The ability to construct the inland dune from offshore sands potentially improves the sediment and habitat quality of the dune, given the consistent, beach-compatible characteristics of sediment from the available offshore borrow areas, and it avoids impacts associated with upland truck-haul delivery of sand to the site. The nourishment of the beach and primary dune, constructed in addition to the secondary inland dune, would partly restore and stabilize the eroded beach/dune system; as such, it would serve to protect the inland dune and, therefore, augment its longevity.

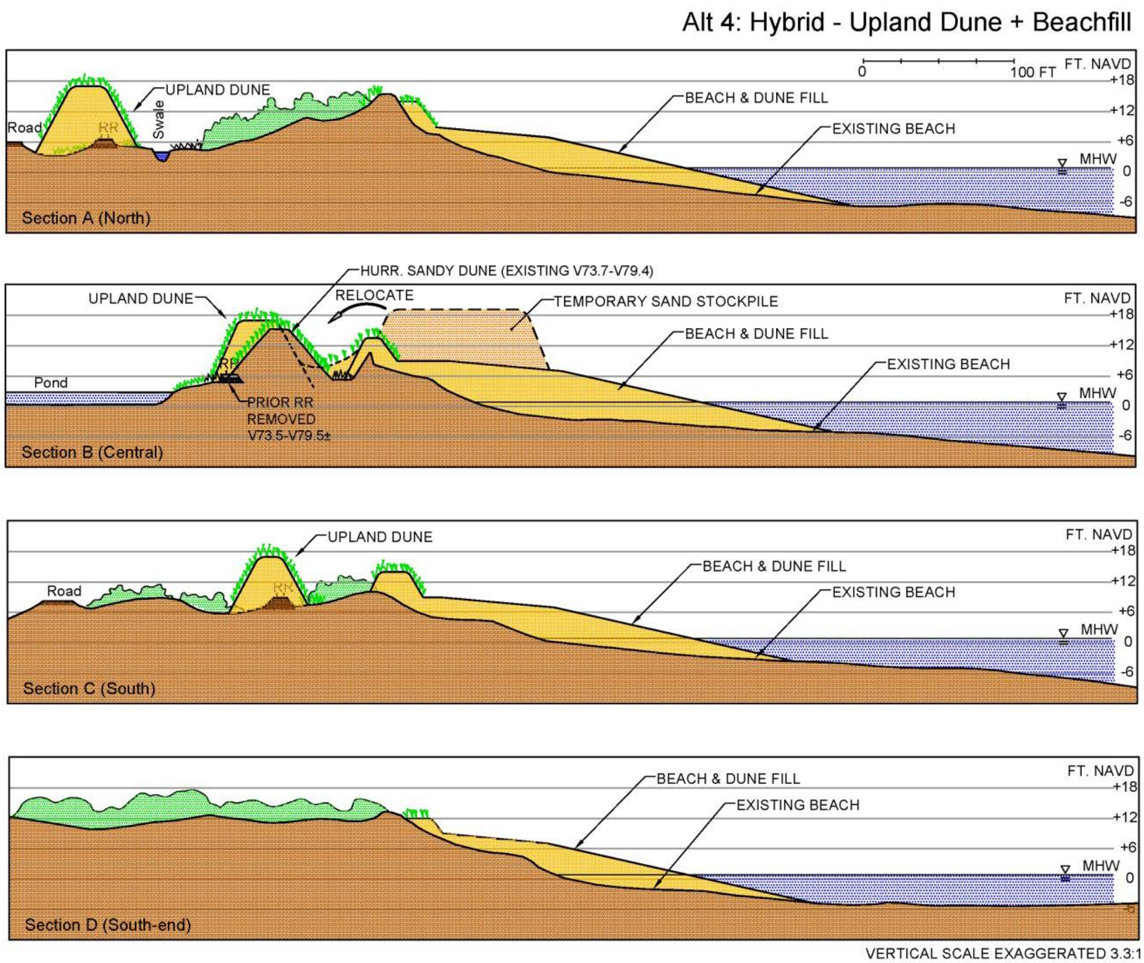


Figure 2-6. Alternative Four: Inland Dune Plus Beach Fill.

The sand placed on the beach and primary dune would ultimately erode and require renourishment. However, future renourishment is not inherently critical to the long-term integrity of this project alternative because the inland dune provides a longer term measure of shore and flood protection.

Alternative Four consists of three overlapping principal elements: nourishment of the beach and primary dune, construction of the secondary inland dune, and a temporary sand stockpile on the beach if offshore sand is used to construct the inland dune. The overall dimensions and layout of the inland dune would be similar to that described for Alternative One (Section 2.1). The beach and dune restoration, north of monument V-087 would consist of augmentation of the primary dune to a crest elevation of at least +4.3 m (14 ft) with varying crest width of at least 3.0 to 6.1 m (10 to 20 ft), and seaward dune slope of about 1(v):2.5(h). The beach nourishment berm would be constructed at a width of 23 to 30 m (75 to 100 ft), sloping from about +2.7 m (9 ft) at the dune to +2.1 m (+7 ft) at the seaward edge, sloping 1(v):15(h) to the seabed. The southern 460 m (1500 ft) would be constructed as a long tapered transition into the existing beach and dune.

For construction of the inland dune, a temporary sand stockpile would be built on the beach nourishment berm between monuments V-070 and V-080 (approximately), above the typical limit of wave run-up, to an elevation of +5.8 m (19 ft). The nominal storage volume would approach 229,500 m^3 (300,000 cy). This stockpile would be created during hydraulic placement of the beach nourishment fill, and then offloaded by trucks to create the inland dune. A similar operation was employed at Patrick Air Force Base (PAFB) in 2005 whereby sand was stockpiled to the beach nourishment berm and then offloaded by trucks at appropriate locations for inland dune construction. The resulting inland dune and nourished primary dune would be planted with salt-tolerant native dune vegetation.

Up to 1,484,000 m^3 (1,940,000 cy) of beach fill sand would be required to initially construct Alternative Four. This equates to an average fill volume placement of about 223 m^3/m (88 cy/ft) along the principal project area (V-065.3 to V-087). Exclusive of the inland dune, the beach/dune renourishment volume along the principal project area (V-065.3 to V-087) requires 173 m^3/m (68 cy/ft) on average. The latter value is similar to the initial construction volume of the Brevard County Federal Shore Protection Project in 2000-2003, which used 140 m^3/m (55 cy/ft) and 203 m^3/m (80 cy/ft) for the North Reach (NR) and South Reach (SR) project segments, respectively. Dune vegetation requirements are estimated to be on the order of 1,018,000 plant units at nominal spacing of approximately 46 cm (18 in). Actual spacing would vary.

Approximately 3430 m (11,200 ft) of remaining shorefront railbed would be removed or buried by Alternative Four, beyond that already removed during the post-Hurricane Sandy dune repairs in 2014. This includes about 2,300 m (7,500 ft) of railbed between V065.9 and V073.4, and 1,130 m (3,700 ft) of railbed between V079.7 and V083.4, more or less.

The source of the beach-compatible sand fill would be the existing CS-II offshore borrow area in federal waters, or alternately, the CS-I offshore borrow area in State of Florida waters, if use of the CS-II site was not available (see Section 3.1.6). The sand would be excavated by hydraulic hopper dredge, pumped to the project area via temporary pipeline, and then spread and graded by payloaders and bulldozers. Up to 1,681,000 m^3 (2,100,000 cy) of excavation at the borrow area might be required to construct a 1,484,000 m^3 (1,940,000 cy) beach fill. One or more hopper dredges would carry the excavated sand in 1,500 to 3,000 m^3 (2,000 to 4,000 cy) loads, moor to one of several submerged pipelines temporarily placed between the nearshore and the beach with the aid of temporary anchors or tender vessels, and pump the sand load to the beach through the pipelines via a seawater slurry. The temporary sand stockpile would be constructed during the hydraulic beach fill operation using the same bulldozers and payloaders to lift and shape the stockpile. During and/or immediately after placement of the sand stockpile, excavators, payloaders and trucks would transfer the stockpiled sand to the inland dune locations using access paths established at discrete locations through the primary dune and along the footprint of the inland dune. After final spreading and grading, the beach fill area would be tilled above the wave zone to reduce compaction and facilitate marine turtle nesting activity. Between six and eight access paths would be established over the dune, between the beach sand stockpile and the existing upland roadway, North Phillips Parkway, for construction vehicle access. These paths would be established at 762 m to 1,523 m (2,500 ft to 5,000 ft) intervals where existing resources are least sensitive, and the pathways would be revegetated after construction. All dune plant material would be native species provided from nurseries and from relocation of native dune plants that are otherwise displaced by the dune construction, as practicable.

If properly sequenced, initial project construction would require on the order of 30 days for mobilization, 165 days for sand placement (beach fill and inland dune), plus between 30 and 75 days for dune vegetation installation after sand placement. At least three months would be necessary in advance of construction for removal of the railbed materials, though this could be partly conducted during initial dredge and fill placement. Staging of some equipment on the beach would be required beginning not later than October 15. Sand fill placement would be limited to the period November 1 to April 30, and vegetation installation would likely occur in April through July thereafter. Dredging and beach placement of up to 1.48 million m^3 (1.94 Mcy) of sand would require about 160 days. Constructing the beach fill and the inland dune from a beach fill stockpile in one season (between November 1 and April 30) would require the following sequence: the central 3,048 m (10,000 ft) of beach fill and sand stockpile would be constructed first, requiring about 85 days after initial mobilization. Offloading of the sand stockpile to construct the inland dune would commence about one-third of the way through this process and continue through the remainder of the construction season, requiring at least 125 days to complete inland dune sand placement. The north and south ends of the beach/dune nourishment would then be constructed, requiring about 70 days after the central stockpile section is completed, plus additional time for tilling. Allowing initial mobilization of equipment upon the beach to commence October 15, and assuming a dredge start date of not later than November 15, would require net sand placement of about 9,557 m^3 (12,500 cy) per day, including downtime. At this site, this is a reasonable expectation of one large hopper dredge ($3{,}000^+$ m^3 [$4{,}000^+$ cy]), or two medium dredges ($1{,}500^+$ m^3 [$2{,}000^+$ cy]) each. It would require regulatory allowance for some construction activity on the beach to begin no later than October 15 in order that construction can be completed by April 30. Upland relocations, salvage and demolition, including railbed, should be completed prior to, or within several weeks after commencement of beach fill. Alternatively the inland dune portion (only) of this effort could be constructed in stages independently of the beach fill over a period of several years as funds become available.

As a function of construction requirements, Alternative Four can be scaled to dredge and place only the volume of offshore sand necessary to build the upland dune (Alternative One) and the beach-nourishment platform to support the temporary stockpile of sand from which the upland dune is constructed. This would potentially decrease the fill volume of the project to on the order of 803,000 m^3 (1,050,000 cy) and the beach nourishment length to about 3,350 m (11,000 ft) from about V070 to V081, while constructing all of the upland dune described in Alternative One.

After construction, the placed beach nourishment sand would initially equilibrate to a natural, barred profile extending to depths of between -3 and -5 m (-10 and -16 ft) NAVD 88. The post-project loss rate of sand from the project area is anticipated to be on the order of 91,750 m^3 (120,000 cy) per year. If elected, periodic renourishment of the beach element of the project would be required at intervals of 6 to 10 years. This would likely comprise between 550,480 m^3 (720,000 cy) and 917,470 m^3 (1,200,000 cy) per event, depending upon the renourishment frequency and the severity of storm erosion between events. Interim renourishment may be required after severe storm erosion. Unlike Alternatives Two and Three, however, periodic renourishment is optional (i.e., it could be delayed or forgone) because long-term defense against flooding and coastal inundation would be provided by the inland dune in the event that the primary dune and beach are eroded or breached by storms, similar to that described for Alternative One. Maintenance beach renourishment, when elected, would seek to more or less restore the initial project construction template, adjusted to reflect the project performance observed through monitoring. Project renourishment construction would be accomplished by hopper dredge, using offshore sand sources, between November 1 and April 30, as outlined above.

2.5 No Action Alternative

Under the No Action Alternative the KSC beach would be left in its current state, the CS-I and II offshore sand sources would not be utilized, and the lease with BOEM would not be required. An onshore borrow area would not be used for dune repair or construction. Nature would be allowed to take its course and storms would continue to erode the beach and further threaten or destroy KSC infrastructure and critical coastal habitat. The historical progression of dune and beach erosion along the northern 7.1 km (4.4 mi) of the KSC shoreline (north of False Cape) documented over the past decades, combined with the continuation or possible acceleration of sea level rise, strongly indicates that the beach and dune would continue to degrade in the absence of intervening actions. In the No Action Alternative, overtopping and breach of the primary dune, particularly between LC 39A and LC 39B, are likely to occur in the near future, which could result in large-scale inundation, habitat alteration, and land loss along the coastal strand.

2.6 Alternatives Not Carried Forward

Several additional alternatives were evaluated during the course of this assessment, including:

- Non-structural (management) alternatives including revisions to proposed coastal development
- Facilities relocation and coastal retreat strategies
- Armoring the shoreline using concrete or sheet pile seawalls, or rock revetments and riprap
- Construction of coastal structures including groins and breakwaters
- Beach fill without dune enhancement.
- Primary dune enhancement without beach fill

Non-structural (management) alternatives are not relevant because the eroded project shoreline is not the site of, or subject to, commercial or other coastal development that is specifically endangered by the erosion. KSC regulates, controls, and plans any development along its coastline. Modifications to regulations and planning protocols would not eliminate the potential for dune breaching, interior coastal flooding, land loss, and damage to mission critical infrastructure that is posed by the existing eroded state of the beach and dunes.

Landward relocation of existing infrastructure and/or retreat, of itself, would not eliminate the potential for damage posed by the existing beach and dune erosion. Relocation of launch facilities would be both cost prohibitive and result in significant adverse impacts to the natural environment. Action Alternatives One, Three, and Four evaluated in this EA incorporate a strategy of managed retreat, including abandonment of all or portions of the existing shore-parallel railbed behind the dune; however, this is proposed in conjunction with proactive measures of constructing an inland dune and/or beach nourishment for requisite shore protection.

Shoreline armoring by seawalls or revetments would protect the upland from further erosion and most storm flooding. Such armor could be constructed within the dune or upland, landward of the wave zone, and exempt from State permit restrictions. However, as chronic erosion progresses, the dune and beach in front of the armor would disappear, ultimately resulting in little or no beach habitat along the exposed armor. Beach (flank) erosion would also occur along the shorelines adjacent to the ends of the exposed armor. Maintaining dune or dry beach in front of shoreline armor, particularly in the face of the relatively high rates of shoreline erosion exhibited along central KSC, requires high-frequency sand placement. Experience at similar locations indicates that it becomes more or less impractical to maintain a beach or dune in front of the armor after the beach becomes severely eroded by storms or where there is prolonged exposure of the armor to the wave zone. Armoring the beach would also have disastrous effects on sea turtle nesting habitat. While this alternative might fulfill the objective of protecting man-made assets, critical natural resources, including habitat for several federally protected species, would eventually be destroyed.

Groins, breakwaters and similar structures, with or without beach fill, can reduce erosion and/or stabilize the shoreline in the immediate vicinity of the structures. However, along an open-coast shoreline such as KSC, the presence of coastal structures could result in unacceptable erosion south of False Cape that ultimately extends beyond the KSC shoreline to the CCAFS shoreline. There is also the potential to adversely affect sea turtle nesting both at the groin field beaches and downdrift beaches. Introduction of coastal structures along an otherwise natural, open-coast shoreline, particularly prior to initial application of non-stabilized dune/beach restoration, is not a recommended coastal engineering or management practice because of its potential to cause adverse impacts along the adjacent shorelines. Evaluation of structural alternatives such as armoring, groins, and breakwaters may be warranted in the future, but not at present.

Beach fill alone, without dune enhancement, would not provide the needed elevation to protect from overwash and flooding, and therefore does not meet the shoreline protection objective.

Dune fill alone, without beach fill, would consist of periodic placement of sand along the seaward face of the eroded dune to elevate and maintain the primary dune. This would be accomplished through frequent truck-haul placement of beach-compatible sand from upland sources. Given the severely eroded state of the primary dune along the north-central shoreline, the chronically high annual erosion rates, and the potential damage to KSC assets when the dune is overtopped or breached, this is a high-frequency, high-maintenance alternative that is not likely to reliably meet the shoreline protection objective.

3.0 Affected Environment

3.1 Physical Environment

KSC is located on the east coast of Florida, 64 km (40 mi) due east of Orlando on the north end of Merritt Island adjacent to Cape Canaveral. KSC is relatively long and narrow, approximately 56 km (35 mi) in length and varying from 8 to 16 km (5 to 10 mi) in width. It is bordered on the west by the IRL and on the east by the Atlantic Ocean and CCAFS. The Indian River, Banana River and the Mosquito Lagoon collectively make up the IRL system. The northernmost end of the Banana River lies between Merritt Island and CCAFS and is included as part of KSC submerged lands. The northern border of KSC lies in Volusia County near Oak Hill along Mosquito Lagoon. The southern boundary of KSC runs east west along the Merritt Island Barge Canal, which connects the Indian River with the Banana River and Port Canaveral at the southern tip of Cape Canaveral.

3.1.1 Air Quality

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. NASA activities at KSC and CCAFS are classified as a major source of air pollution. NASA holds a Title V Air Operation Permit which governs the air emission from those activities.

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, occurring infrequently but throughout the year, include launches and prescribed fires which play a role in the quality of air as episodic events. Air Quality Standards and KSC air quality data are described in the most recent Air Quality report (IHA 2014).

3.1.2 Climate Change

Solar irradiance, the greenhouse effect, and Earth's reflectivity are the key factors interacting to maintain temperatures on Earth within limits conducive to life. Specifically, the climate of the Holocene (the past 12,000 years) is the set of conditions under which human civilization has arisen. Within the range of temperatures experienced by Earth in the past 2.5 million years, changes in solar irradiance due to orbital perturbations known as Milankovitch Cycles have forced climate into and out of glacial cycles, with greenhouse gas concentrations thought to provide a positive feedback. However, changes in greenhouse gas concentrations in the atmosphere have been identified as the primary forcing functions of current climate change on Earth (EPA 2009a, IPCC 2007, IPCC 2013). Human land use changes, burning of fossil fuels for energy, and other activities are contributing to increases of greenhouse gases in the atmosphere.

The potential impacts of increasing concentrations of atmospheric carbon dioxide (CO_2) and other climate altering materials such as methane, aerosols, and black carbon particulates on the Earth's climate have been well documented by the Intergovernmental Panel on Climate Change (IPCC) and are the dominant reason for societal interest in the carbon cycle (IPCC 2007, IPCC 2013). These impacts include warmer temperatures, rising sea levels, changes in rainfall patterns, and a host of other associated and often interrelated effects. However, the consequences of the buildup of CO_2 in the atmosphere extend beyond climate change alone. "CO_2 fertilization" of plants (Caspersen et al. 2000, Schimel et al. 2000, Houghton 2002) and ocean acidification are foremost among these direct, non-climatic effects. The absorption of anthropogenic CO_2 by the world's oceans over the last century has made them more acidic. This acidification will compromise the growth and survival of corals, plankton, and other marine organisms that build their skeletons and shells from calcium carbonate, and could dramatically alter the composition of ocean ecosystems, possibly eliminating coral reefs by 2100 (Orr et al. 2005).

Emissions of CO_2 at KSC are primarily associated with commuting vehicle traffic, ground support operations, and launch events. However, a comprehensive carbon budget for each activity is not available. A baseline annual estimate for the last 30 years of the Shuttle Program was calculated with the following assumptions:

- An average workforce of 15,000 employees with 13,000 vehicles (NASA 2010) averaging 20 miles per gallon, and driving an average of 60 miles a day, 240 days a year
- KSC power consumption of 1,400,000 million British thermal units (MMBtu) from a combination of electrical purchases, natural gas, fuel oil, diesel, and gasoline
- Four Space Shuttle launches per year using two solid rocket boosters per launch

Commuting contributed approximately 83,200 metric tons (mt) of CO_2, KSC energy use contributed 60,600 mt, and the four shuttle launches contributed 156 mt (Dreschel and Hall 1990) for an estimate of 144,000 mt of CO_2 per year for each year of the 30 year Shuttle Program. With retirement of the Space Shuttle and the reduction in the work force and ground support operations, annual CO_2 emissions are currently estimated at approximately 99,000 mt. This assumes a reduction to 7,000 vehicles, KSC energy use of 1,200,000 MMBtu derived from fossil fuel sources, and no Space Shuttle launches (NASA 2013). Continued reductions in carbon emissions are expected with improvements in vehicle emissions, energy production by alternative energy sources, and improved facility energy use efficiencies planned for all new construction. Reductions may be off-set in the future by planned expansion of commercial operations, increases in the number of facilities and workforce, and increases in the number of days of warm weather requiring increased use of air-conditioning. The KSC 2012 Sustainability Plan identifies greenhouse gas reduction targets for the Center (NASA 2012a).

In 2010, the NASA Headquarters Office of Strategic Infrastructure and the NASA Earth Sciences Office established the Climate Adaptation Science Investigator (CASI) team to develop downscaled climate change forecasts for the different NASA centers and to address potential impacts and adaptation strategies to ensure sustainability of valuable NASA infrastructure. As of 2014, members of the team have developed regional and local climate projections for KSC using 33 different global climate models (GCMs) and statistical methods to link the model values to empirical long-term data from the City of Titusville covering the period between 1900 and 2010. The Titusville data for temperature are presented in Figure 3-1.

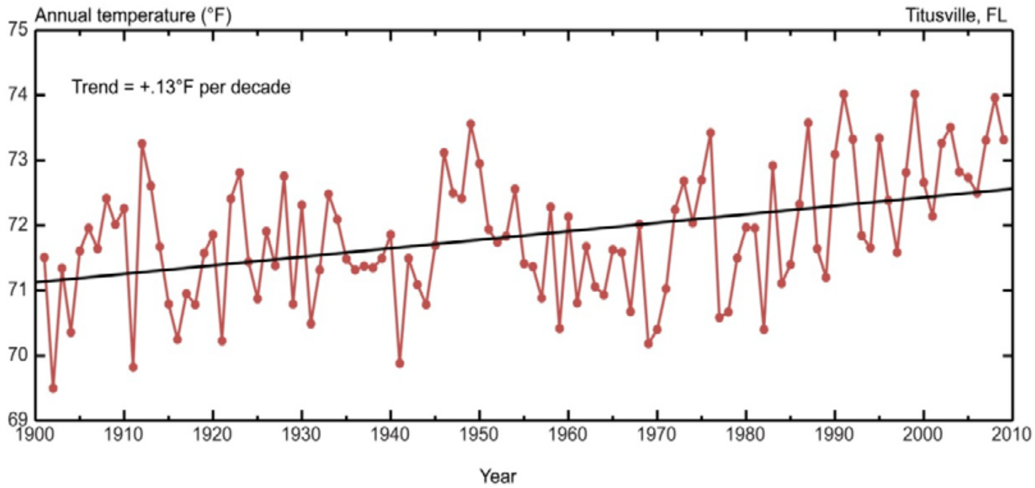


Figure 3-1. Long-term temperature data from Titusville, Florida. The trend is +.13 °F per decade.

Temperature has been trending upward for the period of record. Rainfall has displayed no upward or downward trend in intensity or volume. Average air temperature for the 30-year climate baseline period of 1971 to 2000 is 22^{o} C (72.2^{o} F). Climate forecasts for the region suggest average temperatures will increase by as much as 7.2^{o} F during the latter part of the century. Rainfall projections indicate little change in the total annual amount of 135 cm (53 in). Estimated climate conditions for air temperature and rainfall for KSC are found in Table 3-1. Projections for the occurrence of days above and below temperatures that impact the outdoor workforce and current estimates suggest there will be a dramatic increase in the numbers of days above 32^{o} C (90^{o} F) when compared to the annual baseline average. This will greatly influence the potential for heat stress and require additional management action. The number of cold days is expected to decrease slightly. Projections of the occurrence of extreme events are summarized in Table 3-2. As the amount of energy in the atmosphere increases, the probability of events like heavy downpours and extreme winds (including hurricanes) increases. Heat stress conditions will likely increase.

Table 3-1. Estimated climate conditions for air temperature and rainfall for KSC, FL[1].

a. Temperature

Baseline (1971 - 2000) 72.2°F	**Low Estimate (10th Percentile)**	**Middle Range (25th to 75th Percentile)**	**High Estimate (90th Percentile)**
2020s	+ 1.0 °F	+ 1.5 to + 1.9 °F	+ 2.3 °F
2050s	+ 2.2 °F	+ 2.7 to + 3.9 °F	+ 4.5 °F
2080s	+ 2.8 °F	+ 3.2 to + 6.1 °F	+ 7.2 °F

b. Precipitation

Baseline (1971 - 2000) 52.8 inches	**Low Estimate (10th Percentile)**	**Middle Range (25th to 75th Percentile)**	**High Estimate (90th Percentile)**
2020s	- 5 percent	- 1 to + 8 percent	+ 12 percent
2050s	- 7 percent	- 2 to + 8 percent	+ 17 percent
2080s	- 11 percent	- 3 to + 10 percent	+ 16 percent

[1]Based on 33 GCMs and two Representative Concentration Pathways. Baseline data are for the 1971 to 2000 base period for Titusville, Florida and are from the NOAA National Climatic Data Center (NCDC) Shown are the low-estimate (10th percentile), middle range (25th percentile to 75th percentile), and high-estimate (90th percentile).

Table 3-2. Projected likelihood of extreme events through the later part of the 21st Century, based on global climate simulations, published literature, and expert judgment (Adapting Now to a Changing Climate, NP-2010-11-687-HQ, NASA).

Event	Trend	Likelihood
Heat Stress	Up	Very Likely (>90%)
Downpours	Up	Likely (>66%)
Intense Storms	Up	More likely than not (>50%)
Extreme Winds	Up	More likely than not (>50%)

Sea Level Rise

At the coast, mean sea level 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 mean sea level 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. Relative sea level changes are not an indication of sea level rise. A eustatic sea level change is that which is caused by an alteration to the volume of water in the world ocean (i.e., true sea level rise).

According to the IPCC, global mean sea level continues to rise due to thermal expansion of the oceans and the loss of mass from glaciers, ice caps, and the Greenland and Antarctic ice sheets (Church et al. 2001, Bindoff et al. 2007, IPCC 2007, IPCC 2013). There is high confidence that the rate of sea level rise has increased between the mid-19th and the mid-20th centuries (Bindoff et al. 2007). For the 20th century, the average rate was 1.7 ± 0.5 millimeters/year (mm/yr) (0.07 ± 0.2 in/yr), consistent with the 2001 IPCC estimate of 1 to 2 mm/yr (0.04 to 0.08 in/yr) (Church et al. 2001). However, satellite observations available since the early 1990s provide more accurate sea level data with nearly global coverage. This decade-long satellite altimetry dataset shows that since 1993, sea level has been rising at a rate of around 3 mm/yr (0.12 in/yr). It is important to note that the change in sea level is variable. The rate of sea level rise experienced in the vicinity of LC 39 for example, might be greater or less than this global average.

The projected increased rates of sea level rise have been attributed to a greater contribution of melting glaciers and increased ice-sheet flow (IPCC 2013). According to Meier et al. (2007), sea level is likely to rise at rates ranging between 2.2 and 5.1 mm/yr (0.09 and 0.20 in/yr), while another study estimates rates of between 3.1 and 6.1 mm/yr (0.12 and 0.24 in/yr) (Carlson et al. 2008).

In the region of Cape Canaveral and KSC, mean sea level is considered to be -0.29 m (-0.9 ft) NAVD 88, while mean water level of the Indian River Lagoon (IRL) in the vicinity is estimated at -0.21 m (-0.7 ft) NAVD 88, based on analysis of data from historic and current NOAA tide gauges in the region. Monthly water levels in the IRL and Atlantic Ocean fluctuate annually on a cyclic basis, with maximum heights generally in October, falling rapidly as the ocean cools and contracts through the winter, with minimal elevations in February and March (Figure 3-2).

Projected sea level rise scenarios for KSC have been provided by the NASA CASI team (Table 3-3). These projections are based on results of the analysis of 16 global climate models and include the more current information on rapid ice melt. At KSC, the rise in sea level will produce a similar rise in lagoon level as a result of their connection through inlets and groundwater. An analysis of the potential for land inundation by rising lagoon and sea level is summarized visually in Figure 3-3. This analysis is based on land surface elevations derived from the 2007 LiDAR mission conducted by the Florida Division of Emergency Management. The analysis shows which areas of KSC land will have the same or lower elevation than the lagoon and be subject to flooding during the fall high water period as a result of any event that raises water levels to these heights. This includes storm events or sea level rise changes in local hydrology.

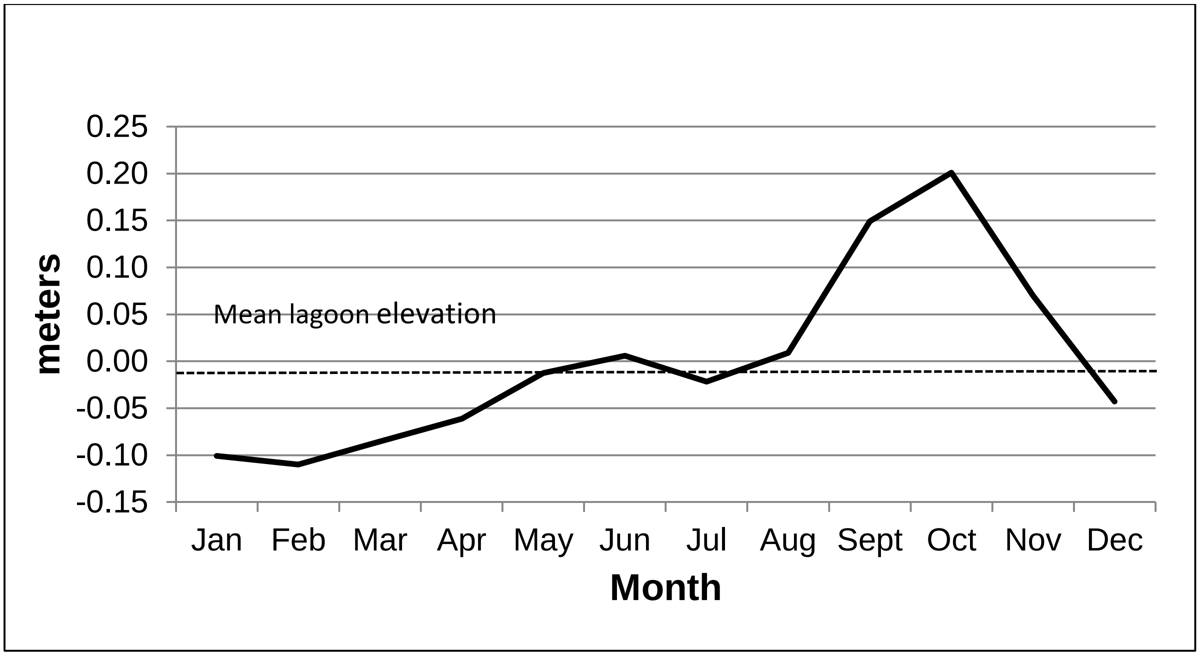


Figure 3-2. Annual average water level in the IRL measured at the USGS water level recording station in Haulover Canal between the IRL and Mosquito Lagoon.

Table 3-3. Projected sea level rise in the vicinity of KSC through the latter part of the 21st Century.

Baseline (2000 - 2004) 0 inches	**Low Estimate (10th Percentile)**	**Middle Range (25th to 75th Percentile)**	**High Estimate (90th Percentile)**
2020s	2 inches	3 to 6 inches	8 inches
2050s	6 inches	9 to 17 inches	25 inches
2080s	10 inches	15 to 33 inches	49 inches

Projections are based on a 4-component approach that incorporates both local and global factors. The model-based components are from 24 GCMs and two Representative Concentration Pathways. Shown are the low-estimate (10th percentile), middle range (25th percentile to 75th percentile), and high-estimate (90th percentile). Projections are relative to the 2000-2004 base period.

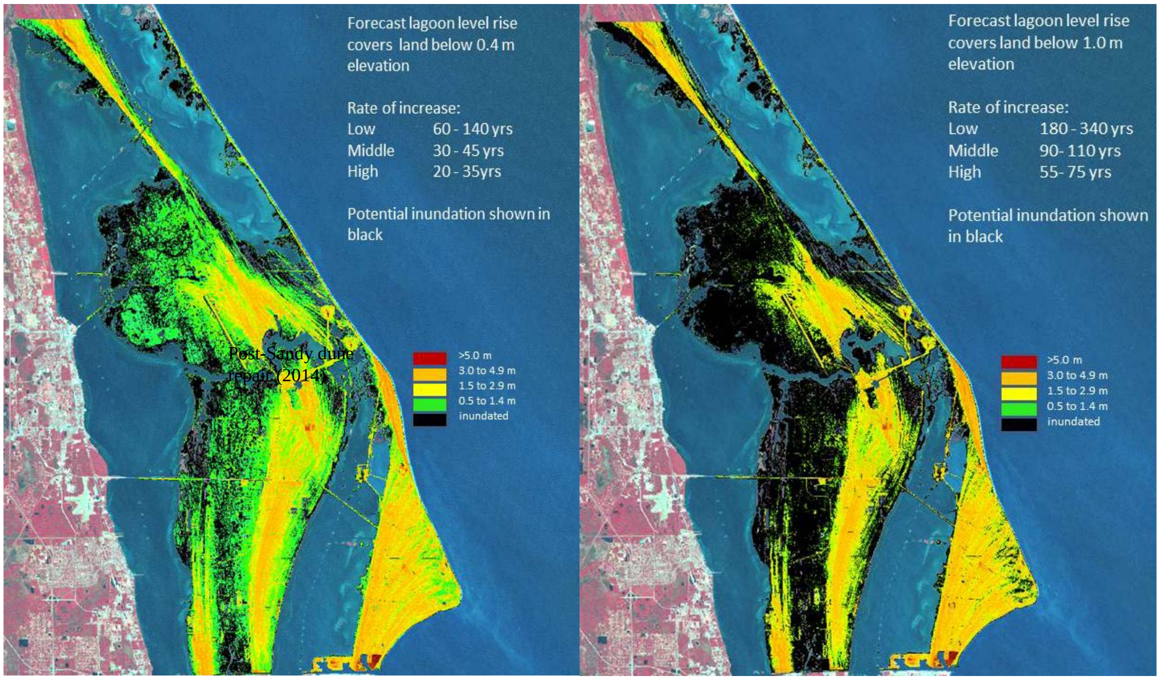


Figure 3-3. Potential land surface inundation estimates at KSC for areas below 0.4 m (1.3 ft) and 1.0 m (3.3 ft) elevation (NAVD 88), assuming three different sea level rise rates (C. Hall, unpublished data): Low = 3-5 mm/year (0.1-0.2 in/year); Middle = 9-11 mm/year (0.3-0.4 in/year); High = 13-15 mm/year (0.5-0.6 in/year). These areas will be inundated by any event that raises water levels to these elevations, including storm surges, floods, or sea level rise.

3.1.3 Bathymetry

Bathymetry is defined as the offshore elevation seaward of the intertidal shoreface. At KSC, it includes nearshore and inner-shelf sandbars, troughs, and shoals. Bathymetric data for the KSC shoreline and inner shelf are available from National Ocean Service (NOS)/NOAA Hydrographic Surveys (1878, 1928, 1958, 1965), the U.S. Geological Survey (2010), and private surveyors (Morgan and Eklund, Inc. and Olsen Associates, Inc. 2012, 2014). The nearshore zone of KSC is characterized by one to two persistent bars (Fig. 3-4) that migrate onshore and offshore as forcing conditions change (Kline et al. 2011). Seaward of this, the offshore bathymetry is complex with linear and isolated shoals and intervening troughs. Figure 3-5 shows the north-northwestward trending shoreface-tied linear shoals (A, B, C) north of False Cape. Larger shore-connected shoals exist at False Cape (Chester Shoal) and Cape Canaveral (Southeast Shoal). Chester Shoal is separated from the shoreline by a 300 m (984 ft) wide trough. Several larger isolated shoals (several kilometers long and wide), such as Bull, Ohio, and Hetzel are found 6-13 km (3.7-8.1 mi) offshore. Isolated and shore-attached shoals change in configuration under modern sediment transport processes. A comparison of historical bathymetric surveys shows that the shoals have gotten shallower, broader and thicker (Field and Duane 1974). The cross-shore survey transects from March 2012 and September 2014 collected by Morgan and Eklund, Inc. depict the nearshore bathymetry at four monument locations within the project area (Figure 3-6).

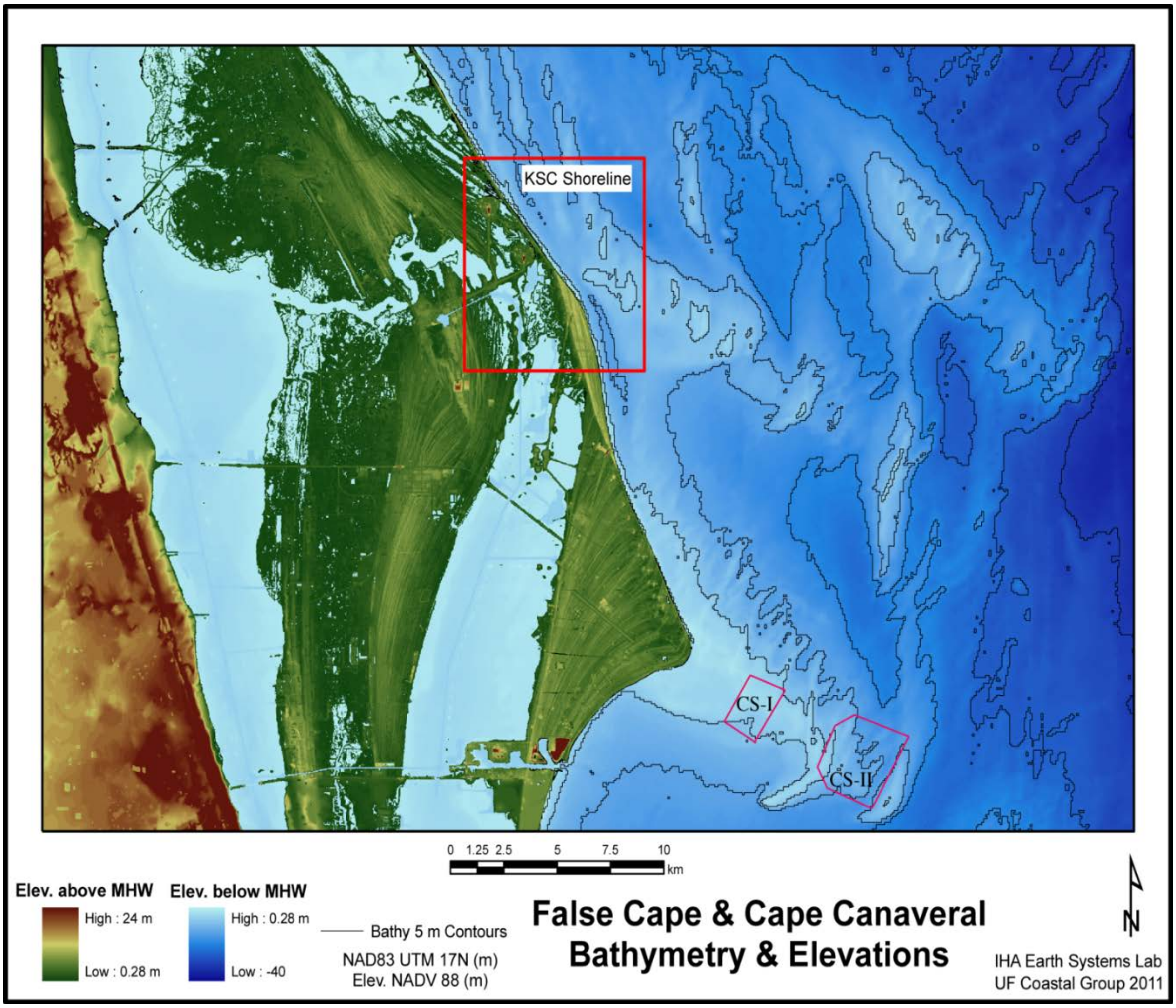


Figure 3-4. Bathymetry and topography of Cape Canaveral and the adjacent coastline. All elevations above mean high water (0.28 m NAVD 88) are colored as topography. Elevation from LiDAR survey (2007). Bathymetry is composite from NOS/NOAA. Approximate positions of CS-I and CS-II borrow areas shown.

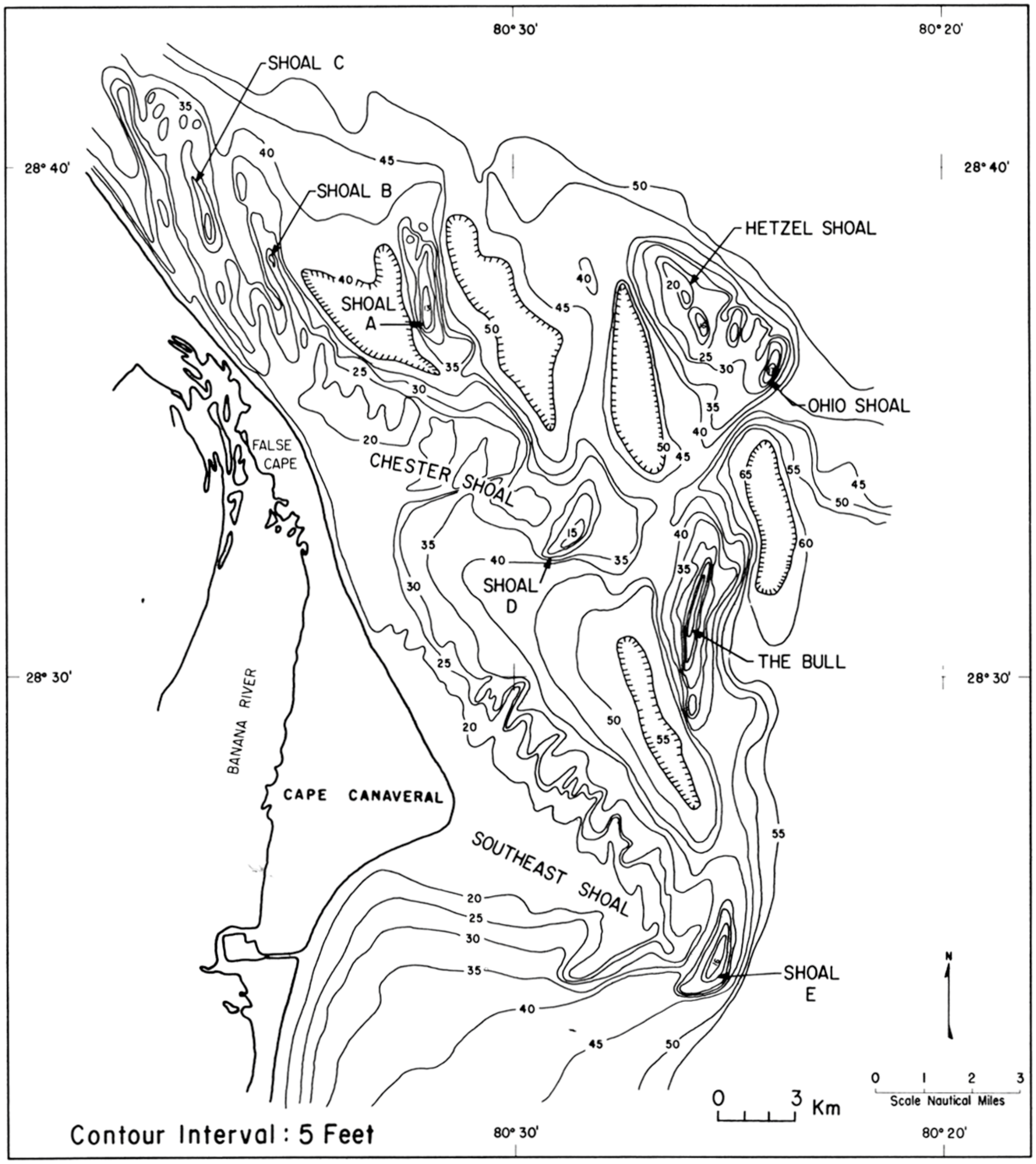


Figure 3-5. Bathymetry and associated relief features of Cape Canaveral inner shelf (Field and Duane 1974).

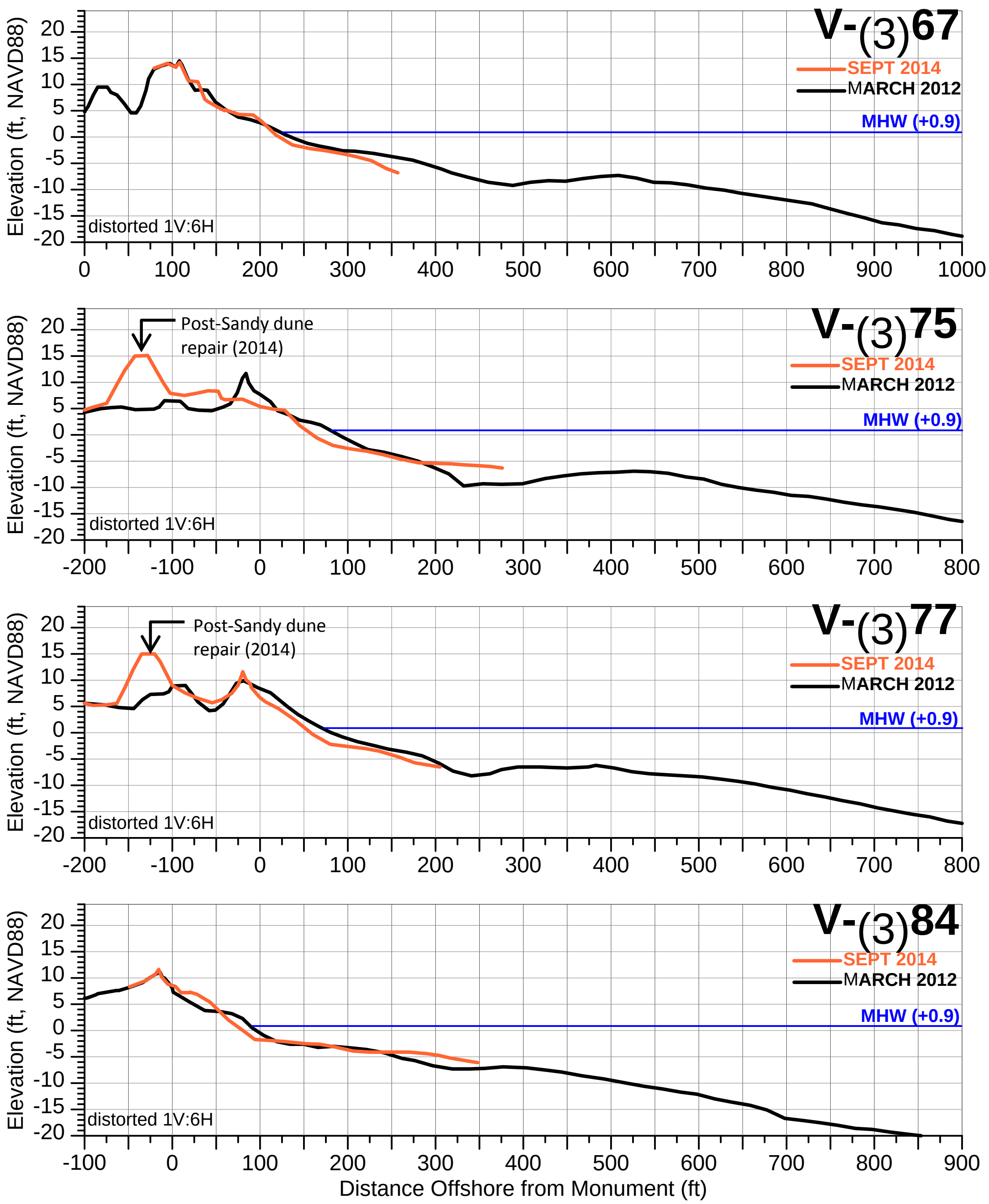


Figure 3-6. Cross-shore elevation profiles for select Florida DEP virtual monuments from survey data collected in March 2012 and September 2014. See Figure 3-7 for location of monuments.

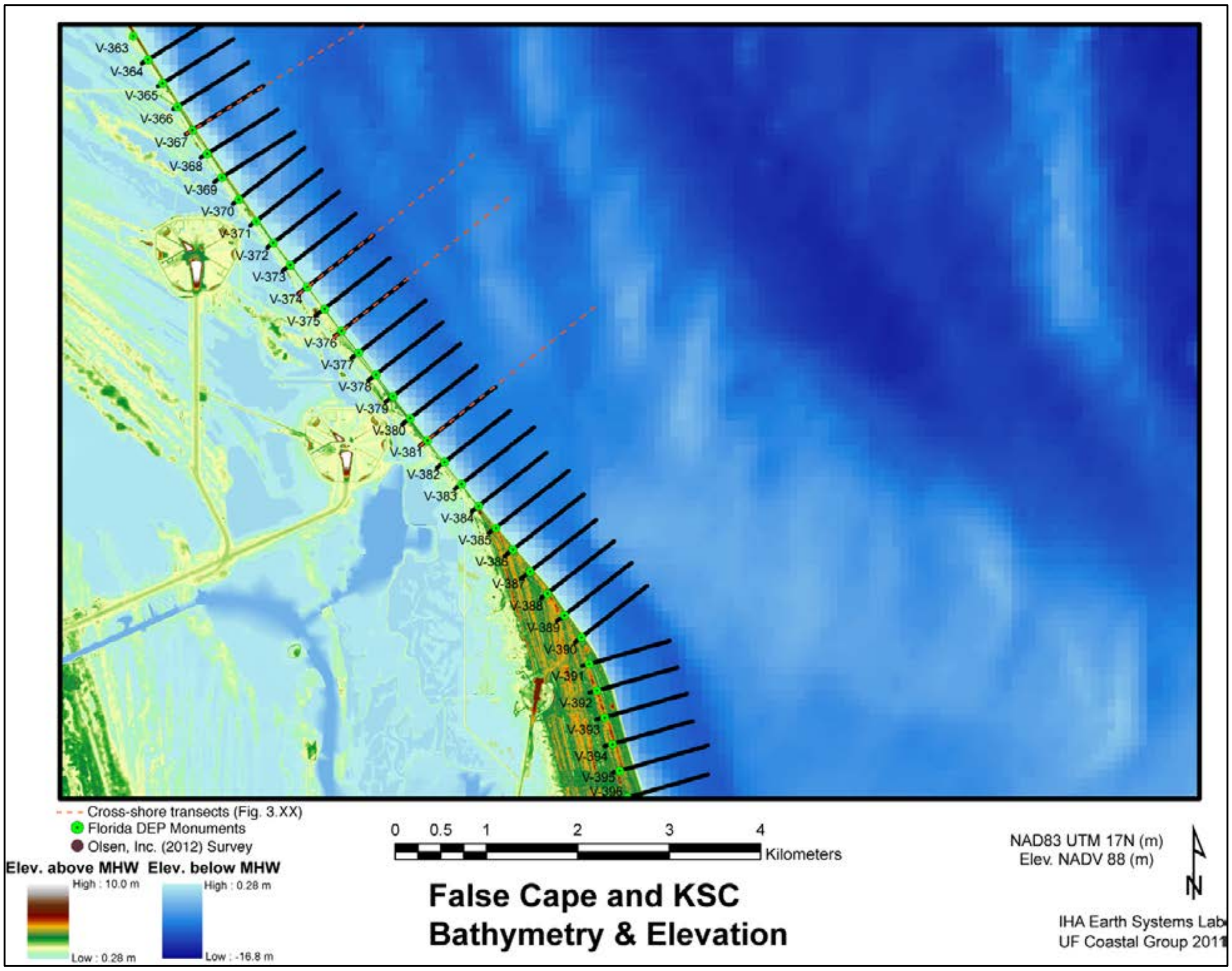


Figure 3-7. Bathymetry and topography of the KSC project area. All elevations above mean high water (0.28 m NAVD 88) are colored as topography. Elevation from LiDAR survey (2007). Bathymetry is composite from NOS/NOAA. Location of FDEP virtual benchmarks shown (note: transects numbers abbreviated in this study to show only last two digits, e.g., V-388=V-88). Approximate extent of 2012/2014 surveys shown (red dotted lines), as well as representative elevation transects shown in Figure 3-6.

3.1.4 Geology and Geomorphology

This section describes the geology and geomorphic elements of the project area, including an overview of the Cape Canaveral-Merritt Island sedimentary complex, the KSC shoreline, shoreline changes, offshore sand shoals and onshore soils. Data regarding the geology and soils of KSC are additionally described in “Geology, Geohydrology and Soils of Kennedy Space Center: A Review” (Schmalzer and Hinkle 1990a). Descriptions for these resources are found in the Shuttle Landing Facility (SLF) EA (NASA 2007) and the KSC Environmental Resource Document (ERD) (NASA 2015) as well.

3.1.4.1 Cape Canaveral Merritt Island Cuspate Foreland

The beach at KSC is part of the Cape Canaveral-Merritt Island sedimentary complex, which is part of the Florida East-Coast Barrier System (Davis et al. 1992). This barrier island system is composed of quartz-rich barrier islands anchored by Pleistocene coquina (Anastasia Formation), resulting in generally high stable foredunes that experience minimal overwash. South of Matanzas Inlet (near St. Augustine, FL), the islands are strongly wave-dominated with widely spaced, approximately 100 km (62 mi), tidal inlets. The Cape Canaveral sedimentary system is a large cuspate foreland that contains a series of accretional Pleistocene-Recent beach ridge and swale sets projecting 20 km (12.4 mi) seaward of the regional coastal trend. Aerial orthographic quadrangle photos taken prior to the construction of KSC on Cape Canaveral indicate the presence of four to eleven individual beach ridge sets (Brooks 1972). Each set exhibits a characteristic orientation, wavelength, period, and amplitude that may reflect the wave climate and sea level conditions responsible for ridge set formation (Rink and Forrest 2005, Brooks 1972).

3.1.4.2 KSC Coastal Zone

The KSC coastal zone is part of the Atlantic Beach Ridge physiographic province as described by White (1970). Sediments underlying KSC have accumulated in alternating periods of deposition and erosion since the Eocene. Surface sediments are of Pleistocene and Recent ages. Merritt Island is comprised of two cape features formed at two different sea level high stands during the late Pleistocene. The west side of Merritt Island (SLF, Visitor Center) was possibly formed during a sea level high stand during Oxygen Isotope Stage 5C (~105 ka). The east side of Merritt Island (LC 39A, LC 39B) was possibly formed during Oxygen Isotope Stage 5A high stand (~ 85 ka) (Rink and Forrest 2005; Burdette et al., 2010). As sea level dropped during the Laurentide Glaciation (~22 ka), Banana Creek likely incised through Merritt Island and flowed through the modern shoreline just north of LC 39A. At its maximum extent during this sea level low stand, Merritt Island was further seaward than it is today. As sea level rose, transgressive shoreline erosion and reworking resulted in the formation of Cape Canaveral proper and the Canaveral Peninsula, on which is found the KSC shoreline. Cape Canaveral has accreted seaward for at least the last 4,000 years (Hoyt and Henry 1971, Komar 1998, Hayes 1994), and is currently migrating to the south as a large-scale (~60 km^2) landform (Komar 1998). Migration proceeds by eroding older ridges in the north (near LC 34, LC 20, LC 19, and LC 16) and depositing to the south of the tip of the cape. False Cape (LC 41, LC 40, and LC 37) is also a southward migrating shoreline feature that is supplied with sand eroded from older ridges on Merritt Island north of LC 39A.

Sand ridge and swale topography dominates eastern Merritt Island and northern Canaveral Peninsula and False Cape. The shoreline of KSC consists of low sloping sandy beaches fronting a coastal dune that varies in elevation alongshore. Subsequent to the 2014 reconstruction of the most severely eroded areas of the frontal dune after Hurricane Sandy, the elevations of the frontal dunes range from +2.6 m (+8.5 ft) to +6.25 m (+20 ft) NAVD 88 within the project area. The NAVD 88 datum is about 0.27 m (0.9 ft) below MHW. The mean elevation in the project area is 1.6 m ±1.1 m (1σ) (5.2 ft) NAVD 88. Northern Canaveral Peninsula and False Cape exhibit environmental zones related to changes in topography across the island profile. Generally, dunes and sand ridges are found at the highest elevations, while beaches, marshes, and wetlands are found at the lowest, or in intervening swales. Based on a comparison with aerial photographs collected in 1943, a significant proportion of the wetlands west of the project area near LC 39A and LC 39B were altered and infilled during construction of KSC (Figure 3-8).

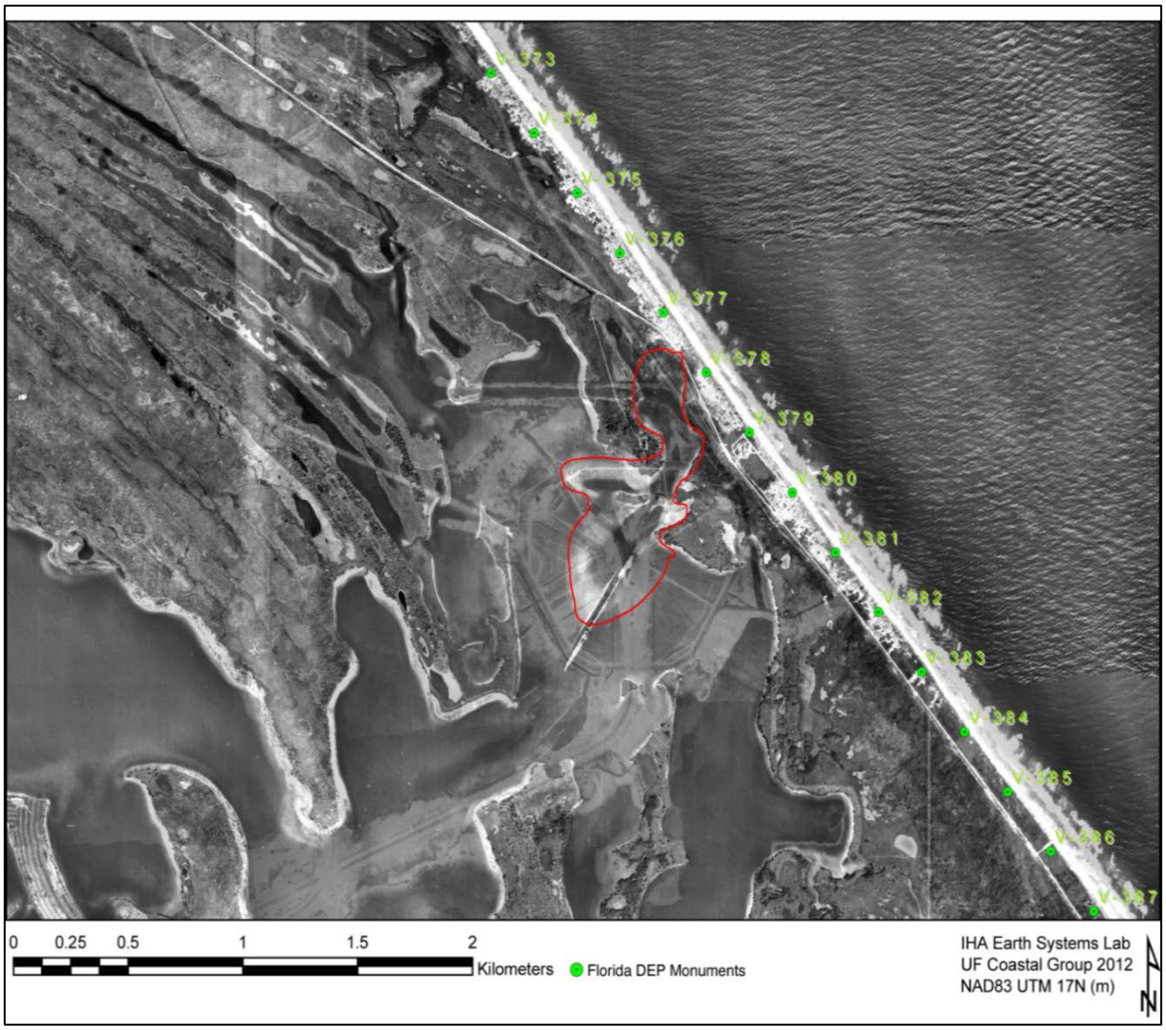


Figure 3-8. Aerial imagery from 1943 showing overwash and possible inlet delta (red outline) that formed near DEP monuments V-77 and V-78. Current locations of LC 39A and 39B are shown as semi-transparent features for reference.

North of V-69, the shoreline is backed by tightly spaced sand ridges that are higher than those landward and to the south. These more closely spaced ridges have provided a supply of sand to the beach at some time in the past as indicated by their truncation along the current coastal dunes. This is an area of historic shoreline stability with dune heights ranging from 4.3 to 5.5 m (14.1 to 18.0 ft). The dune field in this region is comprised of a single dune. From V-69 to V-77 the sand ridges backing the shoreline are further apart and lower in elevation than those near V-66. This area has been susceptible to overwash since at least the 1940s, as seen in historical aerial photographs. Within this region, there are smaller single primary dunes 2.2 to 4.0 m (7.2 to 13.1 ft) in height. Many of these dunes have been eroded or overwashed since 2005. In October 2012, Hurricane Sandy resulted in overwash and erosion of the frontal dune, particularly between V-72 and V-83. Portions of the dune were completely removed by the storm. In the spring of 2014, a new dune was constructed between V-73.7 and V-79.4, immediately inland from the eroded frontal dune, with crest elevation of 4.6 m (15 ft) NAVD 88. The dune was constructed with beach-compatible sand from an existing upland stockpile at Cape Canaveral Air Force Station.

After construction of the dune repairs in 2014, the crest elevation of the frontal dune (including the new dune feature) is approximately 4.6 m (15 ft) along the project area shoreline, except for two areas: 1) between V-71 and V-73.7, where it is as low as 3.5 m (11.5 ft), and 2) between V-79.4 and V-84, where it is as low as 2.5 m (8.2 ft) NAVD 88. South of V-084, through the north shoulder of False Cape near V-090, the frontal dune elevation is between about 4.0 and 4.6 m (13 – 15 ft), but the width of the dune and seaward beach increases. The dunes are backed by a multi-dune system and fronted by several proto-dunes that are part of the accreting False Cape. Further south, from V-090 to V-095, the multi-dune system increases and the frontal dune elevation is uniform at about 3.6 m (12 ft) NAVD 88.

There is evidence of a breach and formation of an inlet some time before 1943 in the area between LC 39A and LC 39B (Figure 3-8). Additionally, as Banana Creek incised through the area near LC 39A during the Last Glacial Maximum low stand, additional sand may have been removed, contributing to the observed long-term shoreline retreat in this region. There currently are no erosion control structures (i.e., groins or seawalls) along the KSC shoreline, and there is no record of the construction of large structures prior to development of KSC.

Beach sands at KSC are supplied from active erosion of the shoreface and dunes, onshore transport of material from adjacent shoals, and southerly longshore transport. Field and Duane (1974) analyzed beach samples from New Smyrna Beach to Melbourne Beach, including 15 samples from KSC/CCAFS. Samples analyzed for grain size and composition were collected from the sediment surface in the swash zone. Beach samples range from coarse to fine sand, containing between 2-58% acid-soluble material. Variations in size and composition appear to reflect general shoreline orientation, relative supply from offshore sediment sources, and local outcrops of coquina (Anastasia Formation). Temporal changes in grain size were interpreted as being forced by periodic storms, tidal excursion, and seasonal changes in wave direction. In conjunction with offshore samples, there is a direct correlation between mean grain size and mass percent shell material (i.e., acid-soluble) (Figure 3-9). Decreased sorting with increasing grain size was interpreted to reflect the greater inclusion of shell material at coarser grain sizes. The coarsest beach sand with the largest component of shell material was found just north of KSC along the Mosquito Lagoon shoreline where the beach is steepest. The authors interpret this trend as reflecting a local offshore source of shell material, possibly subtidal outcrops of Anastasia Formation coquina. They concluded that erosion of upland topography and associated coastal retreat are considered to be the most significant source of sediment to the beach along this shoreline.

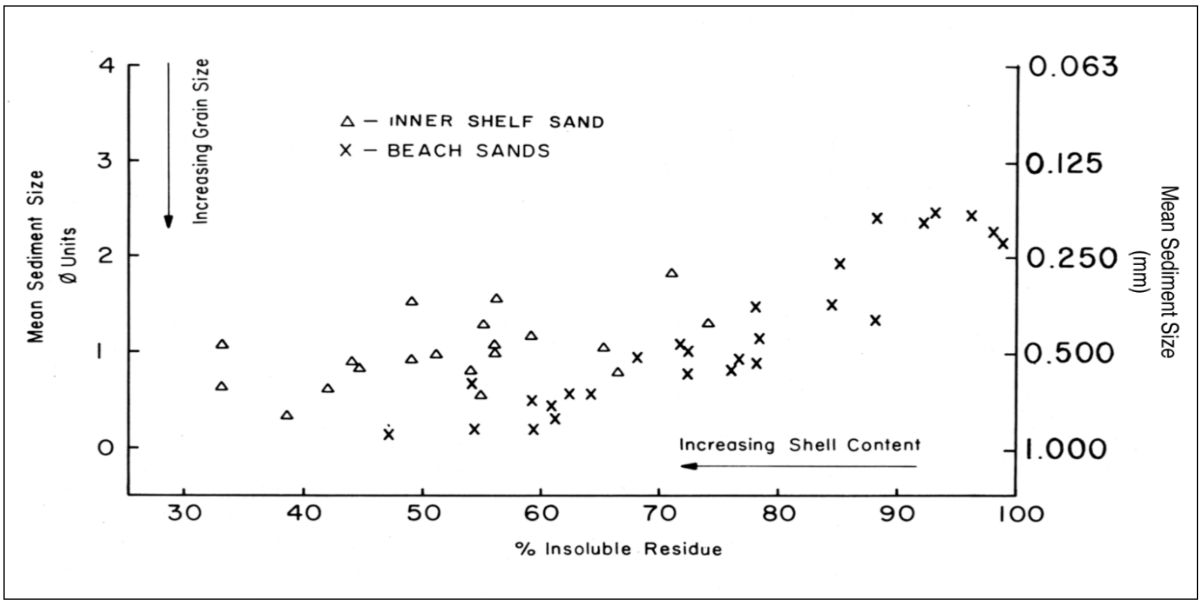


Figure 3-9. Mean grain size versus percent hydrogen chloride (HCl)-soluble material from potential borrow areas offshore and beach samples from Field and Duane (1974).

3.1.4.3 Shoreline Changes

Long-term shoreline change trends and variability about the trend in shoreline positions were calculated for the study area in three discrete intervals: 1875-2008, 1875-1969, and 1969-2008 by Dean (1998) and Absalonsen and Dean (2010) using the historical shoreline data base assembled by the Bureau of Beaches and Coastal Systems (BBCS) of the FDEP (Figure 3-10).

The more recent change rates (1969-2008) do not reflect the longer-term rates (1876-2008). Long-term change rate data are sporadic at this site after 1943 due to KSC's designation as a federal facility bordered by a National Seashore and a U.S. Air Force Base. The KSC shoreline can be divided into four regions with distinctive morphology, grain size, and wave climate (Jaeger et al. 2011). Alongshore reference systems used in this study are noted.

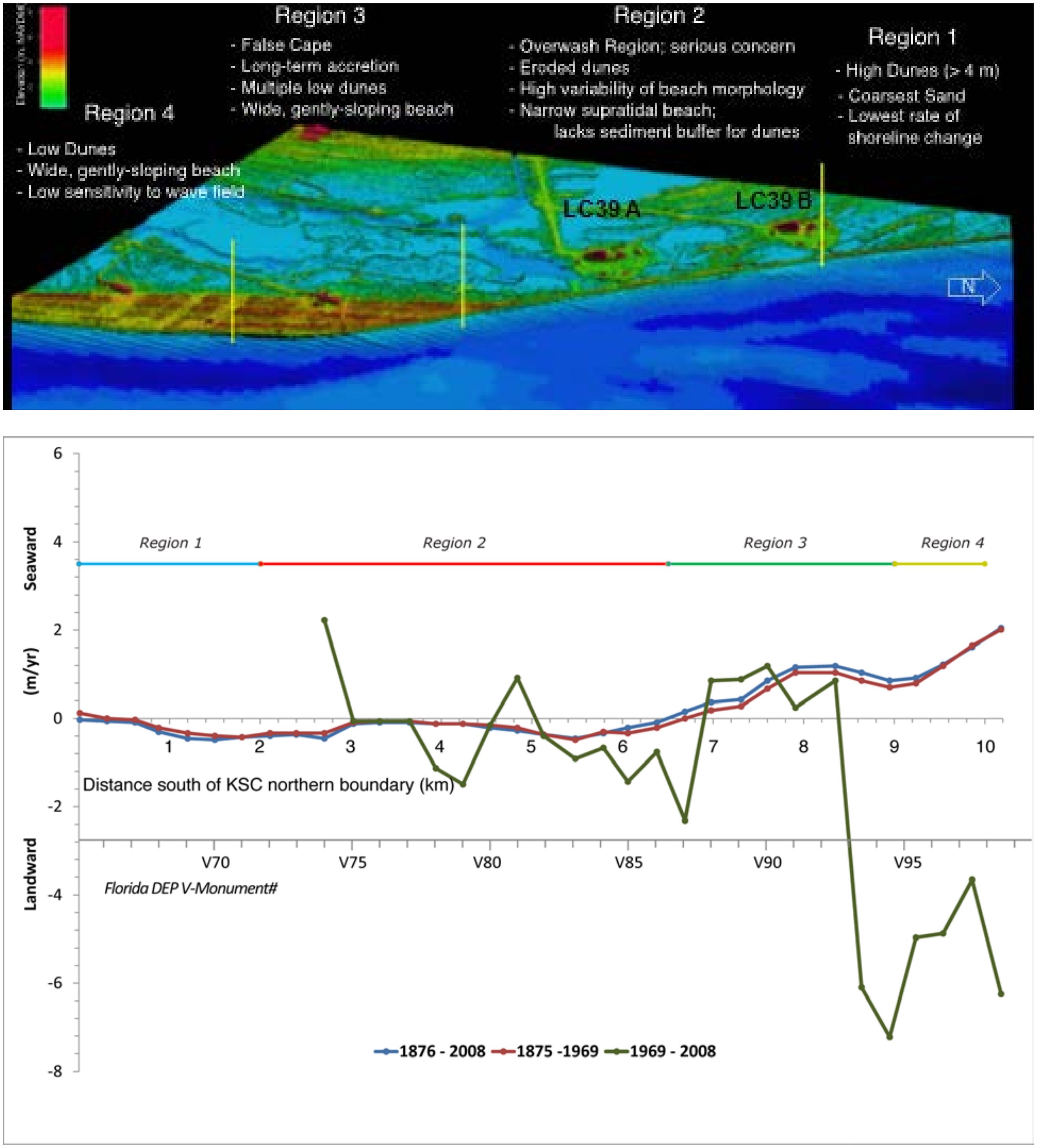


Figure 3-10. Long-term shoreline change rates for study area after Absalonsen and Dean (2010).

The historic shorelines are derived from precision-digitized approximate MHW shorelines, from the U.S. government coastal topographic maps, which generally cover the period from the mid to late 1800s to the mid to late 1970s. The MHW positions have been extracted and tabulated relative to fixed reference “R” points along the beach, spaced approximately 300 m (1,000 ft) apart. Reference points not corresponding to actual “in the ground” survey markers are virtual “V” points. MHW positions have been and continue to be extracted from FDEP beach profile surveys from the 1970s through the present, performed by the FDEP Coastal Data Acquisition section and by a number of commercial surveyors in recent years.

Absalonsen and Dean (2010) showed both a spatial and temporal variability in long-term shoreline position trends and in deviation about the trend throughout the study area. For both the long-term interval (1875-2008) and the early interval (1875-1969), the long-term trend is toward stability from the northern extent of the study area south for the first kilometer, with an area of erosion ~0.25 m/yr (0.8 ft/yr) for ~ 5 km (3.1 mi) in the center of the study area. Deviation about the trend is ~ 7.0 m (23.0 ft) in the stable area and ~ 12.9 m (42.3 ft) in the erosion area. In the southern section of the KSC shoreline, there is net accretion from False Cape to the southern extent of the KSC property of up to 1.5 m/yr (4.9 ft/yr), a ~10.4 m (34.1 ft) deviation from the trend. In the recent interval (1969-2008), no data exist for the northernmost ~ 3 km (1.9 mi) of the study area, however for the next ~ 5 km (3.1 mi) of shoreline, an alternating pattern of accretion and retreat, almost an order of magnitude greater than the long-term average, is found with an average deviation about the trend of ~ 22.3 m (73.2 ft). In the southernmost 1.5 km (0.9 mi) of the study area, retreat of 6.0 m/yr (19.7 ft/yr) was calculated. There were not enough data points to calculate a deviation about the trend for this area.

3.1.4.4 Offshore Sand Shoals

The coastal plain and continental shelf are closely related geologically. Both originate from the deposition and erosion of sediments on the eastern edge of North America caused by changes in sea level over the geologic timescale. A detailed examination of the KSC coastal and nearshore geomorphology and sedimentology was conducted by Field and Duane (1974). They conducted macro/microscopic analyses of 91 exploratory vibracores, averaging 3.0 m (10 ft) in length, collected on a grid from just north of False Cape to northern Cocoa Beach to 15 nautical miles offshore. Sediment samples were collected at 0.3 m (1 ft) intervals in each core. The most common offshore sediment is a fine-to-coarse, moderately well sorted shelly quartz sand, they termed Type A sediments. Minor offshore sediments included a muddy coarse shelly sand and gravel (Type C); very fine silty sand and mud (Type H); and semiconsolidated quartz-rich calcarenites (Type E), which is geographically limited and most often found in deeper water. Type A sediment is found at the surface, whereas Type E is lowest stratigraphically. Type C sediments are interpreted as reflecting relict sediment deposited during lower stages of Holocene sea level. Surficial layers and discrete lenses of mud (Type H) are observed in the Canaveral Bight, and at the bases of Chester (offshore False Cape) and Southeast (CS-II) shoals. Type E is interpreted as partially lithified Pleistocene calcarenite.

South of KSC, the CS-II is located along the eastern edge of Canaveral Shoals, in federal waters of the Atlantic Ocean (Figure 3-4). It has been used as a sand source for renourishment projects in Brevard County. Geotechnical investigations in the CS-II area were conducted by the USACE in 1972 and by Scientific Environmental Applications, Inc., a subcontractor of Olsen Associates, Inc. (OAI) in 1998. These resources are discussed in more detail in Appendix C.

3.1.4.5 Soils

The soils of KSC are mapped in the soil surveys for Brevard County (Huckle et al. 1974) and Volusia County (Baldwin et al., 1980). Fifty-eight soil series and land types are represented at KSC, even though Merritt Island is a relatively young landscape and one formed from coastal plain deposits. The primary source of parent material for KSC soils is sands of mixed terrestrial and biogenic origin. Soils on the barrier island section east of Banana River and Mosquito Lagoon are younger than those of Merritt Island and have had less time to weather. Well-drained soil series (e.g., Palm Beach and Cape Canaveral) in these areas still retain shell fragments in the upper layers. The presence of shell fragments influences soil nutrient levels, particularly calcium, magnesium, and pH. The soils series list for the KSC shoreline vicinity is based on the U.S. Department of Agriculture, Natural Resources Conservation Service database (Feb. 2010) and the distribution is depicted in Figure 3-11. There are eight types found in the region of interest. The soils in this region are relatively undisturbed.

Palm Beach sand covers approximately half of the project area. This soil type is derived from shells and sandy marine deposits and is considered excessively drained. In addition to these well-drained sandy soil types, there are also tidal marsh and swamp, and submerged marsh components to the soil that are poorly to very poorly drained and mucky.

3.1.5 Physical Oceanography and Coastal Processes

This section describes the inner shelf oceanography and local coastal processes of the project area, including the tidal setting, the characteristic wave field, description of currents that affect the coastal zone, estimates of longshore sediment transport, and cross shore sediment transport behavior. The NASA-KSC coast is subjected to a semidiurnal tide, meaning that each day, two high and two low tides occur. The mean tidal range is approximately 1.0 m, whereas the mean spring and neap tidal ranges are approximately 1.5 m (4.9 ft) and 0.6 m (2.0 ft), respectively. At the project site, the principal influence of the tides is to migrate the zone of wave activity across the beach. Within the surf zone, tidal currents are overwhelmed by the turbulent water motions associated with wave shoaling and breaking.

The Canaveral Shoals offshore borrow areas CS-I and CS-II are characterized by high wave energy and strong currents. The seabed experiences frequent turbulence resulting in a dynamic littoral environment where sand has been historically deposited along the base and lee of Cape

Canaveral. Periodic bathymetric surveys illustrate natural migration of the bars and shoals, particularly within CS-II (Olsen 2013, 2014a). The homogenous and coarse granularmetric characteristics of sediment within the CS-II borrow area found throughout five major dredging and beach fill events from 2000 to 2014 illustrates the dynamic, turbulent nature of the Canaveral Shoals seabed environment.

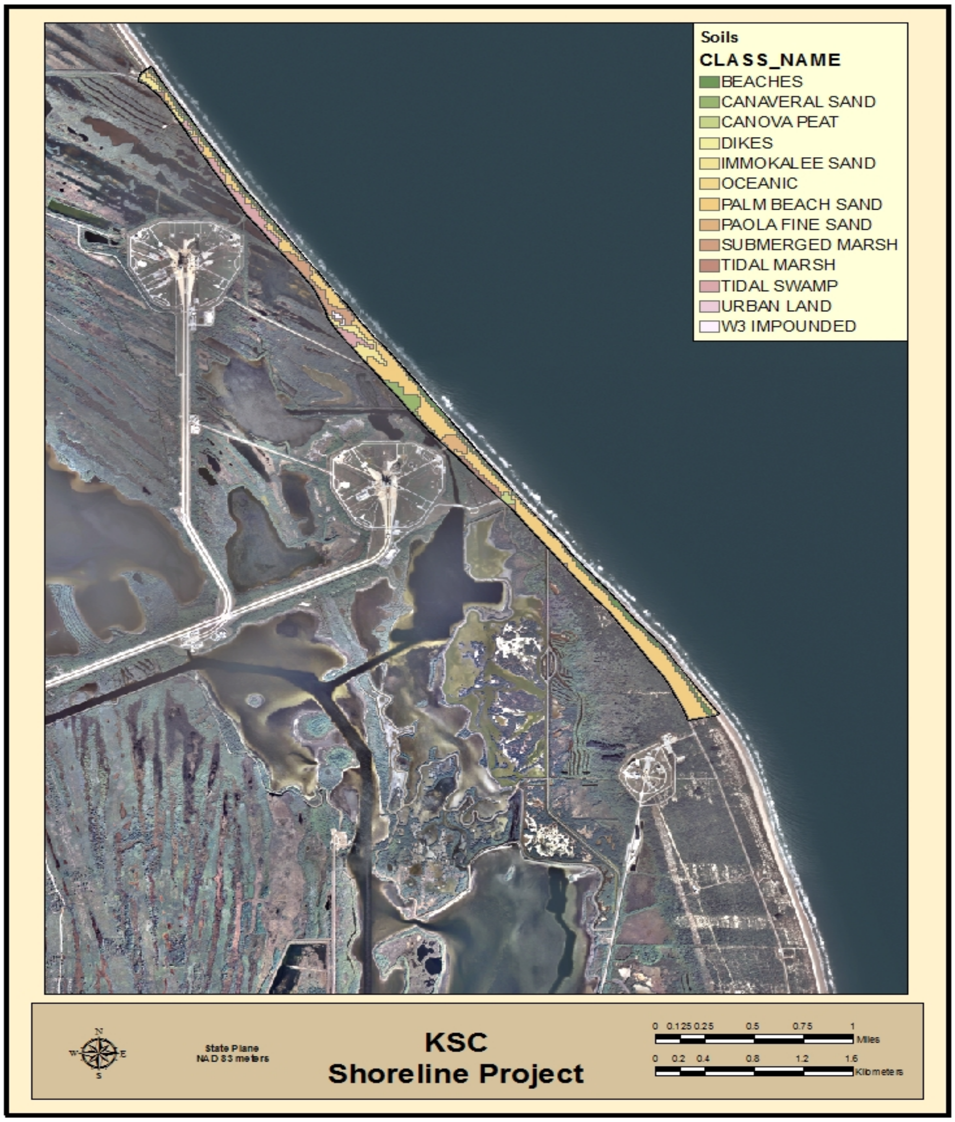


Figure 3-11. Distribution of soil types in KSC shoreline project area.

3.1.5.1 Waves

The assailing wave field at the NASA-KSC site can be characterized on the basis of three independent variables: (1) significant wave height (H_s), defined as the average of the highest one-third of waves during an observation interval, (2) dominant wave period (T_d), defined as the reciprocal of the frequency bin containing the greatest amount of spectral energy during an observation interval, and (3) peak wave direction (D_p), defined as the azimuthal direction of wave approach associated with the dominant wave period (or frequency bin).

Relative frequency distributions of data from two wave buoys (National Data Buoy Center), covering a 2.5-year interval (Jan. 2009 – Jul. 2011) are shown in Figure 3-12. Hourly wave populations of H_s, T_d, and D_p from Buoy #41012 (located approximately 40 nautical miles (NM) east northeast of St. Augustine, FL) are shown in green. Hourly wave populations of H_s, T_d, and D_p from Buoy #41009 (located approximately 20 NM East of Cape Canaveral, FL.) are shown in blue. Buoy #41009 does not collect observations of wave direction. The wave heights (H_s) have a right-skewed distribution, typical of ocean wave populations (Thornton and Guza, 1983), with modal values less than 1 m (3.3 ft). Dominant wave periods (T_d) show two coalescing, broad peaks, in the 4-6 s range and the 7-11 s range, respectively, as well as a notable subset of the population in the 12-13 s range. The peak directions have a modal value of approximately 100˚ (easterly waves), around which most of the population is distributed, save for a small subset of waves coming from the north.

There is a distinct seasonality apparent in the 2.5-year time series of wave conditions for the Florida Atlantic coast (Komar and Allan 2008). Summer months (June – August) are typified by small waves (H_s < 1 m [3.3 ft]), of 8 – 10 s period, from the East (D_p ~=90˚). Tropical storm season waves tend to begin in August and September and are characterized by brief interruptions of the summer background wave field with short-lived (~5 day) increases in wave height. As the storms pass from the south to the north, shifts in peak wave direction from southeasterly to northeasterly can be observed, but this directional behavior is strongly dependent upon an individual storm's track. Winter wave fields are profoundly different from those of the summer and early fall, principally because of their direction. Coherent wave events, lasting 5-8 days each, deliver wave energy to the NASA-KSC coast starting as large (>2 m [6.6 ft]), northerly waves, passing through the northeastern azimuthal quadrant to conclude as small (<1 m [3.3 ft]) easterly wave fields.

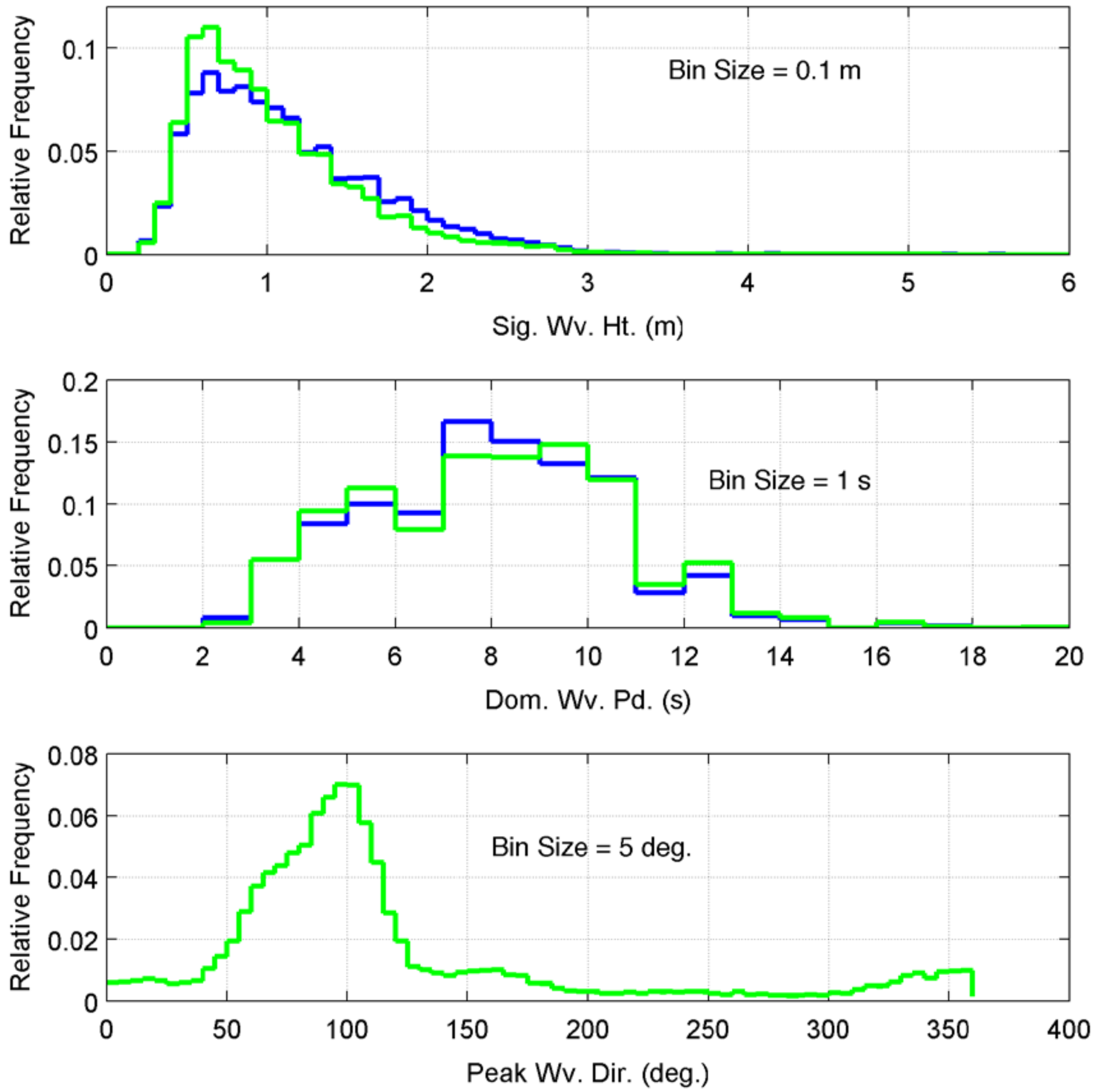


Figure 3-12. Relative frequency distributions of data from two NOAA-NDBC wave buoys covering a 2.5-year interval (Jan. 2009 – Jul. 2011).

Figure 3-13 shows monthly average wave heights from two data sets. Data from NOAA-NDBC buoy #41010, located in deep-water (873 m [2864 ft] water depth), approximately 120 NM East of Cape Canaveral, FL, show that the months of January, February and March have the largest H_s (~1.9 m [6.2 ft]), with the months of October, November and December having a slightly lower H_s (~1.8 m [5.9 ft]). June, July and August have the lowest H_s (~1.0 m [3.3 ft]).

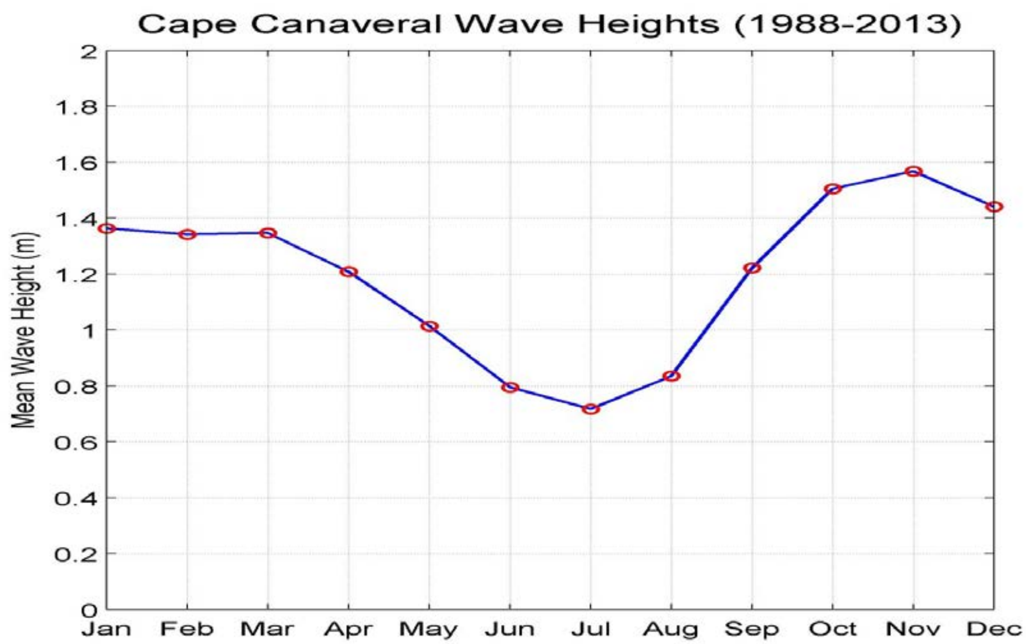


Figure 3-13. Monthly average wave heights (1988-2013) from NOAA-NDBC buoys #41010 and #41009 east of Cape Canaveral, FL.

3.1.5.2 Currents

The Florida Atlantic shelf is dominated by the Florida current, considered to be the southern portion of the Gulf Stream, which transports warm ocean water from low to high latitudes along the Atlantic margin of North America. In the vicinity of the project site, the Florida current detaches from the coast, doubles its width, and increases transport. Despite its important role in the global pattern of thermohaline circulation, the Florida current does not exert significant influence on the nearshore zone at the KSC project site, because of its detached, seaward location.

Coastal surface currents at the project site develop in response to the dominant wind fields and tidal flows. On the rising limb of the tidal cycle, northward-directed currents can reach up to 1 m/s (3.3 ft/s) during calm conditions. These regular flows, however, can be shut off for 1 to 4 days at a time during nor'easter storms, when winds blow from the north to the northeast as storms pass just north of the project site region.

3.1.5.3 Longshore Sediment Transport

At the KSC project site, waves typically approach from the northeast quadrant. The result is that net longshore transport is southward (or positive, as it is conventionally defined – to the right for a seaward facing observer). However, intervals of negative (northward-directed) transport are not uncommon, given that the mode of the direction distribution is +100˚and the shoreline orientation is rotated approximately 20˚ counterclockwise from north-south, making the modal angle of incidence -30˚.

Regional estimates of net longshore sediment transport rates along the Florida Atlantic coast reveal a monotonic decrease from approximately 600,000 m^3/yr (21,188,685 ft^3/yr) in the north, near Jacksonville, to approximately 10,000 m^3/yr (353,145 ft^3/yr) in the south near Miami (Davis et al. 1992). This dramatic spatial decrease in longshore sediment transport rate may be related to changes in shoreline orientation, as well as the southward-increasing influence of the Florida current, whose flow is directed opposite that of the longshore component of wave energy flux.

The longshore sediment transport rate along the southeast-facing shoreline of Cape Canaveral, about 20 km south of KSC, is described as about 267,590 m^3/yr (350,000 cy/yr), declining to about 152,910 m^3/yr (200,000 cy/yr) immediately north of Port Canaveral Entrance where sand impounds updrift of the north jetty (Kriebel et al. 2002).

3.1.5.4 Cross-Shore Sediment Transport

The primary response of a beach to changes in assailing wave conditions is an adjustment of its cross-shore profile through cross-shore sediment transport. During high wave activity (storm conditions), sediment is temporarily moved offshore, accumulating in subtidal bars which enhance wave energy dissipation, thereby providing a natural defense for the beach-dune system. During quiescent conditions, sediment is slowly pushed back onshore, often resulting in a prominent berm on the upper beach at an elevation near the mean high tide line.

The KSC project site exhibits a typical cross-shore response to variations in wave conditions, not unlike those described above (Kline et al. 2011). Scarping of an accreted beach has been observed during intervals of high wave (nor'easter storm) activity. Berm building and beach accretion are common during the fair-weather conditions of summer months. One noteworthy, but not unique, aspect of the KSC beach system is the presence of a subtidal double bar profile that persists throughout the year. The outer bar shows significant variability in cross-shore position and has been observed to merge with the inner bar in places during high wave activity intervals.

3.1.6 Sand Sources

The following briefly describes potential borrow areas for beach-compatible sediment in the vicinity of KSC. Specific descriptions are given of: 1) the native dune and beach sediments at KSC, 2) existing offshore borrow areas previously permitted and used for beach nourishment in Brevard County, 3) upland borrow areas previously permitted and used for dune restoration in Brevard County, and 4) the potential for new offshore borrow areas that may be developed in the immediate proximity of KSC.

For purposes of both environmental (habitat) protection and proper physical performance, sediment placed to the beach system should be compatible with the native (natural) beach sediments; i.e., generally similar in granulometric distribution, color, and mineralogic composition, and free of debris or contaminants that are inconsistent with natural beaches. In Florida, beach-compatible sediment is typically described by the State of Florida “sand rule” (FAC 62B-41.007[2][j]). And, along federal property such as the KSC where there is no coastal construction control line, sediment placed to the beach seaward of the mean high water line, in State waters, must demonstrate beach-compatibility as defined by the “sand rule”.

To identify the characteristics that define the native beach sediment along KSC, physical samples were collected and analyzed by OAI in March 2012. Data describing the samples, summary statistics, and compatibility/overfill ratio (with respect to permitted offshore borrow areas) are available in Appendix C. Figure 3-14 depicts the composite grain size distributions for the native beach sediments developed from the KSC native beach samples.

Listed below are the sediment characteristics of the native beach determined from this investigation. The grain size statistics are computed from the overall native composite distribution. The overall mean and standard deviation were computed using formulas outlined in the Coastal Engineering Manual (USACE 2008).

- USCS Classification: SP (one sample was SW)
- Median (d_{50}): 0.20 mm (0.008 in) -- range 0.11 mm (0.004 in) to 0.54 mm (0.021 in)
- Mean: 0.22 mm (0.009 in) -- range 0.12 mm (0.005 in) to 0.49 mm (0.019 in)
- Standard Deviation: 1.02 φ -- *range 0.41 to 1.28 φ*
- Fines Content (passing #230): 1.0% -- *range 0.1 to 1.5%*
- Gravel Content (retained on #4): less than 0.1% -- *range 0.0 to 0.2%*
- Carbonate Content: 15.1% -- *range 5.3 to 37.9%*
- Munsell Color (moist): typical 10YR 7.5/1.0 -- *range 10YR 7.0/1.0 to 10YR 8.5/1.5*

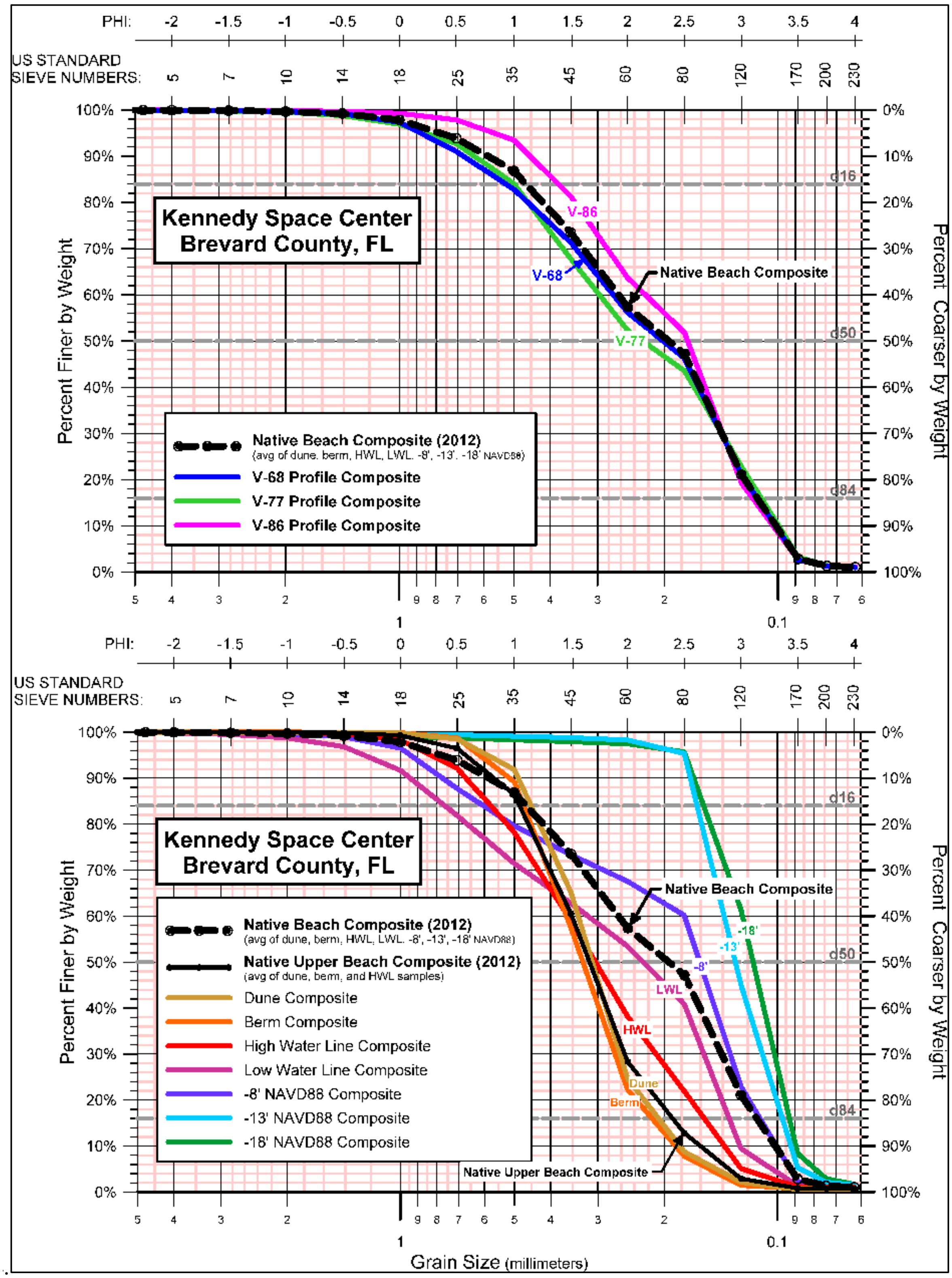


Figure 3-14. Summary of native beach grain size distribution, KSC, FL.

3.1.6.1 Offshore Borrow Areas

The nearshore seabed in the vicinity of the KSC presents abundant potential for economical, beach-compatible sand borrow areas, probably the greatest along Florida's entire coastline. There are two existing, permitted borrow areas within about 16 nautical miles of KSC, CS-I and CS-II, located southeast of Cape Canaveral (Figure 3-4 and 3-15).

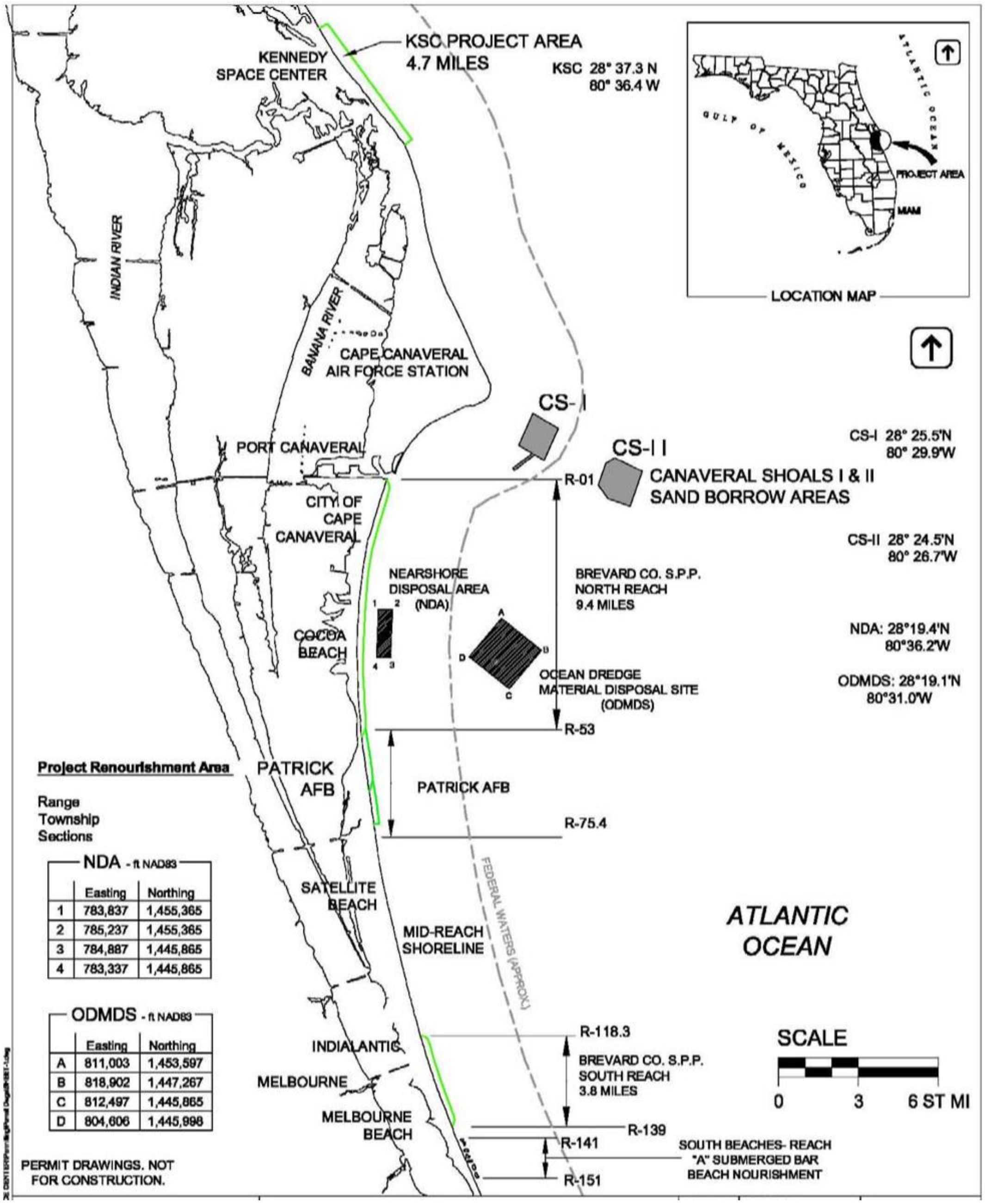
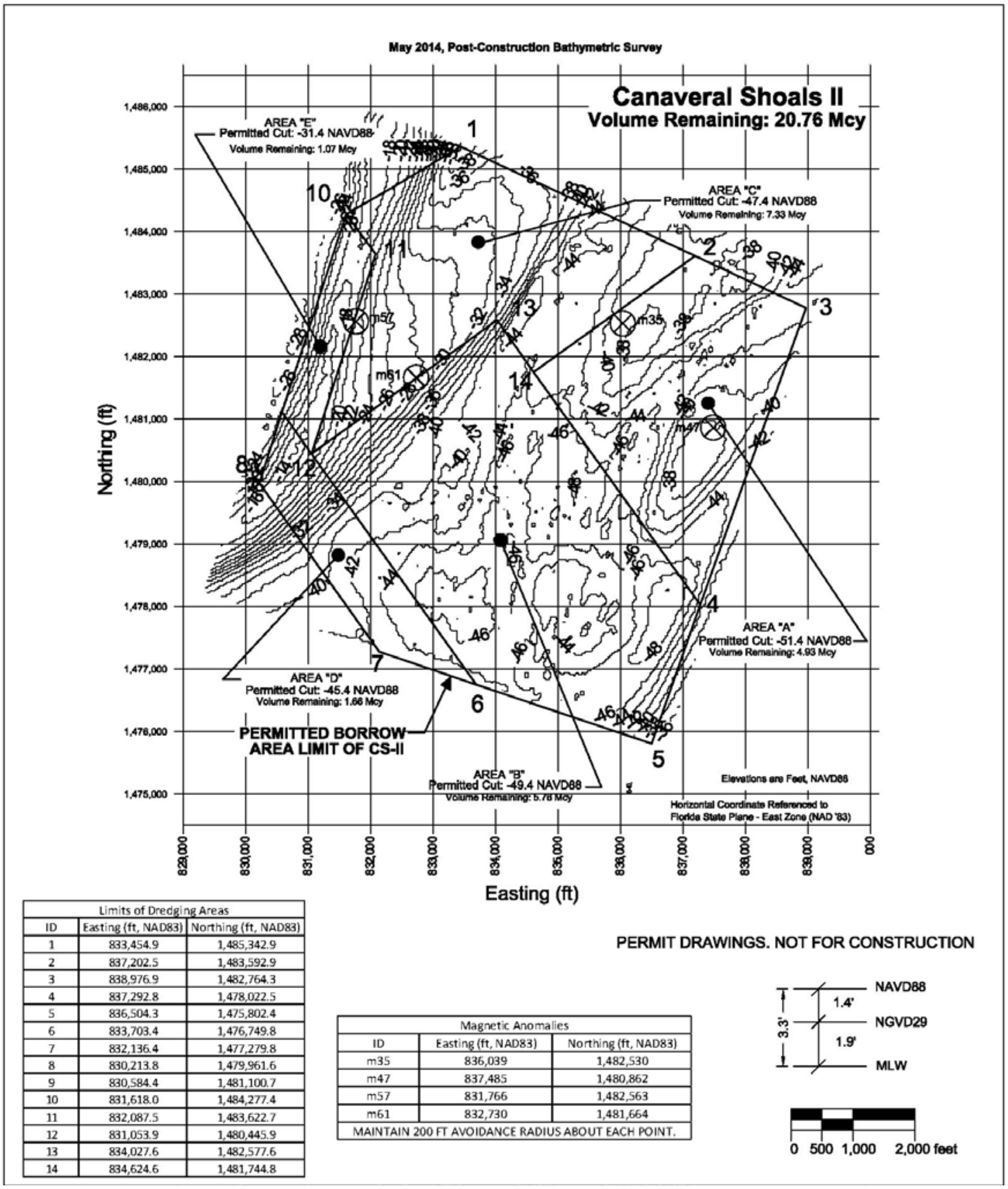


Figure 3-15. Location of CS-I and CS-II borrow areas, Nearshore Disposal Area, and Offshore Dredge Material Disposal Site.

Canaveral Shoals II Borrow Area

The CS-II borrow area is located in federal waters on the Outer Continental Shelf (OCS), approximately 5 nautical miles southeast of the tip of Cape Canaveral (Figure 3-16). It is about 15.5 nautical miles south-southeast of the KSC project area shoreline, or about 17 nautical miles by one-way sailing distance.



Limits of Dredging Areas		
ID	Easting (ft, NAD83)	Northing (ft, NAD83)
1	833,454.9	1,485,342.9
2	837,202.5	1,483,592.9
3	838,976.9	1,482,764.3
4	837,292.8	1,478,022.5
5	836,504.3	1,475,802.4
6	833,703.4	1,476,749.8
7	832,136.4	1,477,279.8
8	830,213.8	1,479,961.6
9	830,584.4	1,481,100.7
10	831,618.0	1,484,277.4
11	832,087.5	1,483,622.7
12	831,053.9	1,480,445.9
13	834,027.6	1,482,577.6
14	834,624.6	1,481,744.8

Magnetic Anomalies		
ID	Easting (ft, NAD83)	Northing (ft, NAD83)
m35	836,039	1,482,530
m47	837,485	1,480,862
m57	831,766	1,482,563
m61	832,730	1,481,664
MAINTAIN 200 FT AVOIDANCE RADIUS ABOUT EACH POINT.		

Figure 3-16. Canaveral Shoals-II permitted offshore borrow area.

Ambient seabed depths across CS-II range from about -0.9 m (-13 ft) to -13.7 m (-45 ft), MLLW. The limits of the borrow area, approximately 500 ha (1233.4 ac) in overall size, are divided into five subregions with varying dredge (cut) depths of 9.6 m (-31.4 ft) to -15.7 m (-51.4 ft), NAVD 88. Following the most recent dredging of CS-II in Spring 2014, there are approximately 15.9 million cubic meters (20.8 million cy) of sediment remaining within the permitted excavation limits (OAI, 2014a). Approximately 7.1 million m^3 (9.3 Mcy) of sediment have been dredged from the CS-II borrow area for purposes of beach nourishment in Brevard County on multiple occasions since the borrow area's development in 1998-99. These dredge events include the initial construction of the Brevard County Federal Shore Protection Project (BCSPP) NR in 2000-01 and SR in 2002-03, initial construction of PAFB shore protection in 2000-01, renourishment of the BCSPP and PAFB in 2005, renourishment of the BCSPP SR in 2010, and renourishment of the BCSPP in 2013-14. The current bathymetry of the CS-II borrow area is shown in Figure 3-16.

For each of these projects, lease or similar agreements for the use of sand from CS-II were executed between BOEM, USACE, Brevard County, and/or 45th Space Wing (45SW) USAF. Use of the CS-II borrow area by KSC will require a similar lease or memorandum-of-agreement between BOEM and NASA-KSC, similar to the two-party agreements between BOEM and the 45SW/USAF.

From core boring data and inspection of the sand placed onto Brevard County's beaches since 2000, the sediment contained in the CS-II borrow area is of consistent, excellent compatibility with the KSC beach and broader Brevard coastline. Comparison of the typical (average) grain size distribution of sediment from CS-II and the native beach is described in detail in Appendix C.

<u>Canaveral Shoals I Borrow Area</u>

The Canaveral Shoals I borrow area is located approximately 2.5 nautical miles southeast of the tip of Cape Canaveral. While it appears closer to KSC than CS-II by 2 or 3 miles, CS-I is actually the same sailing distance from KSC, about 17 nautical miles one-way, because of the need to navigate around the shallow shoals that define False Cape and Cape Canaveral (Figure 3-15).

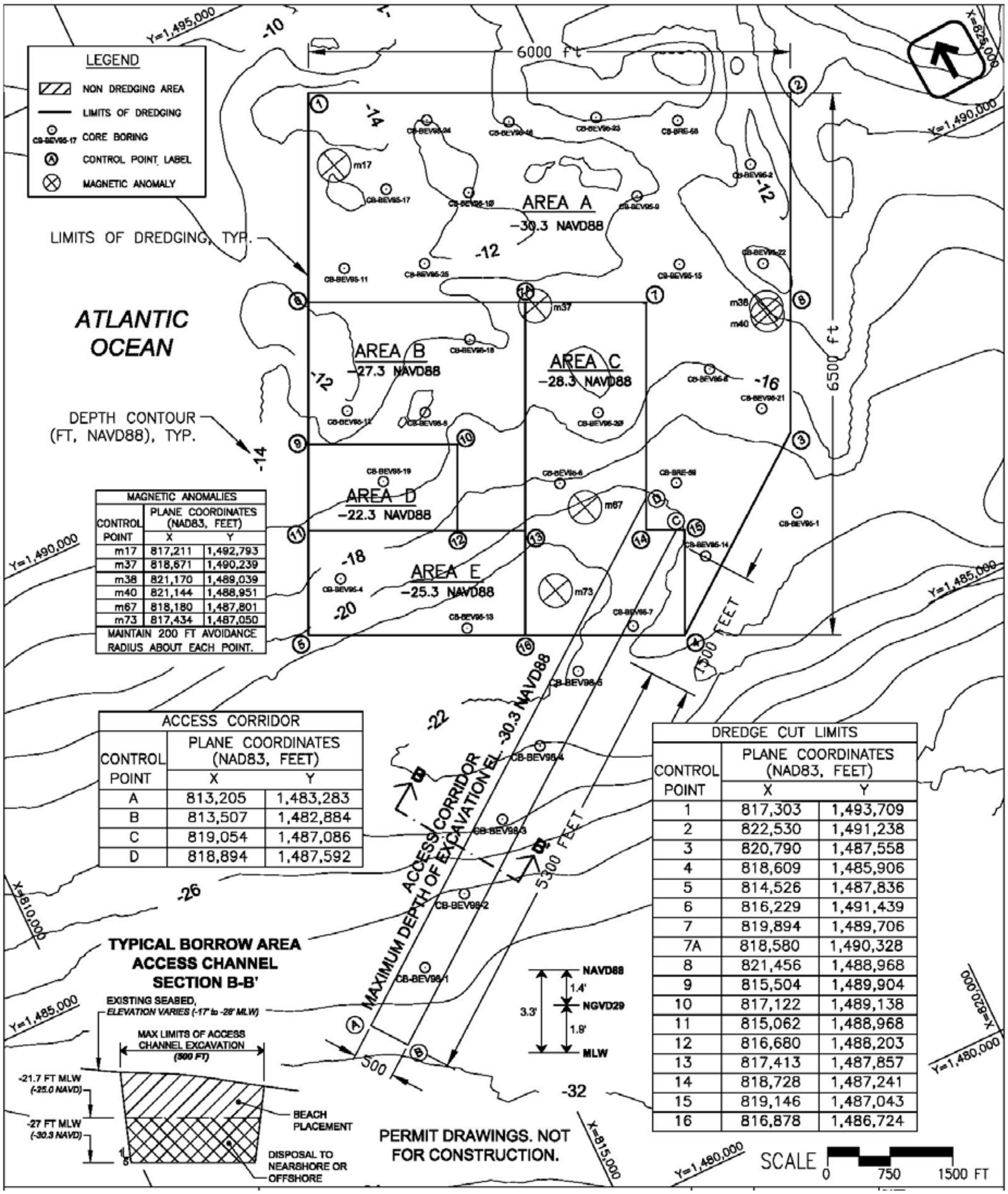


Figure 3-17. Canaveral Shoals I permitted offshore borrow area and access channel.

Ambient seabed depths across CS-I range from about -2.4 m (-8 ft) to -5.5 m (-18 ft) MLLW. The borrow area limits, approximately 1 square nautical mile in size, are divided into five sub-regions with varying dredge (cut) depths of about -6.8 m (-22.3 ft) to -9.2 m (-30.3 ft). Because of the shallow ambient depths of the borrow area, a 1,615 m (5,300 ft) long by 152 m

(500 ft) wide dredge access lane has been identified for this site. The total size of the CS-I borrow area and access lane is 359.8 ha (889.1 ac). Use of the CS-I offshore borrow area would require dredging of the CS-I access channel (Figure 3-17). The access lane has been permitted for excavation to -9.2 m (-30.3 ft) NAVD 88 (-8.2 m [-27 ft] MLLW). Sediment dredged from the access lane above -8.0 m (-26.3 ft) is proposed for beach fill (if compatible and containing and less than 5% fines), or nearshore disposal (if containing less than 20% fines) at the Nearshore Disposal Area (NDA), or otherwise offshore disposal to the Canaveral Offshore Dredge Material Disposal Site (ODMDS). The locations of the NDA and ODMDS are also indicated in Figure 3-15.

A total of approximately 12.2 million m^3 (16 million cy) of sand is available from within the permitted limits of the CS-I borrow area. This borrow area has not been previously dredged but has been re-surveyed for cultural resources by the USACE in 2014. There are six locations of magnetic anomalies within CS-I for which a 200-ft radius dredge-exclusion buffer has been established, indicating potential sites of rocket cylinders. From core boring data the sediment contained in the CS-I borrow area is also of consistent, excellent compatibility with the KSC beach and broader Brevard coastline. Comparison of the typical (average) grain size distribution of sediment from CS-I and the native beach is described in detail in Appendix C.

Both the CS-I and CS-II material is coarser than the overall native beach sediment. While the CS-II material is coarser than the native berm/upper beach, the CS-I material is slightly finer than the native berm/upper beach. This suggests that both the CS-I and CS-II borrow area sediments are compatible with the native beach and berm, but that the CS-II sediment may exhibit slightly greater stability (resistance to erosion) than the CS-I borrow area sediment.

<u>Other Offshore Borrow Areas</u>
The only other offshore borrow area developed and permitted for dredging and beach nourishment in the general vicinity of KSC is the Space Coast Shoals II borrow area, located southeast of PAFB. This area was dredged for construction of the BCSPP South Reach in 2002, exhausted of sediment and is no longer available as a sand source.

3.1.6.2 Upland Sand Sources

Upland sand sources for dune construction may include commercial quarries and other available, permitted sites that contain sediment demonstrated to be of compatible quality with the native KSC dune and beach (Figure 3-18). These sources must also meet the State of Florida “sand rule”, FAC 62B-41.007(2)(j), if placed below the mean high water line at KSC. The availability and quality of upland sources vary with time because existing sources are mined and new sources and excavation projects continually arise. Accordingly, upland sources for project implementation should be specifically identified and evaluated for suitability prior to construction.

In the recent past, upland sources for beach and dune nourishment in Brevard County have included numerous sites, each of which have successfully resulted in placement of beach-compatible material. A partial list of these sources includes the following fourteen.

1. Port Canaveral Cruise Terminal Excavation was the Source of beach nourishment placed along the City of Cape Canaveral in 1993. This source was depleted after construction of the cruise terminals; however, it is typical of local excavation projects that periodically produce beach-quality sand.
2. Poseidon Dredge Material Management Area (Port Canaveral/CCAFS) was the source of beach and dune nourishment placed along PAFB in 1998. This site is currently depleted and not available. The site is proposed for sand stockpiling by the USACE for transfer to the Brevard County Mid-Reach shoreline; however, that sand stockpile will not be available to KSC.
3. Fischer Sand 77th Street (Indian River County) is a commercial mining operation that has provided beach quality sand for 2005 Brevard County dune restoration and other projects conducted by Indian River County and Sebastian Inlet Tax District.
4. Pence Pit 6 (Palm Bay) is a commercial sand mine.
5. CCAFS - Upland beach north of Canaveral Harbor jetty is an on-beach source. It is permitted and was used as a sand source for beach/dune restoration at PAFB (2011 and 2014) as sand bypassing southward across the Canaveral Harbor Entrance. It is probably not available as a “backpassing” source for KSC, unless agreed by 45SW.
6. Port Canaveral widening and deepening of the Canaveral Harbor Entrance channel to 46+2 ft was underway in 2014 and is anticipated to generate potentially beach-compatible material (from above -4.9 m [-16 ft] mean low water cut depth) for which disposal sites have not yet been confirmed.
7. Titan Road stockpile, CCAFS has approximately 90,000 cy of sand stockpiled from an upland excavation project. The sand was used to construct post-Hurricane-Sandy dune repairs along KSC in spring 2014. This source is depleted.
8. Central Sand Tico Pit (Titusville) is a principal source of dune restoration material placed by Brevard County in 2005 and 2006.
9. Fischer Sand Mine 99th Street (Indian River County) is a commercial sand mine, utilized in Brevard County 2009 dune restoration.
10. Ranch Road (82nd Avenue, Indian River County) is a commercial sand mine, utilized in Brevard County 2009 dune restoration.
11. Brian Davis Mine (7200 84th Ave., Vero Beach) is a commercial sand mine that provided sand for Brevard County 2014 dune restoration.
12. Rock Solid Rock, LLC Broadway Pits (Brevard County) is a commercial sand mine, utilized in Brevard County 2009 dune restoration.

13. Huntington Pit (JP Donovan) is a stormwater pond excavation at Huntington Lakes II in City of Rockledge, FL; used by Brevard County for 2014 dune repairs. This source is depleted.
14. Cemex Gator Mine, Lake Wales Sand Mine, Davenport Sand Mine (Davenport and Lake Wales, FL) is a commercial sand mine source.

Sand sources 8 through 14 were most recently included on FDEP's approved list of sand sources for dune restoration in Brevard County, south of Canaveral Harbor, as of Spring 2014 (as itemized in the Sediment Quality Assurance/Quality Control [QA/QC] Plan for FDEP Permit BE-1307 issued to Brevard County in August 2013.) Some, but not all, of these sources have been used by the County. Brevard County's dune restoration projects have used sand from sources 8 through 13, in addition to other stormwater excavation sites from which sand is no longer available. Numerous other sources are available, including other commercial mines not listed above. Other sand sources are added to the list of approved sources for dune/beach fill placement, for use by Brevard County, pursuant to review and approval by FDEP, as opportunities and needs arise.

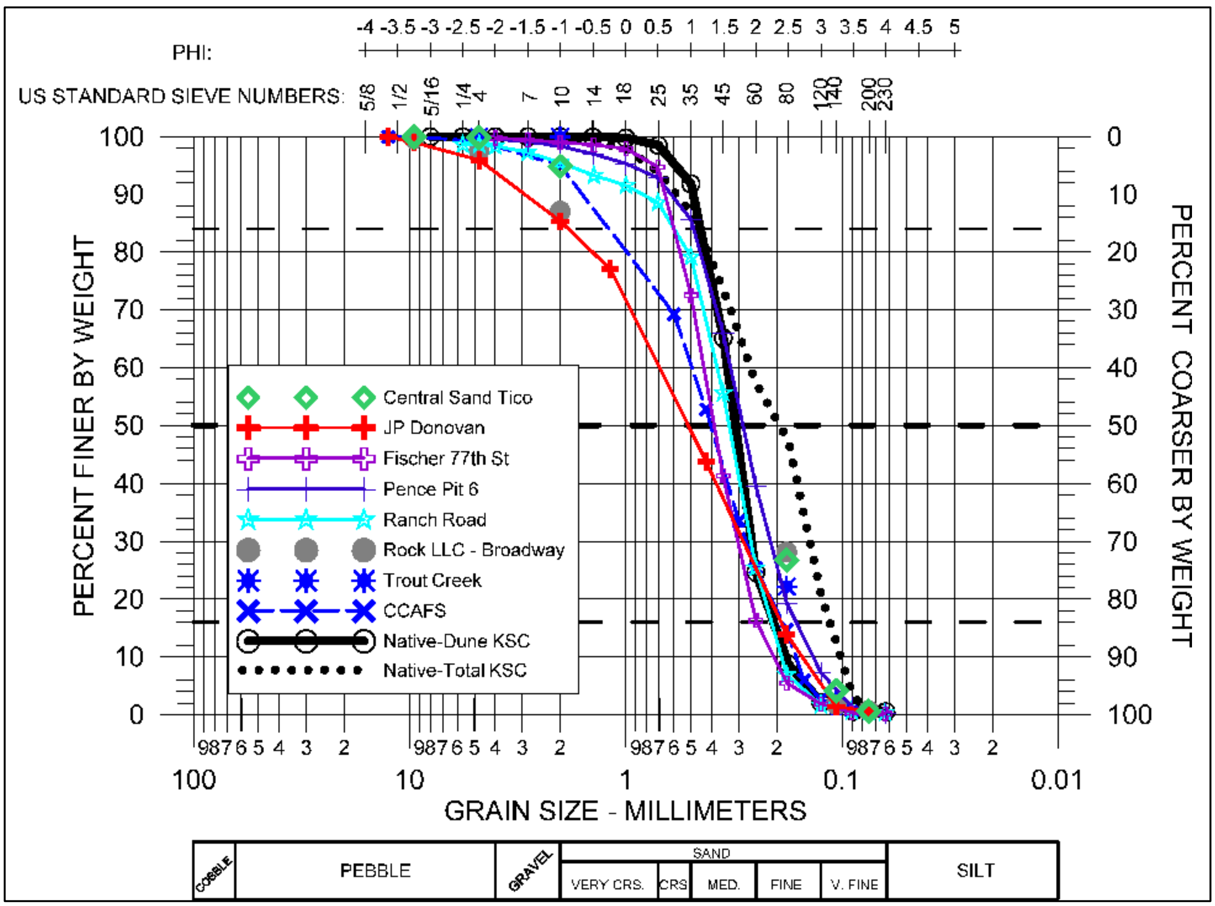


Figure 3-18. Typical grain size data from upland sand sources used in Brevard County, FL.

3.1.7 Water Resources

3.1.7.1 Surface Water

The inland surface waters in and surrounding KSC are shallow estuarine lagoons and include portions of the Indian River, the Banana River, Mosquito Lagoon, and Banana Creek. The area of Mosquito Lagoon within the KSC boundary and the northernmost portion of the IRL, north of the Jay Jay Railway spur crossing (north of State Road [SR] 406), are designated by the State as Class II, Shellfish Propagation and Harvesting. All other surface waters at KSC have been designated as Class III, Recreation and Fish and Wildlife Propagation. All surface waters within MINWR are designated as Outstanding Florida Waters as required by Florida Statutes for waters within national wildlife refuges. Surface water quality at KSC is generally good, with the best water quality being found adjacent to undeveloped areas of the IRL, such as Mosquito Lagoon, and the northernmost portions of the Indian River and Banana River (NASA 2010). A detailed discussion of surface water quality at KSC can be found in the ERD (NASA 2010).

Fresh surface waters within KSC are primarily derived from the surficial groundwater, which is recharged by rainfall. Shallow groundwater supports numerous freshwater wetlands. Groundwater discharge to surrounding estuarine systems helps maintain lagoon salinity levels. Groundwater underflow is also a major factor in establishing the equilibrium of the freshwater-saltwater interface in the Surficial Aquifer system (Clark 1987), prohibiting saltwater from intruding into surface waters. During most of the year, shallow groundwater discharges to swales and canals (Schmalzer and Hinkle 1990a). Many of the larger canals are excavated below the groundwater table and, as a result, always contain water.

Most of the coastal dune systems on KSC lack naturally occurring freshwater bodies. 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. During the early1990s, a significant effort was made by MINWR and SJRWMD to reestablish connection between many impoundments and the estuary in order to return the impoundments to more natural conditions. Many improvements were made to the culvert systems (i.e., more and larger culverts) and in some cases, impoundment dikes were removed completely.

3.1.7.2 Groundwater Sources

The State of Florida has created four categories used to rate the quality of groundwater in a particular area. The criteria for these categories are based on the degree of protection that should be afforded to that groundwater source, with Class G-I being the most stringent and Class G-IV being the least. The groundwater at KSC is classified as Class G-II, 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 (ppm). The groundwater at the LC 39 pads has been classified as Class G-III because of their proximity to the ocean. Any future long-term pumping would allow salt water to encroach into the aquifer, rendering it non-potable (NASA 2003). The subsurface of KSC is comprised of the Surficial Aquifer, the Intermediate Aquifer, and the Floridan Aquifer. The Surficial aquifer is recharged by local rainfall and sand ridges in the center of Merritt Island. Discharge is from evapotranspiration, and seepage into canals, ditches, interior wetland swales, as well as impoundments, lagoons, and the ocean. This aquifer exists in dynamic equilibrium with rainfall and with the fresh-saline water interface. Freshwater wetlands depend on the integrity of this aquifer which also provides freshwater discharge to the lagoons and impoundments.

Deep aquifers beneath KSC are recharged inland but are influenced by the intrusion of saline and brackish surface waters from the Atlantic Ocean and the IRL. These aquifers are highly mineralized in the coastal region and interact little with surface vegetation. This is evident by the high mineral content, principally chlorides, that has been measured in groundwater samples collected during various KSC surveys.

KSC is surrounded by brackish to saline surface water and nearly all of their groundwater originates as precipitation that infiltrates through soil into flow systems in the underlying geohydrologic units. Of the approximately 140 cm (55 in) of precipitation occurring annually, approximately 75% returns to the atmosphere through evapotranspiration. The remainder is accounted for by runoff, base flow, and recharge of the Surficial Aquifer.

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

Surficial Aquifer Systems

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 (Burkhart and Kolpin, 1993; Kolpin et al., 1995, 1998; Barbash et al., 1999). Urban and agricultural land uses have affected some Florida aquifers (Rutledge 1987; Barbash and Resek 1996). Point source contamination to the KSC Surficial Aquifer has occurred at certain facilities (Clark 1985, 1987). The potential for groundwater contamination from industrial operations may exist at multiple sites known as Potential Release Locations (PRLs), located within or adjacent to the project boundary. Detailed information regarding each of the PRL locations and their potential contaminants of concern are referenced in Section 3.1.9.

Baseline conditions of the Surficial Aquifer have been studied in some detail (Schmalzer et al., 2000, Schmalzer and Hensley, 2001). In the 2001 study, six sample sites were located in each subsystem of the Surficial Aquifer, for a total of 24 sites. Shallow and deep groundwater samples were analyzed for organochlorine pesticides, aroclors, chlorinated herbicides, polycyclic aromatic hydrocarbons (PAH), total metals, DO, turbidity, pH, specific conductivity, temperature, total dissolved solids (TDS), and total organic carbon (TOC). The baseline data suggest that widespread contamination of the Surficial Aquifer on KSC has not occurred (Schmalzer and Hensley 2001). The ERD (NASA 2010) provides additional information on groundwater quality at KSC.

The chemical parameters varying most with subaquifer and depth were calcium (Ca), chloride (Cl), magnesium (Mg), potassium (K), and sodium (Na), as well as, conductivity and TDS that are related to these cations and anions. The trends were generally consistent among these; the shallow wells in the Dune-Swale subaquifer had the lowest values. Concentrations increased with depth within a subaquifer. At a given depth, concentrations in the Dune-Swale and West Plain subaquifers were lower than in the Dune and Marsh subaquifers. These trends reflect increased mineralization with depth and differences between the freshwater Dune-Swale and West Plain subaquifers and the more saline Dune and Marsh systems. The Dune and Marsh subaquifers interact with saline water of the Atlantic Ocean and Indian River Lagoon system, respectively (Clark 1987).

Intermediate Aquifer System

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

Floridan Aquifer System

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

3.1.8 Noise

Given certain intensities, frequencies, and duration, noise can change the behavior of humans and wildlife. Noise is usually associated with human activity, although some natural sounds may be considered noise. Noise is measured in decibels (dB) and an A-weighted sound pressure level (dBA) is commonly applied. Noise at KSC was described in detail in the EA for Expanded Use of the SLF (NASA, 2007). Noise generated at KSC originates from: 1) traffic, 2) industrial operations, 3) construction, 4) aircraft, and 5) launches.

Noise levels around facilities at CCAFS and KSC approximate those of any urban industrial area, reaching levels of 60 to 80 dBA. Additional on-site sources of noise are the aircraft landing facilities at the CCAFS Skid Strip and the KSC Shuttle Landing Facility. Other less frequent but more intense sources of noise in the region are launches from CCAFS and KSC. Sonic booms produced during vehicle ascent over the Atlantic Ocean are directed in front of the vehicle and do not impact land areas.

Traffic noise is generated by employees traveling to and from their workplace and the local movement of a mix of trucks and passenger vehicles. The current environment is also influenced by noise levels from traffic along Phillips Parkway. Typical noise levels from passenger vehicles are 72 -74 dBA at 89 km per hour (55 mph) at a distance of 15.2 m (50 ft). Heavy trucks (e.g., semi-trucks, with exhaust located 1.8 to 2.4 m [6 to 8 ft] above the roadway) can produce 84 to 86 dBA at 89 km per hour (55 mph) at 15.2 m (50 ft). Rail operations are extremely infrequent, low speed, and limited to local movement of flight vehicle elements. Port Canaveral Authority is considering developing and connecting a rail from the Port to KSCs existing interior rail system located 4.8 km (3 mi) west of the project area. The scoping efforts for the EIS for this proposed project began in December 2014. The current description mentions four trains passing through KSC per day at low speed. Details will be provided in the EIS expected in 2017.

Noise from aircraft at and near KSC is associated with operations at the SLF with runways 15 and 33, and the nearby Skid Strip at CCAFS runways 12 and 30. KSC has experienced shuttle launch-related noise as well as noise from four active rocket launch pads located on CCAFS (e.g., Atlas, Falcon, Delta, and Titan). At a launch pad, located within 500 m (546 yd) of the project area, launch noise can reach 160 dBA with sound diminishing with distance. Permissible noise exposure limits for humans are established by the Occupational Safety and Health Administration (OSHA). The 8-hour time weighted average noise level on KSC is appreciably lower than the OSHA recommended level of 85 decibels, A-weighted (dBA) (OSHA 2006).

When not influenced by work activities, the project area is anticipated to have in-air sound levels in the range of 34 to 51 dBA, as found at a site on Playalinda Road north of LC 39A during an earlier assessment of the SLF.

While no in-air sound recordings for KSC’s surf are available, such in-air sounds were recorded in 2012 at two sites at NASA’s Wallops Flight Facility in Wallops Island, Virginia (NASA 2013b). These recordings yielded average daily background levels that ranged from 30 to 50 decibels (dBA), with a constant level of low-frequency sound likely caused by the wind and surf.

Existing underwater sound is generated by a variety of sources including breaking waves, wind, rain, marine organisms, commercial shipping, recreational and fishing vessels, dredging activities, and aircraft. In-water sound levels at an offshore borrow area and the nearshore pumpout area were recorded in 2012 during the initial beach fill at Wallops Flight Facility. Sea state and associated sounds generated by waves interacting with the survey vessel likely contributed to the readings. Background sound pressure levels averaged 117 dB across all sampling days, sites, water depths, and weather conditions. Minimum measured sound levels ranged from 92 dB to 107 dB depending on sampling location and water depth. Maximum sound levels ranged from approximately 128 dB to 148 dB (Reine et al. 2014).

3.1.9 Hazardous Materials and Hazardous Waste

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 if characterized as such due to toxicity, reactivity, ignitability, or corrosivity. EPA has also determined that some specific wastes are hazardous, and have published a list of these wastes. All hazardous wastes generated on KSC must be managed, controlled and disposed of according to regulations found in 40 CFR Parts 260 through 282, and FAC Chapter 62-730. In this section, the presence of known or suspected contaminants on or near the action alternative sites is discussed. NASA KSC has a program 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 Solid Waste Management Units (SWMUs), Wilson Corners and 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 warranted. EPA's SWMU Assessment initially identified 16 sites for investigation under the corrective action program. Additional sites were also identified by KSC as the program was implemented. In addition to corrective action sites, the remediation group also manages petroleum contaminated sites.

To date, KSC has identified and/or investigated approximately 250 sites located on KSC. SWMUs and Potential Release Locations (PRL) are generally concentrated in operational areas such as the Vehicle Assembly Building (VAB), LC 39, the Industrial Area, and facilities on CCAFS currently or formerly operated by NASA. The most prevalent soil contaminants are petroleum hydrocarbons, RCRA metals, and polychlorinated biphenyls (PCB); the most prevalent groundwater contaminants are chlorinated solvents and associated degradation products. PRLs located within or adjacent to the Shoreline Protection Project boundary are shown in Figure 3-19.

Figure 3-19. Potential Release Location (PRL) sites within and adjacent to Shoreline Project.

PRL 081Q Titusville Beach Service Station

An investigation of former service stations and their associated fuel storage tanks and dispensing facilities was conducted in 2003. One of the old service station tank sites investigated was named Titusville Beach Service Station. This service station was located on the east side of Phillips Parkway in the former beach community of Titusville Beach, in the current approximate location of Helipad 6, or 506 m (1,660 ft) south of Universal Camera Pad 12, NASA requested that Thrift Oil Company remove the fuel pumps and storage tanks at the property. No documentation of tank removal activities was located. Soil sample organic vapor analyzer (OVA) readings indicated the likely presence of contaminated soil. Subsequent soil assessment hand auger borings showed total recoverable petroleum hydrocarbons (TRPH) at a concentration below the Soil Cleanup Target Levels (SCTLs) established in FAC Chapter 62-777. A groundwater sample collected from a temporary monitor well in the area of highest soil OVA readings was analyzed for common petroleum constituents. None of the parameters analyzed were at concentrations in excess of laboratory detection limits. Based on the soil and groundwater analyses, no further assessment of soil and groundwater quality was recommended or performed since July 2003 (UES 2003).

PRL 174 Area 2 Repeater Buildings

PRL 174 consists of five distinct areas that are locations of electronic communications relay buildings. One of these facilities, the Cable Terminal Building (J8-1567), is within the Proposed Action alternative boundary. A SWMU Assessment was conducted in 2009 and 13 Locations of Concern (LOCs) were identified for PRL 174. None of the areas identified for additional investigation and sampling were located at the Cable Terminal Building. Confirmatory sampling was conducted in 2009-2010, and results indicated that releases had occurred at two of the LOCs identified. Concentrations of copper and carcinogenic polynuclear aromatic hydrocarbons (C-PAHs) were detected in soil from LOC 3 and LOC 6 in excess of FDEP R-SCTLs. No exceedances of GCTLs were confirmed in groundwater samples at any of the LOCs. Interim measure (IM) activities were conducted at these two LOCs to remediate soil affected by contaminants of concern above the FDEP R-SCTLs. Based on the results of the CS and IM at PRL 174, a No Further Action (NFA) was recommended and a Site Rehabilitation Completion Order was obtained in April 2014 (IHA 2009).

PRL 175 LC 39A Operations Support Building Area

The LC 39A OSB Area includes the Pad A OSB, Operations Building No. 1, Sewage Treatment Plant No. 8, Pad A Gate House, Repeater Building No. 4, Rechlorination Building, a survey tower, and Guard House. This site was designated PRL 175. Nine LOCs were identified throughout the area including drainage outfalls, survey tower, service area, former drain field, former crawler parking and lay down area, tank storage area, and transformer areas (NASA 2009). Confirmatory sampling was recommended as a result of the SWMU assessment (SA) and a work plan was developed (IHA 2009a).

PRL 193 Tracking Stations

The Tracking Stations area located along the coastline is comprised of the Beach Tracking Sites North and South and the Sea Surveillance Radar Tower. These sites are used for remotely operated film and video of launches and for radar operations. The Beach Tracking Site North (J8-1821) is located southeast of LC 39A; the Beach Tracking Radar Tower, also known as the Sea Surveillance Radar Tower (K8-0590) is at the south end of the Shoreline Project area; and the Beach Tracking Site, South (K8-0741) is just outside the southern limit of the project. Potential contaminants include hydrocarbons, solvents, and PCBs. Confirmatory sampling was recommended as a result of the SA, and a work plan was developed (IHA 2010a).

PRL 194 Radar Wind Profiler Site D

The Radar Wind Profiler Site D was identified as PRL 194 and a SA was conducted from October 2010 through January 2011. The main structures and areas included in the SA are the Radar Wind Profiler Site D J8-2227, Universal Camera Site #12 J8-2228, Field Mill Site #13 J8-2177 and Guard Shack J8-2075. The current and former usage of the Wind Profiler Site has been as a camera pad for remotely operated film and video operations, weather and lightning detection monitoring, and access control for launches. The site is used by NASA and CCAFS personnel for rocket launches. Five LOCs were identified at this PRL and include electrical equipment locations, the wind profiler refurbishment area, and site groundwater. Potential contaminants include hydrocarbons, solvents, and PCBs. Confirmatory sampling was recommended as a result of the SA, and a work plan was developed (IHA 2012).

PRL 196 Area 2 Universal Camera Pads

Universal Camera Pad #7 is one of three camera pads and other structures and sites included in the Area 2 Universal Camera Pads PRL. Camera Pad #7 is located midway between LC 39A and LC 39B on the east side of Phillips Parkway. It is used for remotely operated high-speed film and video operations and is also a stop on the KSC Visitors' Center bus tour. LOCs include an electrical equipment area, a disturbed area by the railroad, and site groundwater. Potential contaminants include metals, PCBs, hydrocarbons, and solvents. Confirmatory sampling was recommended as a result of the SWMU assessment (SA) and a work plan was developed (IHA 2011a).

PRL 208 Area 3 Camera Pads

Universal Camera Pad #4 is one of the four camera pads included in Area 3 Camera Pads (PRL 208). It is located on the west side of Phillips Parkway 0.4 km (0.3 mi) south of the intersection of Phillips Parkway with Patrol and Playalinda Roads, just outside of the Shoreline Project boundary. This site contains a former residence, electrical equipment, Camera Pad #4 (H7-1986), and Field Mill Site #8 (H7-1965). The SWMU assessment identified four LOCs including active and former electrical equipment, and the former residence. Potential contaminants include PCBs, TPH, PAHs, and VOCs. Confirmatory sampling was recommended as a result of the SA, and a work plan was developed (IHA 2012a).

PRL 212 National Park Service (NPS) Lifeguard Station

Also in the vicinity of the Shoreline Project area is the NPS Lifeguard Station which has been designated PRL 212. This site includes previously identified PRL 81, known as Lloyd's Place. A No Further Action (NFA) status was given for the Lloyd's Place site by FDEP in February 2005. PRL 212 is located where Phillips Parkway meets Patrol Road and intersects Playalinda Road. The NPS Lifeguard Station boundary extends on both sides of Playalinda Road and includes Eagle 4 Observation Tower (H7-1684), Lifeguard Building (H7-1681), Beach Maintenance Garage (H7-1682), and Chemical Storage Shed (H7-1681A). A SWMU Assessment was conducted from June through September 2012. Identified LOCs include former buildings, a chemical storage shed, a materials staging area, a vehicle wash down area, past and present electrical equipment, a helipad, and site groundwater. Potential contaminants are metals, hydrocarbons, PCBs, pesticides, herbicides, and solvents. Confirmatory sampling was recommended as a result of the SA, and a work plan was developed (IHA 2012b).

PRL 221 Beach Warehouse (BEWH)

The Beach Warehouse site (J8-1618) is located on the east side of Phillips Parkway just east of LC 39A at KSC. The BEWH and several trailers were installed on the site by NASA in 1965 to support construction of LC 39A. The warehouse, trailers and associated staging areas were removed from the site in 1969 upon completion of the launch pad, and the site has remained vacant and become overgrown since. A SWMU Assessment was conducted in September 2013, identifying two LOCs that include former 3-Pole Mounted Transformers and the former construction staging area. Potential contaminants include metals, hydrocarbons, solvents and PCBs. Confirmatory sampling was recommended as a result of the SA, and a work plan was developed (IHA 2013).

3.2 Biological Environment

The sections below describe the biological resource currently present within the KSC Shoreline Protection project area, along with nearshore and offshore areas which may be affected. This discussion includes Essential Fish Habitat, and Threatened and Endangered species.

3.2.1 Vegetation

Within the footprint of the four alternatives, there are six major land cover types (Table 3-4) that were derived from the Florida Land Use, Cover, and Forms Classification System, 3rd Edition (Florida Department of Transportation 1999). These are described in the following paragraphs; plant classification follows Wunderlin and Hansen (2011), and species listings follow Schmalzer et al., (2002). Depending on the specific alternative chosen, different quantities of these land cover types may be impacted. Acreages potentially impacted for each alternative are given in Table 3-4.

Table 3-5. Acreages of the six major land cover types found within each Shoreline Protection project alternatives

Land cover type	Alt. 1 ha (ac)	Alt. 2 ha (ac)	Alt. 3 ha (ac)	Alt. 4 ha (ac)
Beach and primary dune	0.8 (1.9)	9.5 (23.5)	4.2 (10.5)	0.8 (1.9)
Coastal strand	8.3 (20.4)	2.7 (6.6)	10.3 (25.4)	8.3 (20.4)
Planted coastal strand	2.8 (6.9)		0.6 (1.5)	2.8 (6.9)
Ruderal - herbaceous	1.9 (4.6)	< 0.1 (0.1)	0.2 (0.5)	1.9 (4.6)
Ditch	0.2 (0.4)			0.2 (0.4)
Wetland scrub-shrub	0.1 (0.2)		< 0.1 (0.1)	0.1 (0.2)

<u>Beach and Primary Dune</u>

Primary dunes are poorly stabilized deposits subjected to salt spray and wave action during storms. Depending on sediment supply, these dynamic habitats can be accreting (prograding beaches), or eroding (transgressional beaches), with seasonal variability depending on weather. Vegetation is primarily composed of colonizing species able to tolerate moving sands and the higher salinities found adjacent to the ocean. These include grasses such as sea oats (*Uniola paniculata*), bitter panic grass (*Panicum amarum*), and marsh hay cordgrass (*Spartina patens*). Additional species include railroad vine (*Ipomoea pes-caprae*), baybean (*Canavalia rosea*), seacoast marsh elder (*Iva imbricata*), and gulf croton (*Croton punctatus*). Two species of cacti, prickly-pear (*Opuntia humifusa*) and shell mound prickly-pear (*Opuntia stricta*), are common. In many areas, saw palmetto (*Serenoa repens*) is found extending to the dune crest.

There are no federally listed plant species present, but the following coastal-occurring plants are protected by the State of Florida: sand dune spurge (*Chamaesyce cumulicola*), beach-star (*Cyperus pedunculatus*), coastal vervain (*Glandularia maritima*), narrow-leaved hoary pea (*Tephrosia angustissima* var. *curtissii*), sea lavender (*Argusia gnaphalodes*), shell mound prickly-pear, and Scaevola (*Scaevola plumieri*). Further discussion of threatened and endangered plants of KSC can be found in Schmalzer and Hinkle (1990b).

<u>Coastal Strand</u>

Coastal strand is located adjacent to the beach zone. It is typically a densely vegetated shrub community subject to effects of salt spray and sand displacement resulting from storms (Schmalzer and Hinkle 1985). Open patches of bare sand are common. The topography is comprised of higher dunes and inter-dune swales. In lower areas, these swales can contain wetland vegetation and standing water, providing habitat for wading birds and shore birds.

Vegetation is primarily composed of shrubs including saw palmetto, sea grape (*Coccoloba uvifera*), wax myrtle (*Myrica cerifera*), nakedwood (*Myrcianthes fragrans*), and live oak (*Quercus virginiana*). These shrubs become more abundant and thick as distance from the primary dune increases. Two species of cacti, prickly-pear and shell mound prickly-pear, are also found in this habitat.

There are no federally listed plant species, but the following coastal-occurring plants are protected by the State of Florida: sand dune spurge, coastal vervain, east coast lantana (*Lantana depressa* var. *floridana*), narrow-leaved hoary pea, nakedwood, shell mound prickly-pear, and Scaevola.

Planted Coastal Strand

Planted coastal strand is an anthropogenic planted vegetation cover type associated with inland dune construction on KSC. The location of these constructed dunes is primarily within coastal strand and previously disturbed coastal strand areas. After construction of these inland dunes they are planted with both coastal dune and strand adapted species to stabilize the sand of the built dunes and restore native vegetation cover. The most utilized species planted include: sea oats, bitter panic grass, seacoast marsh elder, sea grape and saw palmetto. In addition to planted species, additional native and invasive plant species colonize this habitat. The gopher tortoise and Southeastern beach mouse quickly establish populations within these habitats as documented within the KSC Pilot Dune monitoring report provided in Appendix D.

There are no federally listed plant species, but the following coastal-occurring plants are protected by the State of Florida and could volunteer into the planted coastal strand: sand dune spurge, coastal vervain, east coast lantana, narrow-leaved hoary pea, nakedwood, shell mound prickly-pear, and Scaevola.

Ruderal – Herbaceous

Ruderal vegetation is found in areas disturbed by past or present land uses. This land cover is typically dominated by weedy native and introduced species. Typical plants include Brazilian pepper (*Schinus terebinthifolius*), wax myrtle, and grasses such as bluestem (*Andropogon* spp.), groundsel tree (*Baccharis halimifolia*), beggar ticks (*Bidens alba*), and common ragweed (*Ambrosia artemisiifolia*). There are no federally or state-listed plant species documented from the ruderal-herbaceous land cover type.

Ditch

Ditches occur throughout KSC and were constructed to facilitate water movement away from facilities and roads. Ditches contain primarily fresh water, but when the nearby estuary water levels are high or there is overwash from the beach, brackish water can flow into the ditches. Increased salinity within ditches affects plant species composition by selecting for salt-tolerant species.

Typical plant species found within the ditches include the submersed widgeon grass (*Ruppia maritima*) and emergent species such as maidencane (*Panicum hemitomon*), pink red stem (*Ammannia latifolia*), herb-of-grace (*Bacopa monnieri*), sawgrass (*Cladium jamaicense*), spikerush (*Eleocharis* spp.), marsh penny wort, (*Hydrocotyle* spp.), southern cattail (*Typha domingensis*), and arrowhead (*Sagittaria lancifolia*). Ditch slopes and adjacent areas generally support ruderal – herbaceous species (see the description of ruderal - herbaceous habitat below). There are no federally listed or state-listed plant species documented from the ditch habitat.

<u>Estuarine Wetland Scrub-Shrub</u>
Estuarine wetland scrub-shrub habitats are found adjacent to the estuary often intermixed with saltmarsh. Most have altered hydrology and salinity due to impoundment construction for mosquito control that occurred in the 1960s (Schmalzer and Hinkle 1985). Additionally, several decades of fire suppression and decreased fire frequency caused by landscape alterations have led to changes in plant species composition, increasing the cover of this community type at the expense of saltmarsh. Woody species less than 5m (16 ft) tall comprise the majority of plants within this habitat, with graminoid species representing a minority component. Common species found include: black mangrove (*Avicennia germinans*), white mangrove (*Laguncularia racemosa*), buttonwood (*Conocarpus erecta*), sea oxeye daisy (*Borrichia frutescens*), saltwort (*Batis maritima*), annual and perennial glassworts (*Salicornia bigelovii* and *Sarcocornia perennis*, respectively), mixed stands of saltgrass (*Distichlis spicata*) and seashore paspalum (*Paspalum vaginatum*), and leather fern (*Acrostichum danaeifolium*). This habitat is often compromised by coverage of the invasive Brazilian pepper tree. There are no federally listed plant species within this habitat, but mangroves are protected by the State of Florida.

3.2.2 Wildlife

Four hundred thirty species of amphibians, reptiles, birds, and mammals have been documented on KSC. Of these, ten are federally protected and one is a Candidate species for federal protection (see Section 3.2.4, Threatened and Endangered Species and Table 3-6 for further information). Fourteen additional species are protected by the State of Florida as either Threatened or Species of Special Concern (Table 3-5).

Table 3-6. Wildlife species documented on KSC which are not federally listed, but are protected by the State of Florida.

SCIENTIFIC NAME	COMMON NAME	PROTECTION LEVEL
Lithobates capito	Gopher frog	SSC
Pituophis melanoleucus mugitus	Florida pine snake	SSC
Pelecanus occidentalis	Brown pelican	SSC
Egretta thula	Snowy egret	SSC
Egretta caerulea	Little blue heron	SSC
Egretta tricolor	Tricolored heron	SSC
Egretta rufescens	Reddish egret	SSC
Eudocimus albus	White ibis	SSC
Ajaia ajaja	Roseate spoonbill	SSC
Falco sparverius paulus	Southeastern American kestrel	Threatened
Grus canadensis pratensis	Florida sandhill crane	Threatened
Sterna antillarum	Least tern	Threatened
Rynchops niger	Black skimmer	SSC
Podomys floridanus	Florida mouse	SSC

SSC= Species of Special Concern

<u>Herpetofauna</u>

Fifty species of reptiles and 19 species of amphibians have been documented to occur on KSC (Seigel et al., 2002). Six of these are federally protected as either Threatened or Endangered and are discussed in Section 3.2.4 (Threatened and Endangered Species). Three of the 69 species are protected by the State of Florida. These include the Florida gopher frog (*Lithobates capito*), the gopher tortoise (*Gopherus polyphemus*), and the Florida pine snake (*Pituophis melanoleucus mugitis*). The Florida gopher frog and Florida pine snake are uncommon on KSC and little is known about their numbers or distribution. The gopher frog is associated with two habitat types. On KSC, it inhabits uplands (scrub and scrubby flatwoods) and lives in gopher tortoise burrows most of the year, but must go to the freshwater swales to breed (Blihovde, 2006). The Florida pine snake also inhabits the uplands on KSC, but is rarely observed. They will use gopher tortoise burrows as den sites, but seem to prefer pocket gopher (*Geomys pinetis*) burrows (Franz, 1992); pocket gophers do not occur on KSC. The gopher tortoise is listed by the State of Florida as a Threatened species and has been classified as a Candidate species for federal listing. The gopher tortoise is discussed further in Section 3.2.4 (Threatened and Endangered Species) of this document.

<u>Birds</u>

KSC provides habitats for 331 bird species (U.S. Geological Service 2007; R. Bolt pers. comm. 2011); 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 discussed in Section 3.2.4 (Threatened and Endangered Species) of this document. In addition, there are 11 species that are protected by the State of Florida (Table 3-5). Six of these belong to a group of birds commonly called waders (Order Ciconiiformes). They are typically associated with wetlands and aquatic habitats and include the storks, egrets, herons, ibises, and spoonbills. The wading bird population on KSC is very large, and it is estimated that between 5,000 and 15,000 birds are present at any given time, depending on the season (Smith and Breininger 1995). The largest numbers occur during the spring while the fewest birds are present in the winter.

<u>Mammals</u>
Thirty species of mammals inhabit KSC lands and waters (Ehrhart 1976). Typical terrestrial species include the opossum (*Didelphis virginiana*), hispid cotton rat (*Sigmodon hispidus*), raccoon (*Procyon lotor*), river otter (Lutra canadensis), and bobcat (*Lynx rufus*). Due to the regional loss of large carnivores such as the Florida panther (*Puma concolor coryi*) and red wolf (*Canis rufus*), the bobcat and otter now hold the position of top mammalian predators on KSC. The gray fox (*Urocyon cinereoargenteus*) and red fox (*Vulpes vulpes*) also occur on KSC, and there has been an increase in sightings of coyotes (*Canis latrans*) since the mid-2000s (R. Bolt pers. obs. 2011). A proliferation of mid-level predators such as the raccoon and opossum has resulted from an imbalance of predator/prey ratios and human-induced habitat changes. Opportunistic species such as the cotton rat and eastern cottontail rabbit (*Sylvilagus floridanus*) account for a large portion of the small mammal biomass, rather than habitat-specific species such as the State-listed Florida mouse (*Podomys floridanus*) and the federally protected southeastern beach mouse (*Peromyscus polionotus niveiventris*). Other small mammals include the least shrew (*Cryptotis parva*), eastern mole (*Scalopus aquaticus*), round-tailed muskrat (*Neofiber alleni*), and the eastern spotted skunk (*Spilogale putorius*). At least three species of bats have been documented. They occasionally use facilities as roost sites, and when conflicts occur due to facility renovations or demolition, or human health concerns, the bats must be excluded from those facilities. Several bat houses have been erected on KSC to help mitigate impacts. A large bat roost and maternity colony is located in the NASA Causeway/SR 3 overpass. Even though it is the busiest intersection on KSC, several thousand bats, mostly Brazilian free-tailed (*Tadarida brasiliensis*), have used this site for at least 25 years (R. Bolt/IHA, 2012, pers. obs.).

3.2.3 Essential Fish Habitat

Essential Fish Habitat (EFH) is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (16 U.S.C. § 1801[10]). "Fish" includes finfish, mollusks, crustaceans, and all other forms of marine animal and plant life other than marine mammals and birds. The Magnuson-Stevens Act requires EFH be designated for all species covered under a federal fishery management plan (FMP), and all habitats utilized by a species for spawning, breeding, feeding, and growth to maturity are included in the EFH analysis. The Magnuson-Stevens Act also allows for a subset of EFH to be classified as Habitat Areas of Particular Concern (HAPC) in order to focus conservation efforts on areas that play a particularly important role in the life history of federally managed fishery species, are especially vulnerable to degradation, or are naturally rare.

Several FMPs protect economically valuable fish and invertebrate resources off east Florida. These include: Spiny Lobster, Shrimp, Golden Crab, Highly Migratory Species, Coastal Migratory Pelagics, Dolphin-Wahoo, and the Snapper-Grouper Complex. In addition, FMPs are also in place for Coral, Coral Reefs, Live/Hardbottom, and Sargassum (which does not have designated EFH) due to the large number of managed fish and invertebrate species intimately dependent on these habitats. Red drum also have a FMP and locally-designated EFH, although management of the species has been largely transferred to the Atlantic States Marine Fisheries Commission because virtually all harvest now takes place in state (not federal) waters. A report on the EFH within the vicinity of the project area was completed and is found in Appendix E. Descriptions within this EFH subsection are taken directly from that document.

3.2.3.1 Habitat Types

Soft Bottom Substrates

Soft bottom sand-mud substrates compose 77-90% of the inner continental shelf of the South Atlantic Bight (Rowe and Sedberry 2006). In a 10-year (1990-1999) study, 195 finfish taxa, 30 elasmobranchs, and 90 decapod crustaceans were collected (ASMFC 2000). Fish captures were dominated by two species: spot (*Leiostomus xanthurus*) and Atlantic croaker (*Micropogonias undulatus*), which together totaled 36% of all fish and invertebrates taken. Other abundant taxa included Atlantic bumper (*Chloroscombrus chrysurus*), porgies (*Stenotomus* spp.) and striped anchovy (*Anchoa hepsetus*). The most common macrocrustaceans included white shrimp (*Litopenaeus setiferus*), coarsehand lady crab (*Ovalipes stephensoni*), and brown shrimp (*Farfantepenaeus aztecus*).Elasmobranchs, particularly carcharhinid sharks and pelagic and demersal rays, were collected less frequently but constituted a large percentage of overall biomass due to their large average sizes. More locally, a brief Minerals Management Service survey of nine sand shoal sites offshore Brevard, Indian River, St. Lucie, and Martin Counties (including the Canaveral Shoals II borrow site) produced 63 fish taxa with dusky anchovy (*Anchoa lyolepis*) and silver seatrout (*Cynoscion nothus*) comprising 69% of all fish caught (Hammer et al., 2005).

Surf Zone

Surf zone habitats at Cape Canaveral do not include hard-bottom resulting from exposed Anastasia limestone or reef-building polychaetes. Consequently, the resident fish fauna is likely qualitatively similar to sand-shell-mud communities in adjacent deeper water but may be somewhat depauperate, supporting elevated densities of those taxa best adapted to surf conditions [e.g., whiting (*Menticirrhus* spp.), Florida pompano (*Trachinotus carolinus*)] (Gilmore, 1977), while largely excluding species poorly adapted to high energy wave action. Only one published survey (Peters and Nelson 1987) near Melbourne and Sebastian Inlet (~75 km [46.6 mi] south of False Cape) has described the surf zone ichthyofauna of the central or north Florida Atlantic coast in any detail. This study documented 61 fish species with the scaled herring (*Harengula jaguana*), shortfinger anchovy (*Anchoa lyolepis*) and Florida pompano (*Trachinotus carolinus*) composing 70% of total catch. Data on surf zone fish abundance are unavailable but density of several economically valuable fish species (e.g., red drum, black drum, pompano, sheepshead, whiting) appears quite high (E. Reyier, 2012 pers.obs.). And most notably, the open surf zone here serves as a high value nursery for juvenile lemon sharks which gather in aggregations up to several hundred individuals each winter from November through March (Reyier et al., 2008).

Consolidated Substrates

Along the east-central and northeast Florida continental shelf, natural hard bottom substrate largely consists of low to moderate relief limestone pavement, ledges, and escarpments which are apparently relic Pleistocene dune formations. A comprehensive survey of limestone reefs and their associated fauna in the vicinity of the project area has not been undertaken, although Perkins et al. (1997) compiled all available locational data of hardbottom substrates along the entire Florida Atlantic coast. This study demonstrated that hard bottom is widely distributed in waters off Cape Canaveral but did not identify any within either the proposed Canaveral Shoals I or II borrow sites or beach renourishment footprint affected under Project Alternatives Two through Four. The only consolidated substrate confirmed in the project area consists of low-relief (~0.25 m [0.8 ft]) humate sand outcroppings in the mid and lower-intertidal and shallow sub-tidal zones near LC 39A (N 28.6070/W 80.5924; Figs. 8-9; Jaeger et al., 2011). Opportunistic field observations suggest that these formations are small, experience significant wave action, and have a spongy consistency supporting only poorly developed communities of algae, sessile invertebrates and fish (E. Reyier/IHA, 2011, pers. obs.).

3.2.3.2 Managed Species

Spiny Lobster

Spiny Lobster life history is described in Appendix E and is considered the most valuable lobster species in the western central Atlantic. It supports a sizeable recreational and commercial harvest out of Port Canaveral. EFH for spiny lobster includes seagrass, unconsolidated soft bottom, coral and other hard bottom substrates, sponges, algal communities, and mangroves. All estuarine and nearshore waters in the Cape Canaveral region are designated as EFH. A small area of EFH-HAPC has been identified directly adjacent to the Canaveral Shoals II sand borrow site.

Shrimp

Five shrimp species are managed under the federal shrimp fishery management plan, including pink shrimp (*Farfantepenaeus duorarum*), brown shrimp (*Farfantepenaeus aztecus*), white shrimp (*Litopenaeus setiferus*), rock shrimp (*Sicyonia brevirostris*), and royal red shrimp (*Pleoticus robustus*). Life histories for these species are described in the EFH Report (Appendix E). Cape Canaveral is a hub of commercial shrimping on the Florida east coast. For penaeid shrimp ("prawn"), EFH includes inshore nursery areas, nearshore Atlantic waters, and all interconnecting water bodies from North Carolina to the Florida Keys (SAFMC 1998). Both the Canaveral Shoals I and II borrow sites, and beach nourishmnent areas listed in Project Alternatives Two through Four are classified as penaeid shrimp EFH. For rock shrimp, EFH consists of offshore sand bottom habitats from 18 to 182 m (59 to 591 ft) in depth from North Carolina through the Florida Keys. The Gulf Stream is considered EFH for its role in dispersing rock shrimp larvae, and the deeper waters off Cape Canaveral are considered EFH because the shelf current systems may help inshore recruitment of shrimp larvae. The project area is not considered royal red shrimp EFH, and no HAPC has been identified for this species.

Highly Migratory Species (Tuna, Billfish, Swordfish, Sharks)

Life histories for highly migratory species (HMS) are found in Appendix C. In additional to most coastal sharks, five tuna species (albacore, bigeye, bluefin, yellowfin, skipjack), four billfish species (blue marlin, white marlin, sailfish, longbill spearfish), and the swordfish are included in the HMS FMP. The Cape Canaveral region sustains a diverse shark fauna (Dodrill 1977) and supports a modest commercial gill net and longline fishery (Trent et al., 1997; Burgess and Morgan 2002). This fishery historically targeted blacktip and sandbar sharks but has shifted somewhat to other large coastal species (e.g., lemon and bull sharks) as the former species have become depleted. Recent scientific studies have demonstrated that the Canaveral region serves as an important nursery for lemon sharks, nurse sharks (Reyier et al., 2008), spinner sharks (Aubrey 2001) and scalloped hammerhead sharks (Adams and Paperno 2007; Reyier et al., 2010). Young lemon sharks aggregate each winter within the surf zone at Cape Canaveral in schools often containing several hundred animals. Scalloped hammerheads, nurse sharks, and spinner sharks are also found near the beach and along the shoals, but in slightly deeper waters.

EFH has been delineated for most species under the HMS FMP. The project area is classified as EFH for twenty HMS species including sailfish, yellowfin and bigeye tuna, as well as sharpnose, blacknose, blacktip, bonnethead, bull, dusky, finetooth, great hammerhead, lemon, nurse, sand tiger, sandbar, scalloped hammerhead, silky, spinner, tiger, and white sharks (NMFS 2009).

Coastal Migratory Pelagics, Dolphinfish, Wahoo

The coastal migratory pelagic FMP includes the king mackerel (*Scomberomorus cavalla*), Spanish mackerel (*S. maculatus*), cero mackerel (*S. regalis*), cobia (*Rachycentron canadum*), and little tunny (*Euthynnus alletteratus*). Dolphinfish (*Coryphaena hippurus*), historically included under this FMP, are now managed under a more recent dolphin-wahoo FMP (SAFMC 2003).

All species are highly migratory along the southeast U.S. coast, with stocks jointly managed (when necessary) by the SAFMC and GMFMC. All species grow fairly rapidly, mature early, produce pelagic larvae, and have relatively high fecundity. Each species is important to some extent in regional recreational and commercial fisheries. A life history account for each of these species is found in Appendix E.

EFH for coastal migratory pelagics in the South Atlantic Bight includes shoals, capes, and offshore bars, the surf zone, high relief hard bottom, coastal inlets, and floating sargassum from the shoreline to the Gulf Stream (SAFMC 1998; NOAA EFH Mapper 2012). In addition, the Gulf Stream itself is EFH because it provides a mechanism to disperse pelagic larvae. In the project area, EFH occurs in the surf zone at the northern boundary of the KSC Shoreline Project footprint. No HAPC is designated locally except that associated with pelagic sargassum EFH for dolphin and wahoo includes the Gulf Stream, Charleston Gyre, Florida Current, and pelagic sargassum (SAFMC 2003). The proposed project area does not include EFH or HAPC except when sargassum is present.

<u>Reef Fish</u>

The Snapper Grouper complex is represented by seventy-three species from ten fish families (Balistidae, Carangidae, Ephippidae, Malacanthidae, Haemulidae, Polyprionidae, Labridae, Lutjanidae, Serranidae, Sparidae) and managed under the snapper-grouper FMP. This group contains among the most economically valuable finfish species in the U.S. South Atlantic. Groupers (family Serranidae) and snapper (Lutjanidae), in particular, are of tremendous commercial and recreational value to the region. These species are managed collectively because they all exhibit some association with coral reef or other hard bottom habitats throughout their life history. Most species in the snapper-grouper complex should be expected within nearshore waters of Cape Canaveral; 26 species from this group were documented from hard-bottom habitats within nearby Port Canaveral, (Reyier et al., 2010). Scamp, gag, and red grouper, gray and red snapper, and amberjack are of particular importance to recreational and commercial fishermen locally. Goliath grouper are a common presence on shallow reefs, while sheepshead, gray snapper, and jack crevalle are of considerable interest to the recreational fishery in the nearby Indian River Lagoon.

EFH for species listed in the snapper-grouper management plan includes coral reefs, other live/hard bottom, artificial reefs, unconsolidated soft bottom, and submerged aquatic vegetation (seagrass and macroalgae), from the shore to at least 183 m (600 ft) deep where annual water temperature is adequate to sustain adult populations (SAFMC 2009). EFH also includes the water column overlying adult demersal habitats, as well as pelagic Sargassum, because these habitats are utilized for spawning and/or pre-settlement larvae. Locally, all areas within and adjacent to both the offshore sand borrow site and nearshore deposition site are classified as snapper-grouper EFH. Snapper-grouper HAPC is limited to a small area adjacent to the northwest corner of the CS-II sand borrow site (NOAA EFH Mapper 2012).

Corals, Coral Reefs, and Live/Hard Bottom

While the majority of the Florida east coast continental shelf is characterized by expansive sand and mud-covered plains with rather low biological productivity, hard bottom habitats are scattered at varying densities and depths throughout the region (Struhsaker 1969, Sedberry and Van Dolah 1984, SAFMC 1995). These features serve as attachment substrates for a diverse assortment of marine algae and invertebrates, and provide shelter and foraging opportunities for a wide variety offishes including many of considerable economic value to the region. Hard bottom in nearshore waters off east Florida consists of many different materials. Non-coral nearshore hardbottom habitats are the primary natural reef structures in east-central and north Florida. These habitats are derived from large accretionary ridges of coquina mollusks, sand, and shell marl which lithified parallel to ancient shorelines during Pleistocene interglacial periods. Nearshore hardbottom habitats on the inner shelf are patchily distributed among large expanses of barren, coarse sediments and show reduced coral diversities. Nelson (1989) recorded 325 species of invertebrates and plants from nearshore hardbottom habitats at Sebastian Inlet. In some areas, the hardbottom reaches heights of 2 m (6.6 ft) above the bottom and is highly convoluted. Hard corals are rare due to high turbidities and wave energy; however, hard corals that are encountered are *Siderastrea radians, Oculina diffusa* and *Oculina varicosa*.

Along the east coast of Florida, the areas of concern (HAPC) for corals, coral reefs, and live/hard bottom *Phragmatopoma* (worm) reefs include: the Oculina Banks from Ft. Pierce to Cape Canaveral, the nearshore (0-4 m) hard bottom from Cape Canaveral to Broward County, and the the offshore (5-30 m) hard bottom that runs from Palm Beach County and south. Within the project area, coral EFH and HAPC is designated in the immediate vicinity of both the Canaveral Shoals I and II borrow sites as well as immediately offshore the KSC shoreline.

3.2.4 Threatened and Endangered Species

Twelve species of federally protected wildlife have been documented within the Shoreline Protection project area of influence; one additional species historically occurred, but is no longer believed to be present. These thirteen species are listed in Table 3-6.

Table 3-7. Federally protected wildlife species documented to occur or occurred historically within the Shoreline Protection project boundary. Status: T – threatened; E – endangered; C – candidate for listing.

Scientific Name	Common Name	Status	Identification
Caretta caretta	Loggerhead	T	documented
Chelonia mydas	Atlantic green turtle	E	documented
Dermochelys coriacea	Leatherback sea turtle	E	documented
Gopherus polyphemus	Gopher tortoise	C	documented
Drymarchon couperi	Eastern indigo snake	T	documented
Nerodia clarkii taeniata	Atlantic saltmarsh snake	T	historical
Charadrius melodus	Piping plover	T	documented
Calidris canutus rufa	Rufa red knot	T	documented
Sterna dougallii	Roseate tern	T	documented
Aphelocoma coerulescens	Florida scrub-jay	T	documented
Peromyscus polionotus niveiventris	Southeastern beach mouse	T	documented
Eubalaena glacialis	Northern right whale	E	documented
Trichechus manatus	West Indian manatee	E	documented

<u>Marine Turtles</u>

Three species of marine turtles currently nest on KSC beaches. The loggerhead (*Caretta caretta*) and green sea turtle (*Chelonia mydas*) are abundant during their nesting seasons (May – October) and numbers of leatherback (*Dermochelys coriacea*) nests have increased over the past 20+ years; they are no longer considered rare.

In July 2014, NOAA Fisheries and the USFWS announced two final rules to designate critical habitat for the threatened loggerhead sea turtle *(Caretta caretta)* in the Atlantic Ocean and on coastal beach habitat along the Atlantic and Gulf coasts. Relative to KSC, the marine critical habitat listed by NOAA includes nearshore reproductive areas directly off of the nesting beach, breeding habitat, adjacent migratory corridors and *Sargassum* habitat. The USFWS-designated terrestrial critical habitat area affects six states. It includes the KSC nesting beach as part of a region that accounts for 48 percent of an estimated 1,531 miles of coastal beach shoreline used by loggerheads, and about 84 percent of the documented nests (NOAA 2014).

The nearby Canaveral Ship Channel has been recognized as important habitat for sea turtles since the 1970s. Due to concerns about interactions with navigation, dredging, and commercial trawling along this channel, numerous studies have been conducted over the last four decades including Carr et al. (1980), Henwood (1987), Bolten et al. (1994), Arendt et al. (2011) to name a few. The channel continues to attract juvenile and adult turtles year round and also serves as a wintering site when ocean water temperatures decline. Arendt et al. (2011) found adult males in peak numbers between February and April, just before the nesting season starts. This was followed by a drop in males and influx in adult females. Overall distribution patterns showed movements of both resident and migrant male sea turtles in the vicinity of the Cape Canaveral shoals. They noted a period of nearshore and inshore distribution over the Cape shoals out to about the 60 m (197 ft) contour, followed by dispersals extending to the middle and outer continental shelf (Arendt et al. 2011). The Cape is located about 40 km (25 mi) north of Melbourne Beach, Florida, the largest sea turtle nesting rookery in the U.S.

The KSC property beach extends from the CCAFS north boundary for 25.5 mi (41 km) ending in southern Volusia County, and in total experiences over 4000 sea turtle nests per year, in recent years. A subset of this shoreline is the KSC security beach, where the launch operation zones occur, which is limited to the southernmost 10 km (6.2 mi) adjacent to CCAFS. The northern KSC beach property is collocated with the CNS and managed daily by CNS, while the secured section is managed by MINWR with specific monitoring tasks performed NASA's KSC Ecological Program staff. Table 3-7 shows the number of nests, by species, deposited on the KSC security beach from 2008 through 2014. The Shoreline Protection project boundary consists of the northernmost 7.6 km (4.7 mi) of this secured beach. Nesting occurs in good numbers along the entire security beach but data analyzed though 2012 show that nesting "hot spots" continue to be from km 29 to 33 (Figure 3-20). These hotspot kms coincide with monuments V72 through V81 described in Section 3.1.3. The area between km 30-31 has the highest percentage of false crawls (emergences that do not result in a nest). This location is also where the dune is most highly eroded and wash overs have occurred several times in the past few years.

Table 3-8. Sea turtle nesting data for the KSC security beach, by species for the years 2008–2014 (Data from annual Index Nesting Beach Survey data collected by MINWR).

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

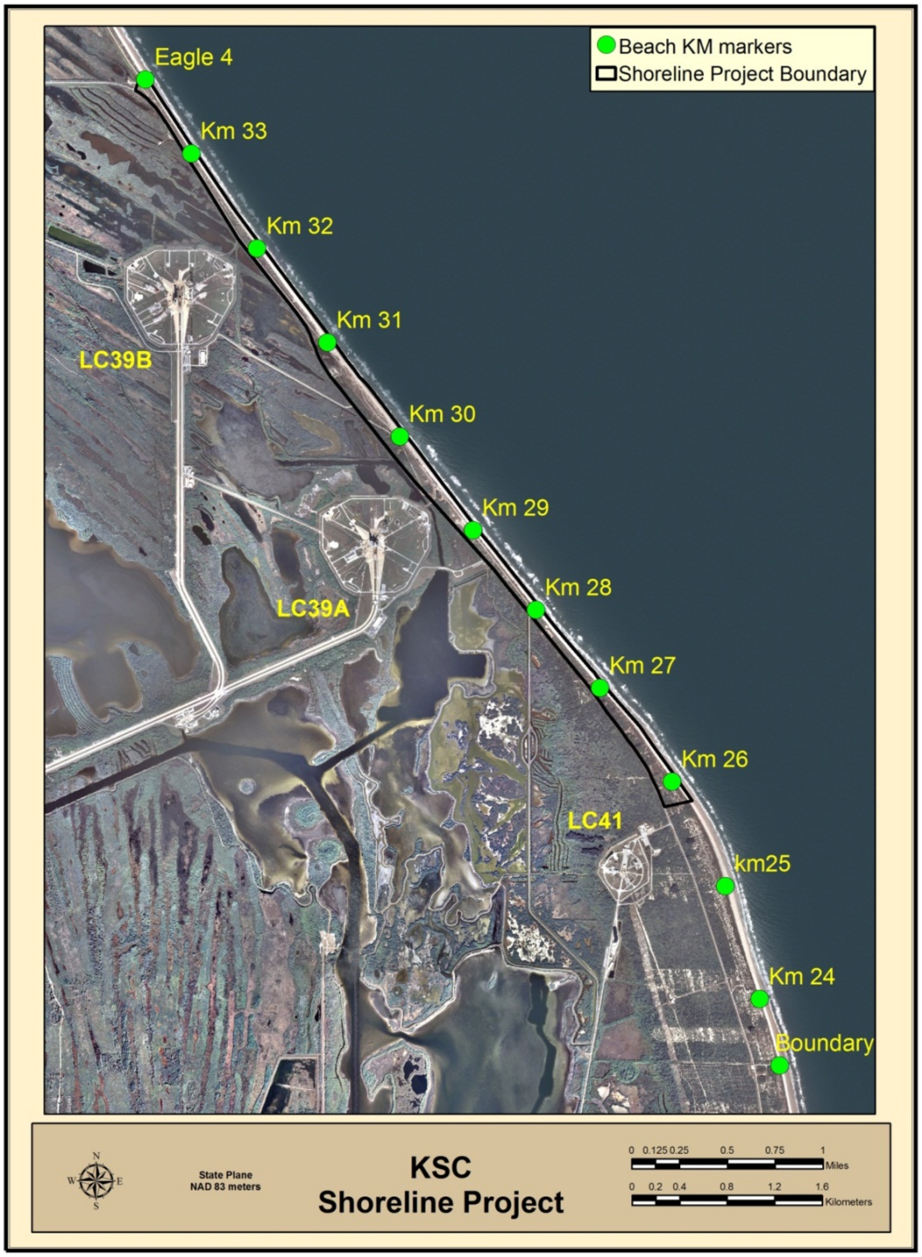


Figure 3-20. The KSC sea turtle nesting beach. Yellow numbers indicate the general locations of kilometer markers used for recording sea turtle nesting data for the Florida statewide Index Nesting Beach Survey.

While the federal beaches represent a relatively dark night time environment compared to the rest of the Florida Atlantic coast, marine turtle disorientation has occurred along the security beach over the last two decades. Disorientations are related to lighting from nighttime space operations and center facilities. The USFWS Endangered Species Office issued an interim

Biological Opinion (BO) to NASA KSC in 2009 pertained to the 2009 - 2011 nesting seasons. The Opinion was tied to the review of KSC lighting impacts and management activities on nesting sea turtles and emerging hatchlings along the KSC security beach only. A rate of take (i.e., hatchling disorientation) allowed by the BO was 3% (USFWS 2009).

Disorientation surveys for adults and hatchlings performed every season on KSC show that hatchling disorientation rates vary from year to year (Figure 3-21), depending on light trespass (photopollution) from facilities and the relative condition of the dunes that lay between light sources and the nesting beach. Over the last 14 years the rate has ranged from about 2% to near 12%. The average between 2008 and 2013 was approximately 4%. In certain years since 2008, KSC biologists deployed nest shields for those located in areas assumed to be high risk light exposure and disorientation. Continual erosion events have re-exposed parts of the nesting beach and associated fauna to the exterior lights located landward. The 2013 disorientation rate was 8.6% and 2014 was 6.1% (S. Gann/IHA, 2014, pers. comm.). This issue continues to be a concern for KSC environmental managers.

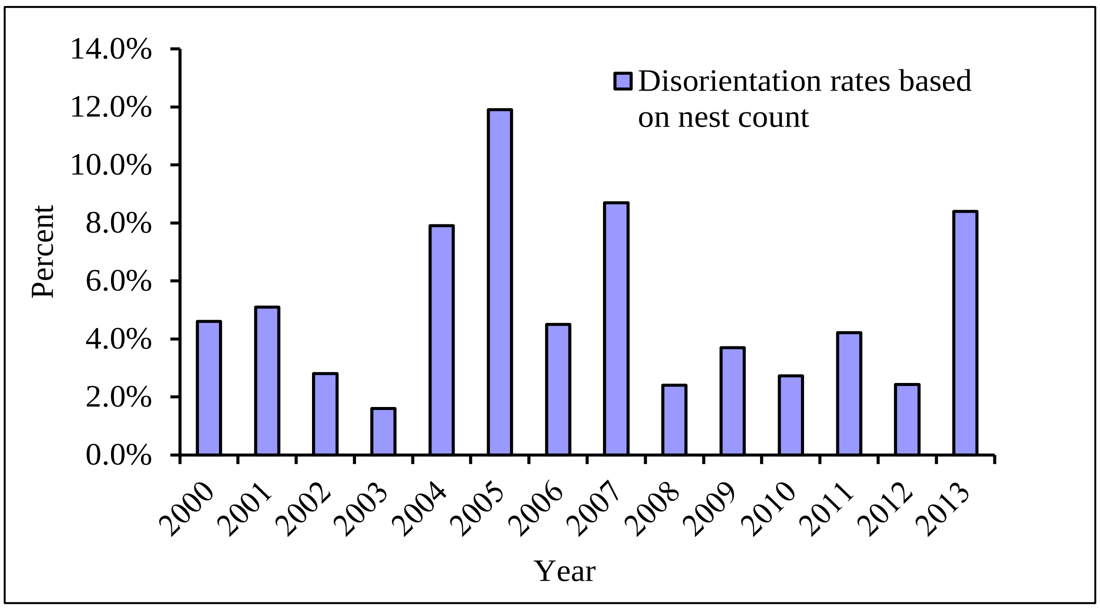


Figure 3-21. Disorientation rates of sea turtle hatchlings on the KSC beach 2000 - 2013 nesting seasons.

Gopher Tortoise

The coastal dune habitat along the KSC shoreline is very suitable for gopher tortoises (*Gopherus polyphemus*). More than 1,000 tortoises have been captured, measured, and permanently marked on KSC property since the mid-1970s (R. Seigel/Towson University, 2012, pers. comm.). Hatchling and juvenile tortoises are common, indicating a healthy, reproducing population.

Studies to determine home range sizes have been done with radio tagged tortoises on KSC. Males' home ranges were between 0.3 and 5.3 ha (0.7 – 13.1 ac); the average size was 1.9 ha (4.7 ac) (Smith et al., 1997). Females' home ranges were smaller and they used between 0.3 and 1.1 ha (0.7 – 2.7 ac), with an average of 0.6 ha (1.5 ac). However, these studies were from scrub and scrubby flatwoods habitats where conditions are much different than those in coastal dune. KSC scrub and scrubby flatwoods have a dense shrub layer that tends to reduce the amount of light reaching the ground, which in turn reduces the herbaceous plant growth used as food by tortoises (Schmalzer and Hinkle 1992; Breininger et al. 1994). Tortoises in those less suitable habitats need larger home ranges in order to have sufficient resources (Ashton and Ashton 2008).

The coastal dune is more open and the vegetation is primarily grasses and herbs, with plenty of documented species of tortoise food available (Ashton and Ashton 2008). Also, the soil of the coastal dune habitat is sandy and very suitable for burrowing. Because of these habitat characteristics, it is not surprising that the project area supports a large gopher tortoise population. In 2013, prior to the construction of the post-Hurricane Sandy inland dune which extended 2 km (1.2 mi), approximately 220 tortoise burrows were discovered within the overall project footprint. 53 tortoises were ultimately removed and relocated from the project area to adjacent sites that were separated from the construction by silt fence. Once the dune was completed, the silt fence was removed. Data acquired from radiotracking nine adult tortoises, as well as incidental observations of other tortoises, showed that they moved into the created dune habitat very quickly to feed and establish burrows.

There are several man-made features within the proposed Shoreline Protection project area that are potentially detrimental to tortoises. The railroad track is an effective trap for tortoises (and other turtle species) when they crawl onto the tracks where road elevations permit. Tortoises often follow the track line, cannot get out, and walk inside the tracks until they overheat or get too cold and die (B. Bolt, 2012, pers. obs.; R. Seigel/Towson University, 2012, pers. comm.) (Figure 3-22). Before the Sandy Dune was constructed, slightly more than 1.9 km (6,300 ft) of railroad track and associated ballast were removed from within the project footprint, eliminating a hazard and improving connectivity within the habitat.

Tortoise road kills are not unusual along Phillips Parkway because the tortoises feed on the grassy road shoulder and regularly cross the road. There are occasionally burrows on the shoulder that open directly onto the pavement. Another potentially unfavorable feature within the project area is the 0.2 ha (0.4 ac) of ditches. These ditches are narrow and extend over a long portion of the project, running parallel along the primary dune. In some places and under the right conditions, the ditches are probably sufficient to hinder access by gopher tortoises to the various habitat types, resources, and other tortoises. All of these man-made features discussed above are likely harmful to the overall health and welfare of the tortoise population.

Figure 3-22. Shell from a gopher tortoise that was trapped inside the railroad tracks in the Shoreline Protection project area, February 2012.

Eastern Indigo Snake

Eastern indigo snakes (*Drymarchon couperi*) on KSC have large home ranges, eat a wide variety of prey, and use many different habitat types (Stevenson et al., 2010; Breininger et al., 2011). Radio tagged indigos tracked in Brevard County 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. A radio tagged indigo from KSC had a home range located just south of the Shoreline Protection project area on CCAFS (Figure 3-23). This male's home range was 117.8 ha (291 ac) and he used habitat types that are found within the project area, including coastal dune. Indigos have been documented on several occasions in the Shoreline Protection project footprint (R. Bolt/IHA, 2013, pers. obs.). A female was captured, measured, tagged with a Passive Integrated Transponders (PIT) tag, and released in November 2011 from a newly created secondary dune that is located within the Project boundary (Bolt et al., 2012).

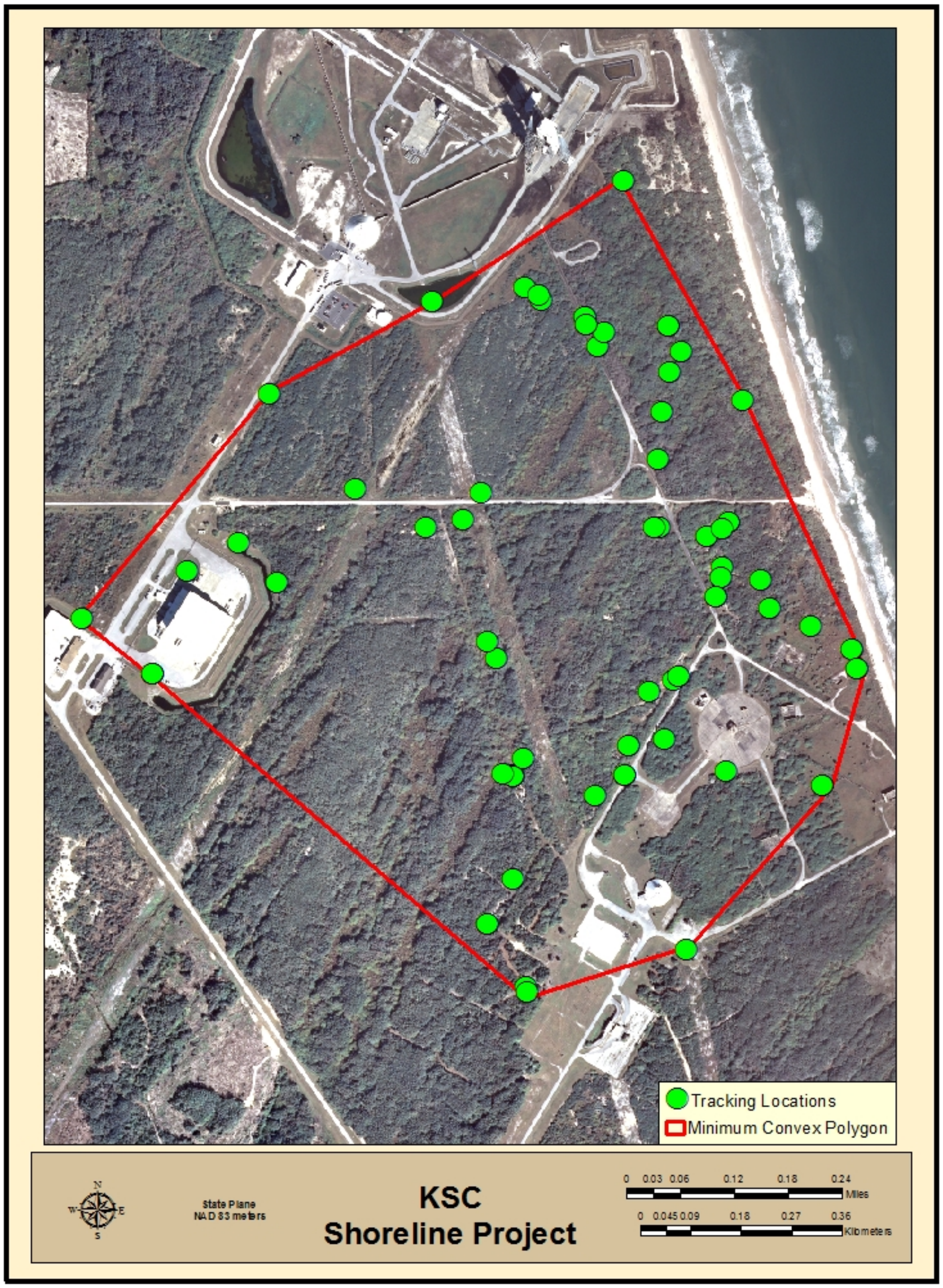


Figure 3-23. Radio tracking locations and the minimum convex polygon home range (117.8 hectares [ha] [291 ac]) for a male eastern indigo snake tracked on CCAFS just south of the KSC Shoreline Protection project boundary.

Habitat fragmentation was found to be a critical factor impacting indigo snake population persistence (Breininger et al., 2012). 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 (Breininger et al., 2004). The project area is relatively intact along the length of the shoreline. However, Phillips Parkway is a potential source of road mortality; road mortality was found to be the most prevalent cause of death in the radio tagged indigos studied in Brevard County (Breininger et al., 2012).

Atlantic Salt Marsh Snake

Although the Atlantic salt marsh snake historically occurred along the coastline from Volusia County through Brevard County south into Indian River County, it is now believed to be restricted to a limited coastal strip in Volusia County (USFWS 2005). Specimens found in Brevard and Indian River counties are believed to be intergrades between the Atlantic subspecies and the mangrove salt marsh snake (P. Moler, 2012, pers. comm.). Little is known about the population size or status of Atlantic salt marsh snakes, but none are expected to occur within the project area.

Shorebirds

The piping plover, rufa red knot, and roseate tern (all listed as federally Threatened) are rare to occasional visitors to the KSC shoreline, mostly during migration seasons. None of these birds are documented nesting here.

Florida scrub-jay

Within the project area, there are 45.5 ha (112.4 ac) of coastal strand habitat that could potentially support Florida scrub-jays (*Aphelocoma coerulescens coerulescens*). However, in order for scrub-jays to occupy the habitat and persist, the habitat must have a narrow range of characteristics related to vegetation height and open space (Johnson et al., 2011). These conditions were historically maintained by wildfires, and along the coastline, by salt spray. Now, scrub-jay habitat types are typically kept suitable through controlled burning and mechanical treatment.

Most of the coastal strand within the project area does not support jays (Figure 3-24), likely because there is too little scrub oak of the appropriate height. In 2010, two territories were documented on the southern end of the project area and their boundaries were determined; territory A was 33.6 ha (83 ac) with two jays and territory B was 23.4 ha (57.8 ac) with four jays (Figure 3-24). Presence/absence surveys done in January 2015 showed that the area of these territories is still occupied, but territory boundaries were not delineated (G. Carter /IHA, 2015, pers. comm.).

Figure 3-24. Florida scrub-jay territories located within the Shoreline Protection project boundary in 2010.

Southeastern beach mouse

Studies have been performed on the KSC southeastern beach mouse (*Peromyscus polionotus niveiventris*) population since the 1970s. Overall the population appears stable, likely due to the continuity of the habitat between CNS, KSC and CCAFS which allows recolonization when subpopulations are extirpated by natural incidents. Multiple trapping events between 2003 and 2005 at seven transects located directly within the Shoreline Protection project area yielded results similar to previous studies in 1989-1991 with good beach mouse capture rates, but lower than those experienced further south on CCAFS, where the expanse of suitable habitat is much larger (Provancha et al., 2005). The abundance and distribution of beach mice on CCAFS is such that they are occasionally found inside facilities as observed from 1999 to 2014 (A. Chambers/45SW, Jan. 2015,pers. comm.). In the KSC project area, all age classes were captured but were mostly adults, many of which were in reproductive condition regardless of season. Studies using footprint tracking tubes affirm that beach mice are distributed along the entire coastline, including the project area (Stolen et al., 2014).

Over the last decade, several significant hurricane and non-hurricane storm events resulted in overwash and severe erosion of the KSC dunes and beach. In 2004, three hurricanes directly hit Florida and affected the Shoreline project area either by rainfall, winds, and/or serious beach erosion. One of the transects established for the 2003-2005 beach mouse study experienced overwash that eliminated much of the vegetation and some of the trapping stations; the primary dune at two other transects was eroded approximately 2 m (6.6 ft) on the ocean side. Sampling was conducted three weeks after the last storm, but no conclusions could be made as to the impact of the storm damage on beach mouse populations. Mice were captured at all sampling locations, although numbers were lower where vegetation losses were high (Provancha et al., 2005). Significant storms also caused damage in 2007 and 2008, but no post-storm surveys were performed. Restoration projects by KSC and MINWR were implemented in 2005 and 2008 to repair dune breaches and rebuild dune height. This was primarily to reduce light trespass on the beach from nearby facilities (potentially disorienting marine turtles). Sand was acquired on-site, either by digging out from the landward side of the primary dune (creating ditches and swales) or pulling sand from the ocean side. It was unknown how long the impacts from such activities affect beach mouse populations, but these impacts were expected to be short-term. Monitoring of a “constructed” secondary dune in 2010 within the Sandy Project boundary showed that at least 33 individual beach mice of all age classes were occupying the new dune within ten months of the bare sand being planted with native vegetation (Bolt et al., 2012).

For the emergency repair (Sandy Dune) project in 2013, three small mammal trapping events were conducted, two preconstruction and one post-construction. The first preconstruction event (2 – 4 December 2013) involved trapping in two areas outside the construction footprint for consideration as recipient sites for beach mice removed from the construction area (Figure 3-25). If large numbers of beach mice were observed within the recipient sites, then the recipient sites would not be used. This was based on advice from FWC (J Gore, Nov 2013, pers. comm.).

regarding potential negative impacts of introducing additional mice into an occupied area. There were 356 trap nights with 10 individual beach mice captured from the south recipient area and none from the mid-recipient site. These results determined that mice would not be relocated/introduced into the already "populated" south recipient site, but that the mid-recipient site would be used. These areas were separated from the construction site by silt fence.

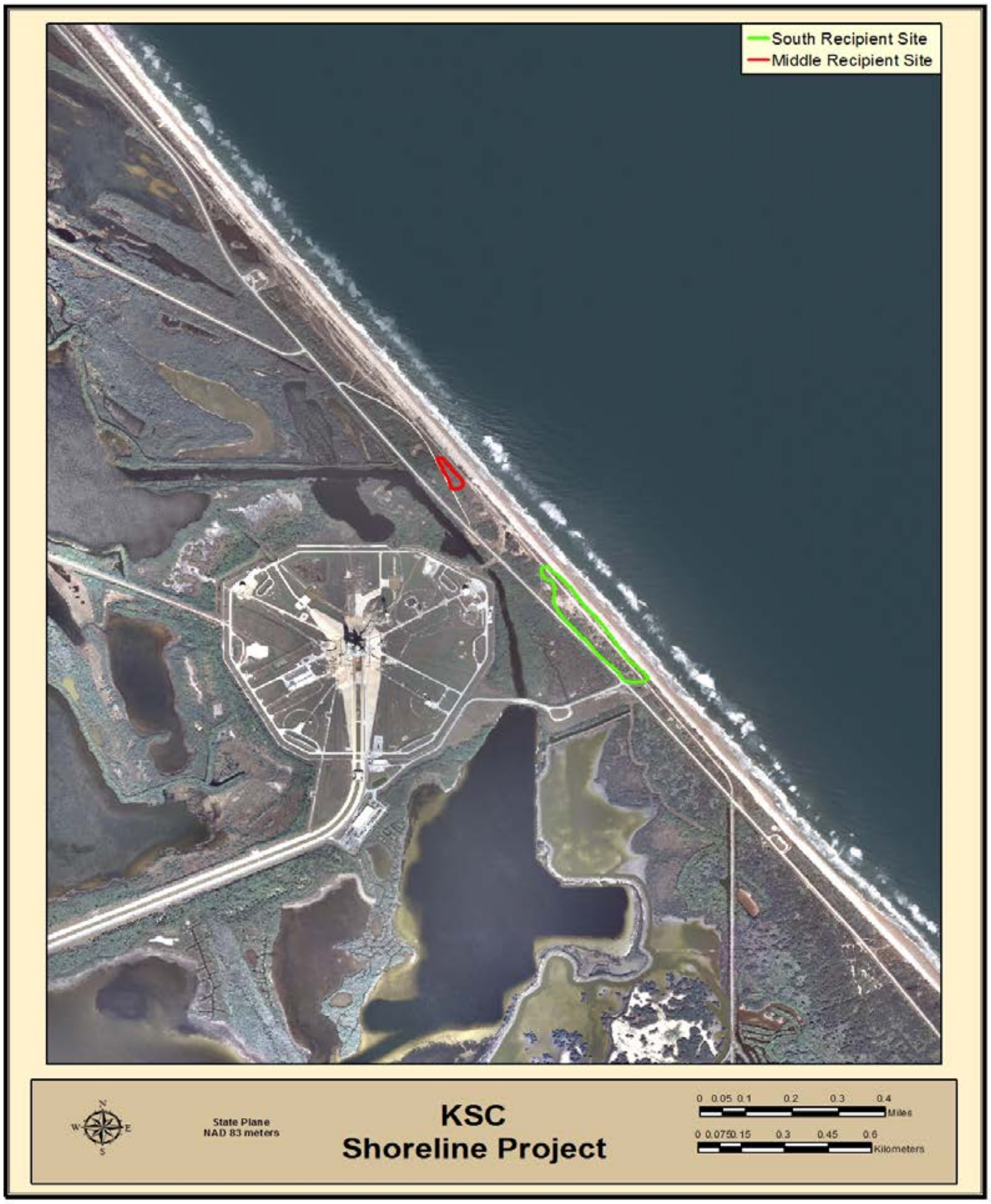


Figure 3-25. Location of two areas surveyed for use as recipient sites for southeastern beach mice relocated from the Sandy Dune footprint before construction.

The second preconstruction trapping effort was conducted to collect beach mice inhabiting the construction footprint and adjacent 6 m [20 ft] to the railroad tracks. Traps were set linearly for approximately 2 km (1.2 mi) from 5 – 9 December 2013, resulting in 1,009 trap nights. There were 18 small mammals trapped, including eight beach mice. Those beach mice were relocated to the mid-recipient site. The first post-construction trapping was conducted 25 – 27 June 2014, just over two months after construction. A total of 152 traps were placed in sets of four at the 38 vegetation monitoring points on the new Sandy Dune. The direction and distance of the traps from the vegetation points were randomly determined. A total of 412 trap nights yielded 46 different southeastern beach mice, and no other species of small mammals. None of the animals were recaptures from the preconstruction trapping events.

In addition to the post-construction trapping, ten mice (5 females and 5 males) were radio tracked from 22 – 25 April 2014. Radio tracking was used to determine how soon and how extensively beach mice might use the newly created dune habitat. Relying solely on trapping data was of concern because the response of mice to baited traps could bias conclusions. The mice were tracked from 3 to 15 days, with an average of 9.8 tracking days per mouse. Two of the mice were tracked directly on the new Sandy dune within a few days of being radio collared, even though the dune vegetation had been planted for less than a month and was still sparse [46 cm (18 in) between plants]. Two other mice crossed the dune at least once during the radio tracking surveys. Observations included: 1) little consistency in the amount of area or distance moved. Some moved once and stayed in the same burrow for the duration of tracking time, while others used several burrows and were active while being tracked; 2) Three long distance movements of 88 m (289 ft), 150 m (492 ft), and 530 m (1,739 ft) over the course of one or two nights were documented. 3) Where the railroad track was not removed within a radio-tracking area (south of the Sandy dune), it was not an obstacle for the mice; three mice used habitat on both sides. 4) At least one mouse (and possibly two) was observed sharing a burrow with another beach mouse. It was clear that mice began using a newly created dune very quickly.

<u>Marine Mammals</u>

All marine mammals are protected under the Marine Mammal Protection Act (MMPA) of 1972 and are under the jurisdiction of NOAA Fisheries. The MMPA prohibits, with certain exceptions, the take of marine mammals in U.S. waters and by U.S. citizens on the high seas, and the importation of marine mammals and marine mammal products into the U.S. (NOAA Fisheries 2005). The only regularly observed species in the nearshore and shelf waters potentially impacted by the Shoreline Protection project waters is the common bottlenose dolphin (*Tursiops truncatus*). Two federally protected marine mammals that are occasionally seen are the northern right whale and the West Indian manatee (Table 3-6).

The northern right whale occupies waters off Boston and Canada for feeding during the summer and migrates south during the winter months (Wynne and Schwartz 1999). Females and calves can be found very close to Georgia and Florida shores, the only known right whale calving grounds, between December and March when pregnant females give birth to their young (NOAA 2012). In 1994, the NMFS designated the coastal waters of Georgia and Florida as right whale critical habitat (Federal Register 1994; Fig 3-26). Right whales are observed regularly off the Brevard County coast; the Cape Canaveral region is generally considered to be their southern limit, although there are occasional sightings further south (NOAA 2012).

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

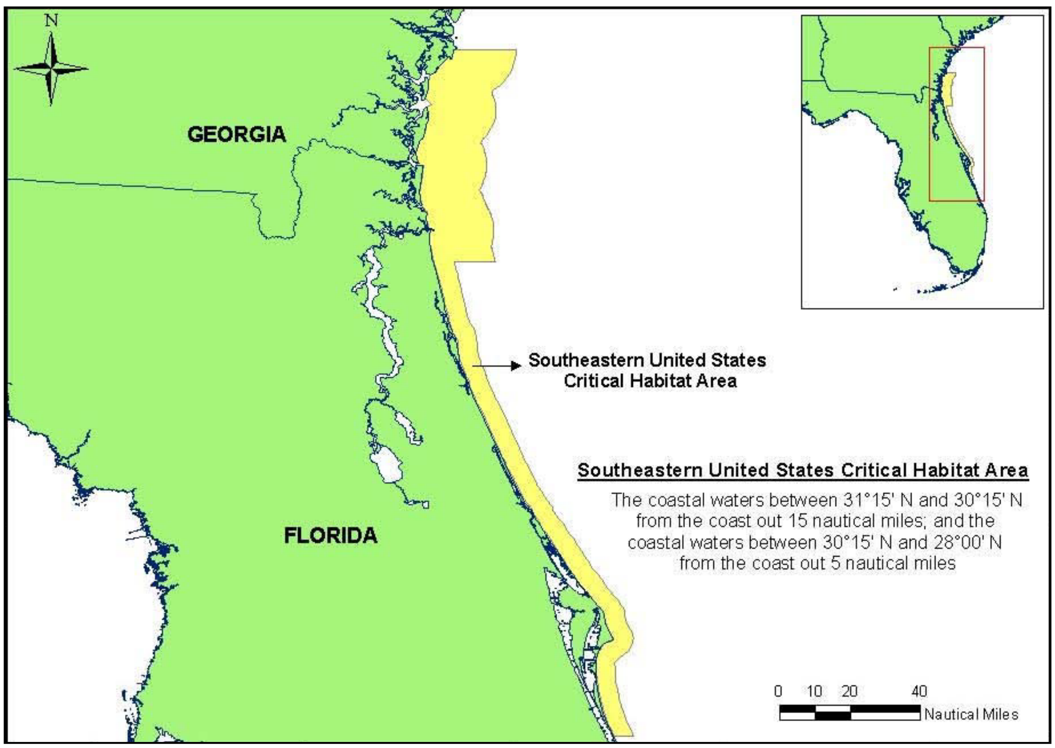


Figure 3-26. Location of designated critical habitat for the northern right whale in the southern part of the range.

West Indian Manatee

The waters surrounding KSC, both near-shore and estuarine, serve to provide year-round safe harbor and foraging areas for West Indian manatees. Monthly aerial surveys of manatees have been conducted over the KSC portion of the Banana River since 1977. Manatees can be found at KSC during all months of the year, except when winter cold fronts drop water temperatures below 19°C (66°F). KSC generally experiences a spring peak in manatee numbers followed by a fairly consistent number of animals in summer, another increase each fall, and then a drop in number of animals each winter. The north end of the Banana River, south to near KARS Park I, is protected from entry of motorized watercraft, either by KSC security restrictions or as a designated manatee sanctuary. Over the last three decades, spring numbers within the KSC survey area have increased nearly 10 fold; in 2012 over 1000 individuals were observed on one survey. This represents approximately 20 to 25% of the total Florida population.

It has been assumed that the quiet KSC waters (within the sanctuary) combined with extensive seagrass beds (primarily *Halodule* and *Syringodium)* provide good habitat that manatees continue to use and teach their offspring to locate (Provancha and Hall 1991). However, recent episodic algal blooms in this region resulted in an approximate 80% reduction in seagrass in 2011 and 2012 (J. Provancha, pers. obs.). The impacts on manatees and other seagrass dependent species remain to be seen. Seagrass mapping in collaboration with the SJRWMD and the U.S. Geological Survey is underway and monitoring of manatee distribution continues.

Manatees are not observed in large numbers in the nearshore waters that would potentially be impacted by the Shoreline Restoration Project as they are in the estuary, but they are not uncommon. Shorelines are used by manatees to navigate in their northward and southward travels along the coast and they have been observed entering the ocean from the estuary via inlets. Manatees have occasionally been seen resting on the beach out of the water (J. Provancha, 2000, pers. obs.).

3.3 Social and Economic Environment

The following sections provide background information on land use, infrastructure, and social and economic characteristics of KSC and the surrounding area.

3.3.1 Land Use

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/project plans, policies, ordinances, and regulations that determine the types of uses that are allowable, and protect environmentally sensitive land. Land and open water resources of KSC comprise 57,400 ha (142,000 ac) in Brevard County and Volusia County, and are located along the east coast of central Florida at approximately 28º 38’N, 80 º 42’W (NASA 2010). The majority of the KSC land areas are located on the northern part of Merritt Island, which forms a barrier island complex adjacent to Cape Canaveral (NASA, 1979). Undeveloped areas (uplands, wetlands, mosquito control impoundments, and open water) comprise approximately 95% of KSC (NASA 2010).

The National Space Act of 1959 enabled the establishment of KSC under NASA jurisdiction for the purpose of implementing the Nation’s space program. NASA maintains operational control over approximately 1,787 ha (4,415 ac) of KSC (NASA 2010). These operational areas 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 area 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's mission is to enable government and commercial spaceflight entities with facilities, an experienced workforce, and the knowledge necessary to support new and existing space programs. NASA considered impacts under Section 4(f) of the Department of Transportation (DOT) Act, which has been recodified and renumbered as 49 U.S.C. Section 303(c). It is the policy of the U.S. government that special effort should be made to preserve the natural beauty of the countryside and public park and recreation lands, wildlife and waterfowl refuges, and historic sites. 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 unique relationship at KSC between spaceflight and protection of natural resources is carefully orchestrated to ensure that both are successfully achieved with minimal conflict. The current KSC Master Plan was developed for programmatic transitional phase between the Shuttle and Space Launch Systems (SLS) programs. It provides the necessary framework to support both NASA and commercial launch operations (NASA 2012).

The designation of MINWR and CNS, in 1963 and 1975, respectively, on the 54,723 ha (135,225 ac) outside of NASA's operational control reflects this mutually beneficial objective. Both MINWR and CNS effectively provide a buffer zone between NASA operations and the surrounding communities. The NPS administers a 2,693 ha (6,655 ac) area of the CNS, while the USFWS administers the remaining 52,030 ha (128,570 ac) of the CNS and MINWR. The USFWS and NPS exercise management control over agricultural, recreational, and environmental programs within their respective jurisdictions at KSC, subject to operational requirements defined by NASA, such as temporary closures for launch and landing-related activities (NASA, 2010). NASA remains the landowner and retains the authority to remove lands or construct facilities within MINWR or CNS as needed to support the space program.

3.3.1.1 Surrounding Land Use

Major municipalities in the immediate vicinity of KSC include Titusville and Merritt Island. Titusville is located on the western shore of the Indian River, on the mainland, approximately 20 km (12.5 mi) from the coast. The unincorporated community of Merritt Island is south of KSC and its northern limit is approximately 16 km (9 mi) from the KSC shoreline; land use is primarily agriculture and residential. Brevard County has zoned the SR 3 corridor as agriculture, rural, residential, and industrial. Agricultural areas are dominated by citrus groves, and industry in this area is limited to a gaseous nitrogen (GN_2) manufacturing plant adjacent to KSC property on the west side of SR 3. This plant is a strategic facility from which nitrogen is piped directly to KSC where it is used to support various payload, Titan, and Atlas facilities. The GN_2 creates an inert environment and is used to purge the vehicles during fueling operations. In addition, the GN_2 is used with communication and camera boxes around the launch pads to prevent condensation and corrosion, and protects electrical components that must be rendered explosion-proof by rendering them inert.

3.3.1.2 Coastal Zone Management

Federal activity in a coastal zone requires preparation of a Coastal Zone Consistency Determination in accordance with the Federal Coastal Zone Management Act (CZMA) of 1972 implemented by NOAA through the State coastal zone management offices. 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 for their activities. Florida's statewide coastal management program, executed by the 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 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, F.S.

3.3.2 Infrastructure and Utilities

There are approximately 486 active facilities located on KSC including space vehicle storage and testing facilities, chemical storage buildings, launch complexes, processing areas, laboratories, and offices. Equipment and personnel in all of these facilities provide a variety of functions in support of the KSC mission, including the following:

- Assemble, integrate, and validate payloads, including International Space Station (ISS) elements and upper stage boosters
- Conduct launch, recovery, and landing operations

- Design, develop, construct, operate, and maintain each launch and landing facility and the associated support facilities
- Maintain ground support equipment required to process launch vehicle systems and their associated payloads
- Partner with Department of Defense launch activities and provide logistics support to CCAFS, Patrick Air Force Base, VAFB, and various contingency and secondary landing sites around the world
- Research and develop new technologies to support space launch and ground processing activities
- Provide government oversight and approval authority for commercial expendable vehicle launch operations.

Existing structures and facilities within and in the vicinity of the Shoreline Project boundary include towers, camera pads, communications buildings, and launch complexes. The Eagle IV Observation Tower (H7-1684) located at northern extent of the project area, is used by KSC Protective Services as a guard and watch tower. It provides visibility necessary for KSC boundary security. Universal Camera Pad #7 (J8-0754) is located east of Phillips Parkway between LC 39A and LC 39B. This camera pad is also a tour bus stop for viewing of launch pads, ocean, and two signs commemorating Apollo and Space Shuttle Program launches from Pads 39A and 39B.

Facility J8-1567, the Cable Terminal Building, houses equipment that serves as a communications interconnect point between KSC and CCAFS. This 11.5 m^2 (124 $ft^{2)}$ facility is constructed on a concrete foundation with concrete block walls, a metal door, and a singly ply roof. The windows have been boarded up to prevent light from attracting nesting and hatchling sea turtles. The 4D Lightning Surveillance System #8 (J8-1568) is located 22.9 m (75 ft) east of J8-1567 and is owned by the USAF. It consists of a 9.1 m (30 ft) tall weather antenna with four guy lines and a perimeter fence.

The Beach Tracking Site, North (J8-1821) is located east of Phillips Parkway just south of Pad A Bypass Road. There is also a lightning protection structure just west of the camera pad. This NASA owned facility is a Universal Camera Site used for remotely operated mobile high speed film and video equipment that supported all Space Shuttle launch operations. It consists of a concrete foundation with electrical and communication panels.

Also within the project boundary is Guard Shack J8-2075, south of LC 39A near the railroad crossing. The Corrosion Atmospheric Exposure Facility (K8-0600) is in the southern portions of the project area. Coated test panels, stress corrosion cracking specimens, and commercially produced components are evaluated in this area of high salt, humidity, and ultraviolet light.

Just 549 m (1,800 ft) south of the corrosion testing facility is Equipment Building K8-0590. This facility is currently used as an equipment shelter for a Radar Tower (K8-0590A). The Radar Tower was used for sea surface surveillance during Space Shuttle launches and is Air Force owned.

LC 39A and LC 39B have historically been NASA-operated facilities. The area was undeveloped prior to the mid-1960s when construction for the Apollo program began. Each launch complex is comprised of 65 fenced ha (160 ac). Retrofitted in 1975 to support Space Shuttle launches, LC 39A encompasses 6,161 m^2 (66,211 ft^2). It is the southernmost of the two launch sites situated along the eastern boundary of KSC. A concrete ramp, inclined at a 5% grade, leads from the end of the Crawlerway just inside the launch complex perimeter to the pad. The pad surface is raised 12.8 m (42 ft) above ground level and consists of the flame trench, a high-pressure gas storage enclosure, Pad Terminal Connection Room and the Environmental Control System (ECS) room. Many of the lights on the LC 39A launch structure have been removed or replaced with low intensity amber lights. LC 39A was leased to SpaceX in April 2014 and will serve as a commercial launch facility. Modifications are being made to support launches of the Falcon Heavy and Falcon 9 rockets.

The northernmost of the two LC 39 sites, LC 39B encompasses 5,350 m^2 (57,589 ft^2) and its construction was similar to LC 39A. The launch tower was removed in 2010 in support of the Constellation program, which was subsequently cancelled. Most of the lights on LC 39B have either been removed with the tower or are turned off. The three 161 m (528 ft) lightning protection towers around the remaining concrete launch pad have Federal Aviation Administration (FAA) required synchronous flashing lights (three high pressure sodium lights per level at two levels on each tower). Modifications to support the SLS Program are ongoing. A launch site for the Deployable Launch System is also being developed at LC 39B.

3.3.3 Transportation

KSC is serviced by over 340 km (211 mi) of roadways, with 263 km (163 mi) of paved roads and 77 km (48 mi) of unpaved roads. Samuel C. Phillips Parkway borders the Shoreline Project area on the west, and Patrol Road on the north. Access to Phillips Parkway from the west is by Saturn Causeway, which can be reached via SR3, followed by either Pad A By-Pass Road or Pad B By-Pass Road. Access to the north from Titusville is from SR 406/402 which becomes Beach Road and then Patrol Road connecting to Phillips Parkway.

A portion of the KSC Railroad runs east of Phillips Parkway within the proposed project area. Construction of the KSC Railroad was completed in 1965. In 1983, NASA purchased the 7.5-mile spur west of Wilson's Corner, and undertook the complete operation and maintenance of the railroad, including the tracks, the Jay Jay Bridge, and crossings (ACI 2012). The west boundary of the railroad is the point where the track meets the Florida East Coast line in Titusville. The NASA Railroad then runs east crossing the Indian River via the Jay Jay Bridge extending for approximately 11.3 km (7 mi) to Wilson's Corner (roughly the intersection of State Highway 402 and Kennedy Parkway North). The west branch of the railroad, with a length of 17.7 km (11 mi), extends from Wilson's Corner to the KSC Industrial Area. The east branch extends 14.5 km (9 mi), to Playalinda Beach, and then curves southeast to parallel the Atlantic coastline. From this branch, there are 0.32 km (0.2 mi) spurs that extend to LC 39A and LC 39B. The east branch of the NASA railroad ends at the boundary between KSC and CCAFS.

The portion of the railroad that runs parallel to Phillips Parkway on the beach side has been often washed out by storms, making it nearly impossible to maintain. This section of railroad is no longer operational and approximately 2 km (6500 ft) of the railroad and rail bed were removed from the shorefront between LC39A and 39B (vicinity of FDEP monuments V-073.5 to V-080) in Spring 2014 during construction of the Post-Hurricane Sandy dune repairs.

Port Canaveral Authority is proposing the construction of 18 km (11 mi) of new rail line from the Port to the existing rail system at KSC to tie into the railroad near the industrial area along SR 3. The proposed rail extension would use approximately 27 km (17 mi) of rail line at KSC to connect to the west, main line of the Florida East Coast Railway. Current plans propose four trains passing through KSC per day at slow speed.

3.3.4 Cultural Resources

Historic property evaluations have been conducted within and surrounding the Shoreline Protection project footprint. Nearby, but not within the project footprint, are the LC 39 complexes which were the first KSC sites to be listed in the National Register of Historic Places (NRHP) in the context of the Apollo Program (ca. 1961-1975). They gained additional importance in the context of the Space Shuttle Program (1969 to 2011). Both complexes are considered part of a historic district, LC 39A (8BR1686) and LC 39B (8BR2010), designed to launch space vehicles. The significance of a cultural resource is evaluated in terms of the eligibility criteria for listing in the NRHP. Both pads are considered individually eligible for National Register listing at the national level under Criteria A and C in the areas of Space Exploration, and Engineering, respectively. Because the complexes have achieved exceptional significance within the past 50 years, Criteria Consideration G applies. Historic context details for each property are found in the survey and evaluation of NASA-owned historic facilities and properties (ACI 2007).

The KSC railroad track portion that extends along the project area is in disrepair and overwashed by storms over the last five years. It was recently surveyed for its historical status (ACI, 2012) and it was determined that only the 30.6 km (19 mi) of the railroad tracks (highlighted in Figure 3-27) are eligible for listing in the NRHP. The Florida State Historic Preservation Officer (SHPO) concurred with this determination (DHR Project File Number: 2012-4670-B, dated January 4, 2013). The portion of rail track within the project boundaries is not eligible.

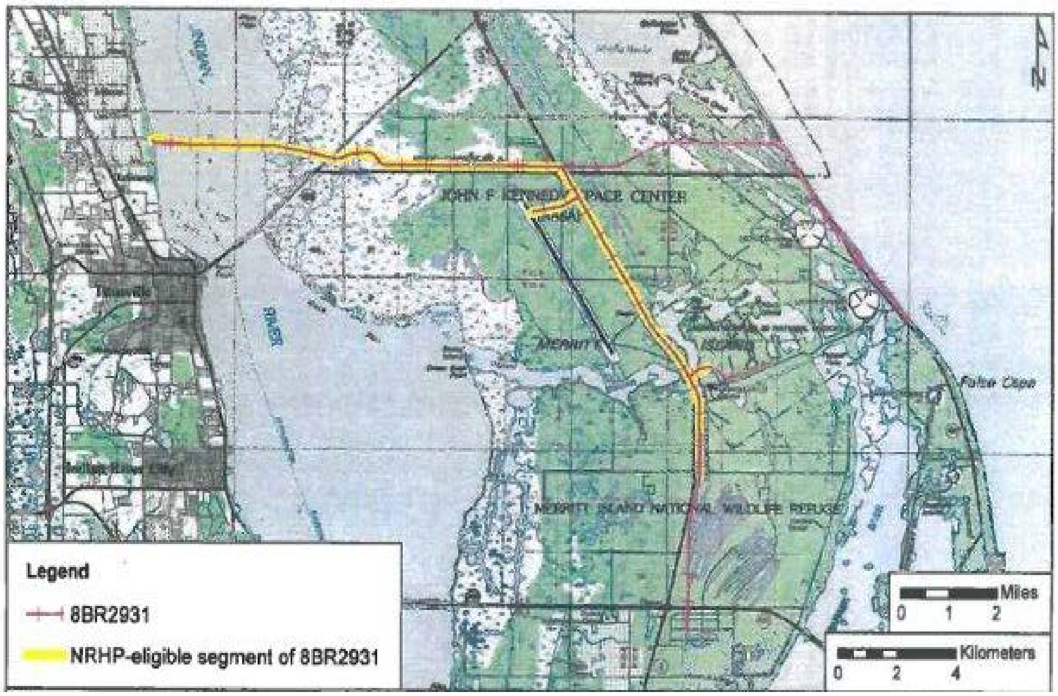


Figure 3-27. Segment of KSC railroad track recently determined for eligibility under the NRHP (ACI 2012).

In addition to historic facilities, there are archaeological and historic areas of significance on KSC within or near the project boundary (Figure 3-27). Between 1990 and 1996 differential zones of archaeological potential (ZAPs) within all areas of KSC were established and updated in 2007-2008 in the Historic Context and Historic Period Archaeological Site Location Predictive Model for KSC, Volusia County, and Brevard County (ACI 2009). The ZAPs were defined as “low, medium, and high” probability with background research and archaeological field surveys within the Industrial and VAB areas. 8BR84 site contains historic refuse, but could not be relocated during the survey; the precise location and nature of the site is problematic. The 8BR79 site is within a “moderate” ZAP area, (Figure 3-28) and contains shell middens and historic refuse. It was largely destroyed by the mid-1960s during construction of the railroad and Coast Guard Station. The site experienced further changes since the 1960s due to extensive land leveling.

Figure 3-28. Zones of archaeological potential and historic areas in the vicinity of the Shoreline project.

The four historic areas (#35, #72, #119, and #121) are described in ACI (2009). Historic Area #35 is the linear zone denoting the roadway (currently known as SR 402) that crosses northern Merritt Island from Indian River to the beach. Historic Area #72, referred to as the Ribault Site is associated with the Archeological site 8BR84, which is believed to have some association with the Ribault shipwreck.

Historic Area #119 shows the location of the Chester Shoals House of Refuge/Coast Guard Station (8BR79, also known as Titusville Beach). 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. The 1949 quad map shows 16 structures in this general area. As stated above in the description of 8BR79, the site was destroyed. The report received concurrence from the Florida SHPO in 2010 (DHR Project File Number: 2009-07626).

Historic Area #121 extends 1.6 km (1 mi) along Titusville Beach and once included 17 structures. Currently, the Beach House (Facility #K8-1699/8BR2990) which is eligible for listing in the NRHP, is the only obvious structure within this area.

Adjacent and west of the project area boundary is Historic Area #118, which consists of seven structures shown on the 1934 Intracoastal Waterway map. Four structures and the label Canaveral Club are found on the 1949 quadrangle map. An archaeological site (8BR2364/Bottle Dump Site) is also located as part of Historic Area #118, and in November 2009, NASA 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 (ACI 2009a). The Florida SHPO concurred that the site is considered ineligible for listing in the NRHP and further testing in this area is not considered warranted (DHR Project File Number: 2010-00809, March 2010).

ACI conducted an archaeological survey and evaluation for the post-Hurricane Sandy repair project (ACI 2013). The purpose was to locate and identify any previously recorded and newly identified archaeological sites within the project area, and evaluate resources for their eligibility for listing in the NRHP. The Sandy Dune project area includes the Titusville Beach, Chester Shoals House of Refuge/Coast Guard Station, and contains or abuts Historic Areas #118 and #119. Archaeological field survey confirmed the Titusville Beach site was no longer extant. No evidence of the prehistoric shell midden component and no *in situ* evidence of the historic component were found. Non-diagnostic artifacts including glass and iron fragments were recovered from Historic Area #119. There were no cultural materials found in Historic Area #118, and no new archaeological sites were discovered. It was concluded the Sandy Dune project would have no adverse effect on any listed, eligible, or potentially eligible archaeological sites or historic resources (ACI 2013).

The Canaveral Shoals I and II Borrow areas were developed for the Brevard County Shore Protection project and CS-II has been used as recently as 2014. Underwater surveys and diver identifications have been conducted in the borrow area and are documented in multiple reports dating from 1994, all coordinated with the Florida SHPO. *Cultural Resources Survey of Proposed Borrow Area, Vicinity of Cape Canaveral, Brevard County, Florida* (DHR File No. 942533) was conducted in 1994 and identified six potentially significant targets. Another survey conducted in 1999, *A Submerged Cultural Resources Remote Sensing Survey of Four Proposed Borrow Areas and Archaeological Diver Identification and Evaluation of Eight Potentially Significant Submerged Targets for the Brevard County Shore Protection Project, Brevard County, Florida* (DHR File Nos. 992156 and 2000-02415) determined that the targets identified in 1994 were not significant and identified eight potentially significant targets in an expanded borrow area. In 2001, *Archaeological Diver Identification and Evaluation of Fourteen Potentially Significant Submerged Targets for the Brevard County Shore Protection Project* (DHR File No. 2001-316) identified eight anomalies, debris from the Space Program, as potentially significant. An updated cultural resources survey and report was completed in 2014 by the US Army Corps of Engineers, Jacksonville District, for both the CS-I and CS-II borrow areas. No magnetic anomalies and no sonar contacts were located in the previous or updated surveys that represent potentially significant cultural resources in the form of shipwrecks (Panamerican 2014). The updated 2014 survey identified six locations in CS-I and four locations in CS-II as potential sites of rocket cylinders. In 2014, the USACE designated dredge exclusion areas described by a 200-ft radial buffer around each of these locations within the CS-I and CS-II borrow areas.

3.3.5 Socioeconomics

KSC's capability to attract, enter, and leverage the commercial space market is critical to its sustainability, and essential for regional economic recovery and long-term growth. KSC was established as a launch operations center in 1962 and grew to become the Nation's premier spaceport. Operations at KSC provide for federal, state and industry access to space and space technology that can infuse the regional economy.

The commercial space and launch manufacturing industry employed over one million employees in 2009 (FAA 2010). Each space-related job was found to create an additional 1.26 jobs within Florida's labor market. KSC's 2011 presence was directly and indirectly responsible for nearly 26,000 jobs State-wide (NASA 2011a). The highest employment levels at KSC were recorded during the Apollo program in 1968 with a peak population of 25,895 and second highest employment period was during the Shuttle Program in 2005, when approximately 14,595 personnel were employed at KSC. In 2011, the workforce was downsized to 9,011 personnel and reductions continued in 2012. The total KSC workforce population in 2013 was 7,864 (NASA 2013a).

KSC has provided a significant revenue source to Brevard County and will continue to stimulate the economy with the additions of NASA's Exploration Ground Systems, Ground Systems

Development and Operations Program, and Commercial Crew Program, as well as with new space research, technology projects and the agency's Launch Services Program. In fiscal year 2012, KSC and other NASA centers spent $1.3 billion in wages and purchases within Florida. Its monetary injection is found to have a total State-wide impact of $2.15 billion in total output (NASA 2013a). In 2009, commercial space transportation and enabled industries (CST and EI) generated $208.3 billion in economic activity, and launch vehicle manufacturing and its services industry generated $828 million. The industry created $76 billion in induced economic activity in the form of housing, consumption and other purchases (FAA 2010).

4.0 Environmental Consequences

Section 4 presents the potential impacts on existing resources described in Section 3 that may result from the KSC Shoreline Project alternatives described in Section 2. Under NEPA (42 U.S.C. 4321 et seq.), significant impacts are those that have the potential to significantly affect the quality of the human environment. Human environment is a comprehensive phrase that includes the natural and physical environments and the relationship of people to those environments (40 CFR Section 1508.14). Whether an alternative significantly affects the quality of the human environment is determined by considering the context in which it would occur, along with the intensity of the action (40 CFR Section 1508.27). A KSC Shoreline Project impacts matrix is provided in (Table 4-1). Additionally, potential mitigation measures that would reduce the extent of some impacts are identified in Section 5.

Impact Category Descriptions:

- Minimal – impacts are not expected to be measurable, or are too small to cause any discernable degradation to the environment
- Moderate – impacts would be measureable, but not substantial, because the impacted system is capable of absorbing the change, or impacts could be reduced through appropriate mitigation
- Major – impacts could individually or cumulatively be substantial
- Beneficial – impacts would be positive in nature

Table 4-1. Resource impacts matrix for the KSC Shoreline Protection project.

Resource	Proposed Actions				No Action
	Preferred Alt. 1	Alt. 2	Alt. 3	Alt. 4	
Physical Environment					
Air Quality	Minimal	Minimal	Minimal	Minimal	None
Climate Change	Minimal	Minimal	Minimal	Minimal	Minimal
Bathymetry	None	Minimal	Minimal	Minimal	None
Geology/Geomorphology	Moderate	Moderate	Moderate	Moderate	Moderate
Longshore Sediment Transport	None	Minimal	Minimal	Minimal	None
Physical Environment (Cont.)					
Water Resources	Moderate	Moderate	Moderate	Moderate	Major
Noise	Moderate	Moderate	Moderate	Moderate	None
Hazardous Materials/Waste Mgmt.	Minimal	Minimal	Minimal	Minimal	Moderate
Biological Environment					
Vegetation	Beneficial	Beneficial	Beneficial	Beneficial	Major
Wetlands	Moderate	None	None	Moderate	Major
Wildlife	Moderate	Moderate	Moderate	Moderate	Moderate
Essential Fish Habitat	None	Minimal	Minimal	Minimal	None
T&E Species	Moderate	Moderate	Moderate	Moderate	Moderate
Social and Economic Environment					
Land Use	None	None	None	None	Major
Infrastructure/Utilities	None	None	None	None	Major
Transportation	Moderate	Moderate	Moderate	Moderate	Major
Cultural Resources	None	None	None	None	Major
Socioeconomics	Beneficial	Beneficial	Beneficial	Beneficial	None

4.1 Physical Environment

4.1.1 Air Quality

Alternatives One through Four

Proposed project activities would be expected to result in insignificant, short-term, intermittent air quality impacts from fugitive emissions (particulate matter [PM]) and other common air pollutants (nitrogen oxides [NO_x], carbon monoxide [CO], and sulfur dioxide [SO_2]) during construction activities from project equipment, vehicles, and ships. A temporary and localized decrease in air quality from construction and dredging equipment would be minimal and not anticipated to cause long-term adverse impacts on air quality or climate change. A conformity determination under the Clean Air Act is not required because KSC is located in an area of attainment for the NAAQS.

Criteria air pollutant emissions were estimated for the proposed dredging of federal sand from CS-II and placement along the KSC beach using estimates of power requirements, duration of operations, and emission factors for the various equipment types. Multiplying horsepower rating, activity rating factor (percent of total power), and operating time yields the energy used. The energy used multiplied by an engine-specific emission factor yields the emission estimate. The horsepower rating of the dredge plant was assumed for each activity as follows: propulsion (3,500 horsepower [hp]), dredging (2,000 hp), pumping (2,000 hp), and auxiliary (1,165 hp). Different rating or loading factors were used for dredging, propulsion, and pumping. KSC Project Alternative Two requires the most fill to be placed on the beach of the four alternatives at 2,140,000 m^3 (2,800,000 cy), and was therefore the alternative used for the emissions calculations. The estimated time to complete each dredge cycle, including idle time, was approximately 6 hours per load. It was assumed that about 2,217 m^3 (2,900 cy) of material would be moved in each cycle, requiring about 1,072 loads to excavate enough material to place 2,140,000 m^3 (2,800,000 cy) of sand on the beach. The placement and relocation of the nearshore mooring buoys used during pump-out might involve up to two tender tugboats, and a pipeline hauler/crane would also be used. It was assumed that the buoy would need to be moved at most five times during the project, with each move taking approximately 12 hours; a crew/supply vessel would operate daily for four hours as well.

All dredging was assumed to occur at CS II, whereas 25% of hopper transport and crew/supply vessel activities were assumed to occur over state waters or at the placement site. The beach fill related estimates assumed the use of up to three bulldozers/pipeline movers and two trucks, each operating 80 % of the time for the duration of the project.

Emission factors for the diesel engines on the hopper dredge, barge, and tugboats were obtained from EPA's *Compilation of Air Pollutant Emissions Factors, AP-42, Volume 1* (2002). Emission factors for tiered equipment used in beach construction were derived from NONROAD (nonroad engines, equipment, and vehicles) model (5a) estimates. Total project emissions of NO_x, SO_2, CO, VOC, and PM are presented along with emission calculation worksheets in Appendix F.

Emissions associated with the dredge plant would be the largest contribution to the inventory. However, the total increases are relatively minor in context of the existing point and nonpoint and mobile source emissions in Brevard County. Projected emissions from the proposed action would not adversely impact air quality given the relatively low level of emissions and the likelihood for prevailing offshore winds. With the proposed action, the criteria pollutant levels would be well within the national ambient air quality standards.

4.1.2 Climate Change

Alternatives One through Four

During the construction phase of any of the proposed action options, greenhouse gas emissions such as CO_2 would be released by fossil fuel powered machinery and vehicles. These emissions are considered minimal and unavoidable, and in many cases represent only a shift in location of machinery and vehicle use, and not an addition to total regional emissions.

Diesel heavy equipment used in construction activities can be assumed to use approximately 0.04 gallons of fuel per flywheel horsepower (0.2 liters per flywheel kilowatt) per hour (Gransberg, et al. 2006). Each gallon of diesel fuel burned produces approximately 10.2 kg (22.4 lbs) of CO_2. Use of "B10" biodiesel fuel (10% biodiesel mixture) can reduce emission of CO_2 by approximately 10% (U.S. Energy Information Administration 2012). With continued implementation of energy conservation measures that minimize the use of fossil fuels, it is expected that emissions from the construction would not make a substantial contribution to GHG emissions or climate change.

Vegetation, alive or dead, is an important carbon stock; ecosystems in the U.S. contain approximately 60,418 million mt (66,600 million tons) of carbon (Heath and Smith, 2004). According to the U.S. Climate Change Science Program, the size of the carbon sink in U.S. forests appears to be declining, based on inventory data from 1952 to 2007 (Birdsey et al. 2007). The carbon density (the amount of carbon stored per unit of land area) is highly variable, as it is directly correlated to the amount of biomass (including the organic component of soil) in an ecosystem or plant community. Land would not be cleared for any of the Shoreline Protection project alternatives, but some land would be covered with sand and then replanted. Therefore, carbon dioxide associated with clearing processes (decomposition and burning) would not be released into the atmosphere.

Many ecosystems can function as carbon sinks, and in addition to the carbon stored in living vegetation, plant communities can contribute carbon to the soil. Consequently, each parcel of land that loses its vegetation through burial results in the loss of a potential carbon sink. The loss of vegetative communities would be mitigated by replanting on newly created and restored dunes, thus resulting in no net significant losses related to carbon sequestration.

No Action Alternative

Under the No Action Alternative, the proposed project would not be implemented, but maintenance activities and emergency repairs such as hauling and placing sand on the beach or behind the existing dunes would continue to occur. These activities would add CO_2 to the atmosphere. However, as the shoreline continues to erode, dune vegetation, which can serve to bind CO_2 as biomass in both living and dead plant tissues, is destroyed. Uncertainties associated with construction and plant biomass make calculation of CO_2 budgets to determine break-even points impossible. In spite of this limitation, the amount of CO_2 added to the atmosphere from this project is a minimal impact compared to daily fuel use by workers commuting to and from work at KSC.

4.1.2.1 Sea Level Rise

The rate of sea level rise is increasing, and evidence is accumulating that this rate is accelerating (Rahmstorf, et al. 2012; IPCC 2013). Sea level rise is probably contributing to increased rates of shoreline retreat at KSC, although the factors responsible for this retreat are complicated and not completely understood. The proposed activity is a response, in part, to sea level rise projections and adaptation of a controlled shoreline retreat philosophy for KSC asset protection.

<u>Alternatives One through Four</u>
Alternative One involves placing beach-compatible sand along or behind the landward side of the existing dune to create a substantial and continuous inland sand dune. Alternatives Two through Four involve sand placement for beach nourishment to restore the dune and beach to a less eroded condition, mitigating erosion. Alternative Four combines the first three alternatives. All of these actions reduce susceptibility of KSC infrastructure to loss due to sea level rise.

<u>No Action Alternative</u>
Under the No Action Alternative, the proposed project would not be implemented, leaving KSC infrastructure and habitats at greater risk of damage due to sea level rise.

4.1.3 Bathymetry

<u>Alternative One</u>
This preferred alternative involves placing beach-compatible sand along or behind the landward side of the existing dune to create a substantial and continuous inland sand dune. As upland sources outside of the project area would be principally utilized as sediment sources, there is no immediate impact on nearshore bathymetry. Due to the dynamic nature of the site, beach-face bathymetry would continue to change in response to physical processes such as waves, wind, and tides, to the extent that the sea or storm erosion reaches the upland dune.

<u>Alternatives Two through Four</u>
These alternatives involve sand placement for beach nourishment to restore the dune and beach to a less eroded condition. As either upland sources or offshore borrow areas outside of the project area would be utilized as sediment sources, there is no immediate impact on nearshore bathymetry beyond the placement and cross-shore equilibration of the sand fill. Because portions of the placed fill are fully exposed to the sea, the placed sand is subject to higher erosion rates. After construction, the placed sand would initially equilibrate to a natural, barred profile extending to depths of between -3 and -5 m (-10 and -16 ft) NAVD 88. Short-term minimal impacts to nearshore subtidal bathymetry may occur from the eroded sand input into longshore and cross transport systems, but would equilibrate quickly to existing natural profiles.

Removal of sand from the offshore borrow areas would result in modification of the bottom substrate. Altered bathymetry may result in a change of depositional patterns at the site and, therefore, a change in sediment grain size. Underlying materials and sediments may be uncovered with different textural and composition properties than the existing bottom substrate. The disturbance and resuspension of bottom sediments, and discharges from dredging vessels and equipment may form plumes of sediments that would settle out from the water column and be deposited some distance from the dredge site. This may result in a layer of sediments that differs from the existing substrate, causing minimal impact to the bottom substrate and no discernable degradation to the area between the dredge site and shore. In four dredging events at Canaveral Shoals II (2002/03, 2005, 2010, 2014) since initial dredging in 2000/01, neither the sedimentary characteristics of the beach fill material placed to the shoreline, nor the morphologic patterns across the borrow area, have substantially changed. The in-place physical characteristics of the sand placed to the shoreline from CS-II to the Brevard County Shore Protection Project and Patrick AFB are more or less identical for each dredging event, and equivalent to those predicted from the composite core boring samples of the pre-dredge borrow conditions (OAI, 2014a).

<u>No Action Alternative</u>
Under the No Action Alternative, the proposed project would not be implemented; however, maintenance activities and emergency repairs such as hauling and placing sand on the beach or behind the existing dunes would occur. The sand fill would come from upland sources, so no impacts on bathymetry would occur as a result of emergency and maintenance activities.

4.1.4 Geology and Geomorphology

<u>Alternative One</u>
Under the Preferred Alternative, beach-compatible sand would be placed along or behind the landward side of the existing dune to create a substantial and continuous inland sand dune. The equipment used to create the dunes would cause temporary moderate impacts on sediments and soil, including compaction and displacement. Other adverse impacts on sediments include potential spills or leaks of pollutants from vehicles. Best management practices (BMPs) including vehicle and equipment fueling and spill prevention and control would be implemented to reduce potential impacts on soils and sediments during excavation, construction, and beach fill work. Dune construction would be done so that the dune is created with a comparable sediment type (a similar percentage of sand, silt, and clay), grain size, and color as the existing dune material. Some wetland soils would be permanently overlain by upland dune soils, locally altering surface hydrology, but similar dune soils are currently found in the project area. Shoreline retreat may eventually erode part of the new dunes as is occurring for Pleistocene sand ridges north of LC 39A. This sand would become part of the beach and long-shore/cross-shore sediment transport system, similar to the supply from sand ridge erosion north of LC 39A. Based on previous studies by the USGS, this could occur as soon as 2026 (Plant et al. 2009). The creation of a secondary dune would serve as a last line of defense to protect critical infrastructure if the dune and shoreline seaward of the new upland dune were eroded. Therefore,

the short-term adverse impacts during construction would be mitigated in the long-term with beneficial impacts to KSC infrastructure.

Alternatives Two through Four

These alternatives involve sand placement to restore the dune and beach to a less eroded condition. The equipment used to create the dunes and beach fill would cause temporary moderate impacts on sediments and soil, including compaction and displacement. Construction activities would cause erosion in the short-term in the areas where heavy equipment is operating on the beach. Other adverse impacts on sediments include potential spills or leaks of pollutants from vehicles. BMPs including vehicle and equipment fueling and spill prevention and control would be implemented to reduce potential impacts on soils and sediments during excavation, construction, and beach fill work.

Dune construction and beach fill would be done so that the dunes and beach are created with a comparable sediment type, including grain size (a similar percentage of sand and fine-grained sediment), and color as the existing material. Dune heights would not exceed current maximum elevations within the project area. The emplacement of beach fill and elevation of dunes would help alleviate the shoreline retreat and dune overwash problem between V-070 and V-080 that would likely result in the loss of habitat and critical infrastructure as the sea level rises, although the timescale over which this would occur is uncertain. Between any potential renourishment cycles, beach fill sand would erode as part of the dynamic nature of the ocean environment. Frequency of beach renourishment cycles may vary depending on the severity and frequency of storm events. This eroded sand would become part of the natural beach and long-shore/cross-shore sediment transport system and is not expect to have any negative impacts on nearshore sedimentary dynamics.

No Action Alternative

Under this alternative, the project would not be implemented, but emergency measures may still be implemented to protect at-risk infrastructure. Moderate impacts on sediments, including compaction and displacement, would be caused by the equipment used to reach facilities to perform emergency operations. Emergency measures could include hauling and placing sand on the beach or behind the existing dunes. In addition, without a beach and dunes to provide a source of sand, the shorelines ability to create and maintain natural dunes is limited. Shoreline retreat between V-070 and V-080 would continue based on past trends in the region, and it is reasonable to assume that substantial changes to the existing foredunes would continue to occur.

4.1.5 Physical Oceanography and Coastal Processes

The sections below outline the consequences, on various aspects of the physical oceanographic system, arising from the proposed alternative actions at the KSC site. It should be noted, however, that tides, waves, and currents are external factors that would not be influenced by the various proposed alternative actions. Sediment transport (longshore and cross-shore) may be affected temporarily, but only under the alternatives that involve placement of beach fill, which alters the volume of the sediment exposed to nearshore processes.

4.1.5.2 Longshore Sediment Transport

Alternative One

Under the Preferred Alternative, the KSC site would be modified by the construction of a sedimentary dune landward of the modern dune (where present). Shoreline Project Alternative One is not expected to result in significant changes to longshore sediment transport in the project area.

Alternatives Two through Four

Under the Restore Beach and Dunes Alternative, the KSC site would be modified by the addition of sediment to the dune, to restore the natural dune volume, as well as with beach fill. This Alternative may result in temporary minimal changes to longshore sediment transport in the project area. Where transport is limited by the quantity of sediment available (under capacity), addition of material to the beach and nearshore would result in an increase in rate of longshore sediment transport, locally. Where transport is limited by forcing conditions (at capacity), addition of material to the beach and nearshore system would result in no increase in rate of longshore sediment transport, with respect to present conditions.

Changes to CS borrow area bathymetry may be expected to affect offshore sediment transport in the vicinity of the borrow areas; however, the resultant effects are not reasonably concluded to be significant relative to the very dynamic natural fluctuations in the seabed at these sites. Wave refraction analyses previously conducted in regard to the dredging of the borrow areas for beach nourishment (USACE, 1996) indicated that differences in both the nearshore (incident) wave field and alongshore transport gradients were modest to negligible, and that no significant effects are anticipated in the wave fields and/or longshore transport potential subsequent to the dredging activity.

No Action Alternative

Under the No Action Alternative, the KSC site would be unmodified, allowing natural processes to continue to operate. The No Action Alternative is not expected to result in significant changes to longshore sediment transport in the project area.

4.1.6 Water Resources

Alternative One

Construction activities can significantly impact surface water quality by increasing run-off from vegetation alteration, soil disturbance, and grading. Exposed soils are more easily transported and can increase turbidity and nutrient loads of surface waters or wetland systems. These moderate impacts, under the Preferred Alternative, would be reduced through the use of BMPs.

Silt fences and turbidity barriers would be installed along existing swales and around other surface water bodies and wetlands during construction of the inland dune.

Alternatives Two through Four
Temporary, moderate impacts would include elevated turbidity and decreased dissolved oxygen in the marine water column of the offshore borrow area and in the nearshore sand placement area. Alternative Four, the hybrid alternative, could also impact the surface waters of the roadside swale and other surface waters as described for Alternative One, but these impacts would be moderate with the use of erosion control BMPs and by mitigation of affected wetland areas.

No Action Alternative
There would be no immediate impacts to water quality from the No Action Alternative. However, the continued loss of beach would eventually result in saltwater intrusion of both surface water and groundwater along the KSC coastline. This would cause major impacts to coastal wetland systems and groundwater quality.

4.1.7 Noise

Alternatives One through Four
In air noise-related impacts from the Proposed Action would be considered significant if an area experienced an increase in the day/night sound level (DNL) of 1.5 dBA or more at or above the DNL 65 dBA exposure level when compared to existing conditions (FAA Order 1050.1E, Chg 1). Moderate impacts from noise would be expected due to construction, but these operations would be consistent with ongoing and historic processes at KSC. The workforce would be protected from undue noise impacts by the OSHA safety practices in place at KSC, and the distance between project area and work locations. Temporary, localized impacts would result during construction, dredging, and sand placement on the beach, but no long-term adverse impacts are expected.

There may also be temporary, localized impacts on wildlife on the dune and marine mammals associated with increased in water noise from vessel activities during dredging. The highest levels of in-water sound generated during dredging would occur from sediment removal and the transition from transit to pump-out according to data collected by Reine et al. (2104), with estimated levels of 172 dB at 3 ft. Based upon observations by Reine et al. (2014), underwater sounds generated by the dredges would be expected to attenuate to background levels at distances of approximately 1.6 to 1.9 mi from the source. However, similar to in-air sounds, wind (and corresponding sea state) would play a major role in dictating the distance to which project-related underwater sounds would be above ambient levels and potentially audible to nearby receptors.

No Action Alternative

There would be no impact from noise with the No Action Alternative.

4.1.8 Hazardous Materials and Hazardous Waste

Alternatives One through Four

Hazardous materials and solid and hazardous wastes are managed and controlled in accordance with federal and state regulations. KSC has established plans and procedures to implement these regulations. The use, management, and disposal of hazardous materials for the construction phase of the Shoreline Protection project are described in KNPR 8500.1, KSC Environmental Requirements. A beneficial impact would be realized by restoring the shoreline and increasing the distance between breaking waves and hazardous materials critical storage areas and accumulation points.

The construction activities would use small quantities of hazardous materials which would result in the generation of small volumes of hazardous wastes. Hazardous materials commonly used during beach restoration activities include diesel fuel and gasoline to power the construction equipment and vehicles, offshore and on the beach; hydraulic fluids, oils, and lubricants; and batteries. Appropriate hazardous materials management techniques would be followed to minimize the use of hazardous materials and waste disposal. Construction contractors would make all reasonable and safe efforts to contain and control any spills or releases that may occur. All hazardous material releases to air, water, soil, and pavement at KSC must be reported per the requirements in KDP-KSC-P-3008, Hazardous Materials Emergency Response. With the proper procedures and safeguards in place, it is expected that minimal soil, surface water, or groundwater contamination would be caused by dredging or beach restoration activities.

The Proposed Action should not have a significant impact on the NASA KSC Remediation Program's plans for managing PRL sites, or interfere with ongoing investigations at these sites. The remediation areas within or adjacent to the Proposed Action are described in Section 3.1.11. Confirmation sampling work plans have been or would be developed for some of these PRL sites. These sampling efforts could occur without impact from proposed shoreline restoration activities. Care must be taken to prevent damage to any of the monitoring wells located at remediation sites throughout the Proposed Action project area.

No Action Alternative

Not implementing the proposed action would have potential adverse impacts from shoreline retreat reducing the distance between hazardous materials critical storage areas and accumulation points from breaking waves and rising waters. These impacts would be considered moderate and require relocation of hazardous materials and waste storage areas.

4.2 Biological Environment

4.2.1 Vegetation

<u>Alternative One</u>

Under the Preferred Alternative, a secondary dune would be built landward of the primary dune in areas most vulnerable to erosion and flooding. Where the primary dune has been severely damaged or is no longer present, the created inland dune would replace it. Where the dune has been repaired and/or replaced by the post-Hurricane Sandy dune repairs, the action would augment the existing dune to raise and widen it to the objective design dimensions. This alternative would result in significant changes in the project area as existing vegetation would be covered by sand in order to build the new dunes. However, these changes would be temporary as the new dunes would be planted with native vegetation and, in many instances, would result in an improvement of highly disturbed and eroded habitat. Monitoring results from the KSC Pilot dune (Appendix D) indicated that planting is very successful for stabilizing the dune and establishing a functional ecosystem in a matter of months. Therefore, long-term consequences (i.e., post-recovery from construction) to vegetation from Alternative One are expected to be positive.

Construction of a secondary dune would have moderate impacts on wetlands within the Shoreline Project boundary, primarily those bordering a ditch in the northern section of the project area. Smaller wetland and surface water areas were also identified west of previous primary dune repair locations and are thought to have formed as a result of the repair activities. The exact acreage of wetland and surface water impacts would be determined during project planning, design and ERP wetland permitting, with concurrence with state and federal permit offices. The approximate impact acreage by land cover type is provided in Table 3-8.

<u>Alternative Two</u>

Alternative Two encompasses addition of sand to restore the natural dune and beach to conditions as they were 10 to 15 years ago. Areas that have not experienced significant erosion or habitat loss would not be impacted. Loss of existing vegetation on the dune would occur as a result of new sand deposition, but bare sand would be planted with native vegetation, resulting in an overall long-term improvement to the habitat.

<u>Alternative Three</u>

Under Alternative Three, Reinforce Dune Plus Beach Fill, the beach and dune would be modified by the addition of sediment to the dune to restore the natural dune volume, as well as the addition of beach fill to accomplish shoreline protection, but not necessarily recreate historical conditions (as in Alternative Two). Alternative Three is not expected to result in significant changes. Loss of existing vegetation in the project area would occur as a result of new sand deposition, but bare sand would be planted with native vegetation, resulting in an overall long-term improvement to the habitat.

Alternative Four
Under the Upland Dune Plus Beach Fill Alternative, the beach would be modified by the addition of sediment to the dune to restore the natural dune volume, as well as with beach fill. Alternative Four is a hybrid of Alternatives One, Two, and Three, so the impacts to existing vegetation would be the same as for those alternatives. Vegetation on and behind the primary dune, and the 2014 Post-Hurricane Sandy dune repairs, would be covered by deposition of sand, but the planting of native vegetation would negate any impacts and eventually improve habitat conditions.

No Action Alternative
Under the No Action Alternative, the KSC shoreline would not be restored or protected from erosion and/or sea level rise, allowing detrimental processes to continue, potentially resulting in major impacts.

4.2.2 Wildlife

Temporary loss of habitat would be the primary impact to wildlife from any of the four Proposed Action alternatives. The immediate impacts of dune and/or beach restoration to the overall wildlife population and biodiversity on KSC from any of the alternatives are expected to be moderate. Long-term (i.e., post-construction recovery) impacts are expected to be beneficial for all proposed action alternatives, except the No Action, which is anticipated to produce moderate impacts to wildlife during the time covered under this EA.

Alternative One
Under the Preferred Alternative, most of the species that might be directly affected by sand deposition on or behind the primary dune are common on KSC and not federally protected (Breininger et al., 1994). Once the sand is deposited, the dune would be planted with native vegetation. Monitoring results from the KSC Pilot dune created in 2010-2011 within the Shoreline Protection project footprint were encouraging; it took less than a year after planting for the dune to support a robust floral and faunal ecosystem. See Appendix D for a complete report of the created inland dune monitoring results.

Alternative Two
The operation of hopper dredges hauling sand to inshore waters would have minimal impact on aquatic vertebrates that are capable of moving away from disturbance. The placement of pipeline along the beach for the purpose of sand deposition could potentially impact a minor amount of loafing habitat for shorebirds, but nesting shorebirds would not be impacted because their nesting season overlaps with the marine turtle nesting season. The beach fill process would be designed as closely as possible to approximate natural, healthy conditions, so impacts are expected to be moderate during construction, but reduced to minimal over a few months. In this alternative, only portions of the dune that are severely eroded would be restored. After sand placement, the dune would be replanted with native vegetation, constituting an improvement of

wildlife habitat over existing conditions. The temporary impacts would be expected to be moderate.

Alternative Three

Impacts to wildlife for Alternative Three are expected to be the same as for Alternative Two, except that the entire dune within the project footprint would be affected. As in Alternative Two, the bare sand on the dune would be replanted with native vegetation and the ecosystem would be expected to recover within a few months (Appendix D).

Alternative Four

Alternative Four is a combination of the other three alternatives, so the impacts are expected to be the same. They would be classified as moderate during and immediately after construction, with conditions improving to minimal gradually over time as the planted dune vegetation becomes established and a functioning ecosystem develops.

No Action Alternative

Under the No Action Alternative, the shoreline would not be modified; allowing processes to continue to operate that are currently eroding many areas of the beach and dune. Overtopping and breaching of the primary dune are likely to continue in the near future, resulting in large-scale inundation, habitat alteration, and land loss along the coastal strand. The landward marching shoreline would degrade the habitat quality as it interacts and creates rubble of the remaining sections of the KSC railroad and asphalt roadway. Other sections would experience connections of the ocean to existing marshes. During the timeframe that is being addressed in this EA, the No Action Alternative could result in moderate changes to wildlife in the project area through loss of habitat. Impacts to habitat and wildlife in the future (>50 years) would be major if model predictions are correct (See Section 1.3 of this document).

4.2.3 Essential Fish Habitat

Alternative One

Under the Preferred Alternative, actions take place entirely in terrestrial habitat, so there would be no impacts to EFH.

Alternatives Two through Four

Beach restoration and sand mining actions described in Project Alternatives Two through Four are expected to primarily affect sub-tidal soft bottom and surf zone habitats with little, if any, anticipated impact to hard bottom substrates of the region. Impacts to lobster EFH during any renourishment of KSC beaches are expected to be minimal because the project footprint is primarily comprised of open sand-shell bottoms where lobster density is expected to be low. While EFH and habitats of concern are found directly adjacent to the Canaveral Shoals II borrow area, no hardbottom is known from the borrow site itself (Perkins et al., 1997).

Project Alternatives Two through Four are expected to disturb penaeid shrimp EFH, although these effects would be temporary and of minimal population-level importance. While some direct mortality of shrimp would be expected at both the Canaveral Shoals borrow site and shoreline restoration footprint, the primary impact may result from degradation of the epifaunal and infaunal communities that serve as a forage base for large juvenile and adult shrimp. These communities are expected to quantitatively recover in time, although the species assemblage may take several years to return to a natural state. Until this occurs, the shrimp carrying capacity in the project footprint may be reduced and force existing shrimp to relocate to adjacent undisturbed habitat.

All highly migratory species should suffer negligible direct mortality from sand mining and beach renourishment. Ephemeral increases in turbidity would also be of limited concern because Canaveral waters are not EFH for pelagic eggs/larvae of sailfish or tuna, and sharks produce precocious young capable of avoiding high turbidity conditions. Possibly the greatest concern would be changes in the behavior of juvenile lemon sharks. This species is exceedingly abundant at Cape Canaveral in winter and regularly inhabits the open surf and longshore troughs in water less than 0.5 m (1.6 ft). Reworking or temporary infilling longshore troughs during beach renourishment may reduce foraging efficiency or cause sharks to displace to less optimal habitat.

No Action Alternative

Under the No Action Alternative, the KSC site would be unmodified, allowing natural processes to continue to operate. The No Action Alternative would result in no impacts to EFH.

4.2.3.1 Potential Adverse Effects of Project on EFH

Coastal dredging and renourishment operations affect marine organisms in several ways. Short-term impacts can include ephemeral changes in habitat quality, water chemistry, or organism behavior derived from the mechanical disturbance of the seafloor during the act of dredging. These impacts, while harmful, are usually localized and dissipate rapidly once dredging activity ceases. Long-term impacts can consist of more permanent changes to benthic substrates and hydrodynamics, or disruptions of vulnerable life history stages of marine species. The potential threats specific to fish and commercially important macroinvertebrate communities that may arise from dredging and renourishment operations along the east-central Florida continental shelf include: 1) entrainment, 2) behavioral alterations, 3) turbidity and sedimentation, 4) changes to soft-bottom bathymetry. These threats are explained in detail in Appendix E.

4.2.4 Threatened and Endangered Species

Depending on the shoreline protection alternative chosen, or no action, impacts would differ for the 12 federally protected wildlife species potentially occurring within the Shoreline Protection project boundaries (Table 3-10). Impacts for seven terrestrial species are described in detail in the Biological Assessment (BA) (Appendix G); the discussion in this section also includes the northern right whale, West Indian manatee, and marine turtles occurring offshore that were not addressed in the BA. Overall, the impacts for threatened and endangered species are anticipated to be moderate (Table 4-2).

Alternative One

No impacts are expected to the two species of marine mammals (northern right whales and West Indian manatees) or any of the marine turtles in open waters from Preferred Alternative. Impacts to nesting marine turtles and shorebirds would be minimal because none of the work occurs on the beach; most of the secondary dune would be constructed west of the primary dune.

Should the final project design require activities that could impact the nesting beach, completing work outside the primary nesting season (May-October) and conducting daily sea turtle nesting surveys prior to work would be implemented. For the other four species, construction impacts are predicted to be moderate because of the loss of coastal dune habitat from the placement of sand for the inland dune.

Alternative Two

Because the densities of right whales and manatees within the Shoreline Restoration impact area are low, the use of hopper dredges and temporary pipelines to deposit sand on the beach is anticipated to have minimal effects. Individual marine turtles occurring offshore could potentially be affected by dredging operations, but mitigation measures including use of trained observers and NMFS “Take” quotas for marine turtle species required by project permits (Section 5.1.2) would reduce these impacts to moderate.

Nesting marine turtles would also be expected to be moderately impacted by Alternative Two actions. No sand would be placed on the beach during the marine turtle nesting season so as to avoid disrupting nesting adult females or hatchlings, or covering existing nests. The configuration of the beach restoration would approximate natural, beneficial conditions as closely as possible. Sand deposition would be limited to the beach, except when repairs were necessary to the primary dune where it is severely degraded. Impacts to the other seven protected species that occur on the beach (shorebirds) and primary dune would be expected to be moderate due to the temporary loss of habitat.

Alternative Three

The difference between Alternative Three and Alternative Two is that the entire primary dune would be rebuilt, or at least reinforced. Impacts to protected species would be the same as Alternative Two, minimal for marine mammals, and moderate construction impacts for all other species.

Alternative Four

This alternative is a combination of the other three alternatives, and includes construction of a new upland dune, primary dune repair, and beach fill. Impacts to marine mammals are expected to be minimal, and construction impacts to all other species would be moderate.

Because the beach and primary dune are expected to continue to degrade over time, an intervention of some sort would be necessary to protect wildlife habitat (Coastal Planning & Engineering 2011). For any of the action alternatives, long-term impacts (i.e., post-construction recovery) are anticipated to be beneficial. The addition of new sand to the beach would protect the dune, and the replacement of existing degraded dune vegetation with planted native vegetation would constitute an improvement as compared to pre-construction conditions.

No Action Alternative

Failure to take any action to protect the shoreline would result in the continued degradation and loss of the beach and inland dune habitats, as well as the wildlife that depends on them. These impacts would likely take decades to manifest, so would be classified as moderate for the time-scale of this assessment. In the No Action Alternative, overtopping and breach of the primary dune are likely to continue in the near future, resulting in large-scale inundation, habitat alteration, and land loss along the coastal strand. The landward marching shoreline will degrade the habitat quality as it interacts and creates rubble of the remaining sections of the KSC railroad and asphalt roadway. Some areas of existing marsh could potentially become connected to the ocean.

4.3 Social and Economic Environment

4.3.1 Land Use

Alternatives One through Four

Land use within the Shoreline Project area would not change from construction of an inland dune or restoration of beach and dunes. Impacts from all four project alternatives would be beneficial and allow the continued use of the KSC shoreline.

No Action Alternative

Failure to implement the Shoreline Protection project would continue to result in the loss of shoreline and associated uses. Significant major impacts to structures including camera pads, towers, launch pads, and test facilities would occur.

4.3.2 Infrastructure and Utilities

Alternatives One through Four

Impacts to existing infrastructure in the project area are not anticipated. There are no apparent utility lines within the Proposed Action limits. As part of the KSC Excavation Permit process, locators would survey the area prior to any excavation to ensure there are no impacts to buried utilities.

No Action Alternative

Failure to protect the KSC Shoreline would eventually have major impacts resulting in the loss of existing KSC infrastructure and utilities.

4.3.3 Transportation

Alternatives One through Four

Removal of the section of railroad within the project limits may be completed prior to construction of the inland dune under Alternatives One and Four. If railroad components are not demolished as part of the shoreline enhancement they would be left in place and buried by the addition of sand landward of the existing dune. Alternatives One and Four would require removal and/or burial of approximately 5.3 km (17,500 ft) of oceanfront railroad and rail bed along the project area, of which at least 1.9 km (6300 ft) have already been removed as part of the post-Hurricane Sandy dune repairs constructed in 2014. The railroad is not within the impact area of Alternative Two. Approximately 1130 m (3700 ft) of rail bed removal or burial would be required for Alternative Three, beyond that which was already removed during the post-Hurricane Sandy dune repairs constructed in 2014. There would be a temporary increase in upland and maritime traffic during dredging and construction. This increase in traffic is considered a moderate impact. However, no long-term adverse impacts are anticipated.

No Action Alternative

Under the No Action Alternative, erosion and loss of beach would continue unchecked resulting in the eventual degradation or loss of Phillips Parkway and the railroad, which would be considered a major impact to the transportation of launch vehicle components, equipment, and personnel. The section of railroad that runs along the coast has already been compromised by previous storms and most recently Hurricane Sandy in October 2012 (Figure 4-1). Approximately 1.9 km (6300 ft) of railroad and railbed were removed after Hurricane Sandy during post-storm dune repairs constructed in 2014. Sandy impacted approximated 3 km (1.9 mi) of beach resulting in severe scarping and landward retreat of the dune, and loss of elevation.

Figure 4-1. Erosion and overwash of railroad after Hurricane Sandy.

4.3.4 Cultural Resources

Alternative One
Under the Preferred Alternative (Inland Dune), the KSC shoreline would be modified by the construction of a sedimentary dune landward of the modern dune (where present). The Inland Dune Alternative would have a base that is expected to cover a small width of land 26 m (85 ft) west of the primary dune, and possibly cover portions of Historic Areas #72 and #119. Coverage of these areas would not constitute a negative impact to existing surface cultural resources.

Alternative Two
Under the Restore Beach and Dunes Alternative, the site would be modified by the addition of sediment to the dune, to restore the natural dune volume, as well as with beach fill. The Restore Beach and Dunes Alternative is not expected to impact any cultural resources.

Alternative Three
Under the Reinforce Dune Plus Beach Fill Alternative, the site would be modified by the addition of sediment to the dune, to restore the natural dune volume, as well as with beach fill. The Reinforce Dune Plus Beach Fill Alternative may cover the easternmost boundary of Historic Areas #72 and #119. However, sand coverage over these areas would not constitute a negative impact to existing surface cultural resources.

Alternative Four
Under the Inland Dune Plus Beach Fill Alternative, a constructed inland dune would have a base that is expected to cover a small width of land (ca. 85 ft) west of the primary dune. This could cover portions of the Historic Areas #72 and #119. Coverage of these areas would not constitute a negative impact to the existing surface cultural resources.

Alternatives Two through Four involve dredging activities in the Canaveral Shoals I and II borrow area. Ten targets potentially associated with the space program were identified in this borrow area. A 61 m (200 ft) radius "no work zone" would be established around each of these locations to protect the potential historic properties from the effects of dredging. Since "no work" zones would be established in coordination with the current determinations of the USACE, dredging in the Canaveral Shoals I and II borrow area would not have an adverse impact on potentially sensitive resources within the borrow areas.

No Action Alternative

Under the No Action Alternative, major impacts would occur as the shoreline site would be left unmodified and the erosion processes would continue to operate at the current rate and scale. The No Action Alternative could result in significant changes to Historic Areas #72 and #119, as the shoreline on which they are positioned is subject to increased rates of erosion. Historic Area #121 could also be impacted but at a relatively reduced rate of erosion.

4.3.5 Socioeconomics

Alternatives One through Four

Under the Action Alternatives, the KSC site would be modified to result in a positive economic impact associated with construction jobs and the stabilization of shoreline retreat and infrastructure protection. Infrastructure protection would ensure longer term utilization of facilities and associated employment opportunities.

No Action Alternative

Under the No Action Alternative, the KSC site would be unmodified, allowing natural processes to continue to operate. The No Action Alternative would not significantly impact socioeconomics unless excessive erosion events damaged NASA infrastructure leading to operational shutdowns and work stoppages.

4.4 Irreversible and Irretrievable Commitment of Resources

Irreversible and irretrievable commitment of resources relate to the use of non-renewable assets or reserves and the effects that the use of those resources would have on future generations. Irreversible effects result from the use or destruction of a specific resource (e.g., energy or minerals) that cannot be replaced within a reasonable time frame. Irretrievable resource commitments involve the loss in value of an affected resource that cannot be restored as a result of the action (e.g., the disturbance of a cultural site). The energy typically associated with construction activities would be expended and irretrievably lost under all of the Shoreline Protection alternatives including the No Action Alternative which would result in the continued loss of sand from the KSC beach. Fuels used during transportation of construction materials (i.e., sand and mobilization of equipment to the site) and the operation of equipment, (e.g., dredges, clamshells, and barges) would constitute an irretrievable commitment of fuel resources.

Sediment removed from the offshore shoals or inland sources would be an irreversible use of the mineral resource. If it is determined that inland sand sources coming from previous dredging operations would be used for the Preferred Alternative, then the rate and volume of consumption of the offshore borrow areas used for the KSC Shoreline Protection could be reduced or eliminated. This could serve to prolong the integrity of the offshore shoals and their benthic communities that are more valuable as commercial and recreational fisheries and that are otherwise being irreversibly consumed for beach renourishment or dune construction. In addition, the placement of sand resources overtop areas landward of the primary dune (to augment or create an inland dune), constitutes an artificial migration of sand but not an irreversible or irretrievable loss.

4.5 Cumulative Impacts

Cumulative effects as are defined by CEQ as the "*impact on the environment which results from the incremental impact of the action(s) when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions*" (40 CFR 1500).

Section Four of this EA described the potential direct and indirect impacts from the four proposed action alternatives and the No Action alternative evaluated for the KSC Shoreline Protection project. Past, present, and reasonably foreseeable future actions that may result in cumulative effects on resources of concern when combined with the Shoreline Protection project are described here. Based on the dynamic nature of the location of the action area (coastal strand and dunes affected by sea level rise and storms), the cumulative effects from the Shoreline Protection project would necessarily be re-evaluated and described in future NEPA documentation for renourishment events or if the Preferred Alternative changes based on adaptive management.

There are no ongoing or planned projects along the KSC or neighboring CNS and CCAFS shorelines. However infrastructure projects west of the coastal dunes of KSC and CCAFS continue in terms of rocket launch pad redevelopment and maintenance of communication and transportation corridors. There are projects in the nearshore and offshore waters that include; dredging of offshore shoals, navigation channel maintenance, beach nourishment projects many miles to the south in Brevard County, commercial fishing, and Port Canaveral infrastructure projects such as construction of pipelines or cables. Port Canaveral Authority is also proposing the construction of 18 km (11 mi) of new rail line from the Port to the existing rail system at KSC. The proposed rail extension would use approximately 27 km (17 mi) of rail line at KSC to connect with a main line of the Florida East Coast Railway. Current plans propose four passings through KSC per day at slow speed.

Nearby beachfronts are essentially undeveloped along CCAFS and CNS. Very limited recreational use of the adjacent CCAFS beach is allowed. There is no recreational use allowed on the KSC beach. In summary the KSC shoreline is used for conservation management of adjacent barrier islands, and ongoing KSC operations buffer zone.

The proposed KSC Shoreline Protection activities, along with past and future actions, primarily impact the sand beach, marine turtle nesting, coastal strand habitat, wetlands, and offshore and upland sand borrow areas. Previous, on-going, and proposed actions within the project area are described below.

In 2005, a dune restoration project repaired erosion caused by Hurricanes Francis, Charley, and Jeanne, and other storms during the 2004-2005 hurricane seasons. Another dune restoration project was implemented in 2008 to repair damage from a non-hurricane storm event in 2007 and Tropical Storm Fay in 2008. In June 2011, MINWR supplied funding for equipment, labor, and materials to repair a breach in the primary dune adjacent to LC 39B. The repair site was approximately 160 m (525 ft) long, 10 m (33 ft) wide, and 3 m (10 ft) in height above the existing beach grade.

An inland dune was created in the summer of 2010 at a highly degraded site behind the primary dune between LC 39A and LC 39B, east of Phillips Parkway. The purpose of the dune was to improve sea turtle nesting habitat by creating a natural visual screen between the beach and LC 39 facilities, and to improve southeastern beach mouse habitat. Details on the created inland dune and results of subsequent monitoring surveys are provided in the BA attached in Appendix E.

In the spring of 2014, an inland dune (Sandy Dune) was created along 1.7 km (5,577 ft) of the KSC shoreline to repair and replace the existing dune that was breached by Hurricane Sandy in October 2012. The dune was constructed between LC 39A and LC 39B (monument locations V073.7 to V079.4) with sand from an existing stockpile on Titan Road at CCAFS, and subsequently planted with dune vegetation. The dune repairs were connected to the existing frontal dune at the north and south ends of the project, and to the previously constructed inland dune between V075.1 and V075.8, described above.

The existing Corrosion Test Facility, located about 3 km (1.7 mi) north of the southern boundary of the KSC shoreline, exceeded its capacity and so was expanded 91 m (300 ft) to the south, in 2014.

Wetland and surface water impacts from the Shoreline Protection project are anticipated to be <0.5 ha (1.2 ac) of estuarine wetland habitats within the project boundary. The affected area constitutes less than 0.1% of the KSC total for similar wetlands and ditches. Mitigation efforts would restore, enhance or create wetlands and surface waters elsewhere on KSC to offset cumulative wetland and surface water impacts.

Sand deposition on the beach is designed to closely approximate natural, healthy conditions thereby restoring the severely eroded beach and improving wildlife habitat over existing conditions. Beach fill would be planted with native vegetation, and also result in long-term improvement to the habitat.

The resulting beach configuration under those proposed actions that include beach fill would approximate natural, beneficial conditions for nesting and hatching marine turtles. Sea turtle nesting data have shown that hatching and emerging success rebounds quickly after the initial beach restoration event, and the re-sloping of the beach/dune profile is a beneficial effect as the sea turtles use this grade to cue in on nesting location, above mean high water (USAF PAFB 2011).

Cumulative impacts to EFH and the local fish fauna are expected to be minimal. Dredging and renourishment operations would most adversely affect soft-bottom demersal fishes through entrainment or removal of their invertebrate forage base. However, given the planktonic dispersal strategies of most local fishes and the relatively high adult mobility of even small fish taxa, recolonization would occur after each dredge cut. This recolonization should proceed rapidly because the species assemblage adjacent to project impact areas is likely similar, offering a proximate source of both adults and young recruits. Cumulative impacts to reef fish taxa, which can be a legitimate issue in many areas due to mechanical damage or siltation of exposed hardbottom, is of minor concern locally since no hardbottom is within the proposed sand borrow areas. Impacts to pelagic fish species are also negligible given their high mobility and limited reliance on substrate type and benthic invertebrate prey.

Cumulative impacts of the proposed action to wildlife are positive. Secondary dune construction would result in temporary changes to coastal strand vegetation, and long-term consequences are expected to be positive. Impacts to the gopher tortoise, indigo snake, Florida Scrub-jay, and southeastern beach mouse would be reduced through conservation measures. The ecosystem is expected to recover quickly and provide long-term beneficial impact. Failure to implement shoreline protection activities would be detrimental to the beach and coastal strand habitat.

The Preferred Alternative would require approximately 321,000 m^3 (420,000 cy) of sand from one or more upland borrow sources, the locations of which have not yet been identified. This would most likely be a one-time removal of sand from these sources for the KSC shoreline but other projects in the vicinity of KSC may use the same sources resulting in some cumulative impact.

Alternatives Two through Four require the use of the offshore Canaveral Shoals borrow areas. The placement of 2,140,000 m^3 (2,800,000 cy) of beach fill for Alternative Two would require the largest volume of sand of the three beach fill alternatives. Periodic renourishment of the project would be required at intervals of between 6 and 10 years and use 596,000 to 994,000 m^3 (780,000 to 1,300,000 cy) per event.

Reasonably foreseeable future offshore dredging and beach nourishment activities along Brevard County coastline include periodic renourishment of the BCSPP NR and SR, initial construction of the BCSPP Mid Reach, and sand bypassing across Canaveral Harbor Inlet. Emergency dune and beach restoration may be required in the future along the Brevard County coastline at the same time, similar to that conducted since 2005. This would create cumulative impacts needing further evaluation.

Beach-compatible sand found in the Canaveral Shoals offshore borrow sites is not likely to be depleted over the life of the current or anticipated authorized projects in Brevard County. The volume of sand potentially excavated from CS-II for Brevard County projects using a 6-year interval until 2048 may represent a removal of approximately 36% of the total usable volume according to prior calculations (MMS/USACE 2005). However, the potential for depletion is possible, though unlikely, should there be more intense storm/erosion damage to coastal beaches, and if more entities are granted use of these resources. Additional sand sources may also be needed if CS-II must be avoided to allow time for recovery between renourishment intervals, noting that such has not been required, nor suggested, since the initial use of this borrow area in 2000/01.

4.6 Permits, Licenses, and Entitlements/Authorizations

The following list of potential permits, licenses, and approvals would likely be required for the Proposed Action. The agency responsible for each is included after the identified permit, license, or required consultation. Any required permits, licenses, or approvals would be obtained prior to implementation of the KSC Shoreline Protection activities.

- CWA Section 404 Dredge and Fill Permit, USACE
- Rivers and Harbors Act Section 10 Permit, USACE
- CWA Section 401 Water Quality Certification, FDEP
- Florida Stormwater Management Program Permits, SJRWMD
- Federal Consistency Determination, Florida State Clearinghouse
- Biological Opinion, USFWS and NMFS
- Magnuson-Stevens Act, EFH consultation, NOAA
- Florida State Historic Preservation Office, Section 106 Consultation
- BOEM and NASA MOA for use of federal offshore sand resources

5.0 Mitigation and Monitoring

The Shoreline Protection Proposed Action would take place in a dynamic environment over a period of several years to fully implement the preferred alternative (Alternative One – Inland Dune). Construction of an inland dune would be accomplished in phases over multiple years as funds are allocated. Beach restoration activities (Alternatives Two through Four) would require advanced funding for project design, permitting and agency consultations. Following project approvals, funding, and award, approximately 10 months would be required for mobilization, dredging, sand placement, and vegetation planting. Monitoring of wetlands, shoreline topography, offshore bathymetry, marine turtle nesting activity, dune vegetation, and protected terrestrial species may occur for a period of up to five years depending on the scope of the project, resources impacted and mitigation employed. There is a degree of uncertainty inherent in predicting how the Proposed Action activities would specifically affect resources. As a result NASA would implement an adaptive management strategy to include:

- Project goals that are well defined
- Current technology and best management practices
- Implementation of planned mitigation measures described below (in addition to those requested by regulatory agencies after formal consultations and permitting requests begin)
- Monitoring and evaluation of results

Monitoring results and project performance would either validate existing practices or suggest alterations in project implementation or mitigation techniques. NASA would ensure that mitigation measures were optimized. The following sections discuss the proposed mitigation measures and monitoring as they apply to the Proposed Action Alternatives and within the framework of adaptive management.

5.1 Mitigation

CEQ regulations (40 CFR 1508.20) define mitigation to include: 1) avoiding the impact altogether by not taking a certain action or parts of an action; 2) minimizing impacts by limiting the degree or magnitude of the action and its implementation; 3) rectifying the impact by repairing, rehabilitating, or restoring the affected environment; 4) reducing or eliminating the impact over time by preservation and maintenance operations during the lifetime of the action; and 5) compensating for the impact by replacing or providing substitute resources or environments. Mitigation measures are either institutional in that they are inherent in project alternative selection, or they are incorporated into the construction, operation, and maintenance of the project. Mitigation techniques can include operational measures or technology-based methods. They can be short or long-term and may be designed to avoid, minimize, remediate, or compensate for environmental impact. The following describes some of the mitigation measures that would be implemented as applicable, for the beach restoration components of the alternatives:

- NASA requires the construction contractor(s) and subcontractor(s) to review general and specific conditions of permits prior to commencement of the activity authorized by the Joint Coastal Permit and/or the Environmental Resource Permit. NASA would conduct a pre-construction conference to review all permit requirements with Permittee's contractors, the engineer of record, and the relevant regulatory agencies prior to each construction phase.
- No impacts to hardbottom (including stony and soft corals, wormrock and sponges) are anticipated. All pipelines would be placed in areas devoid of sensitive environmental resources.
- NASA would conduct project operations only in approved staging, beach access, and dune restoration areas designated in the permit drawings.

5.1.1 Physical Environment

5.1.1.1 Wetlands

Wetland mitigation requirements would be determined through the Environmental Resources Permit process and completion of a Unified Mitigation Assessment Methods (UMAM) analysis. Based on the UMAM evaluation, type for type wetland mitigation would offset the impacts, with wetland functional gain of mitigation sites greater than functional loss of impacted wetlands. Mitigation could include enhancement of onsite wetlands, or use of existing mitigation credits from KSC mitigation project ledgers, as applicable, to offset wetland or surface water impacts.

5.1.1.2 Water Resources

<u>Dredging Impacts</u>
Dredging would occur preferentially in naturally accreting portions of the borrow areas and be avoided in erosional areas of the shoal to the extent possible. Dredging would be performed so that the hopper dredge excavates material using relatively shallow, uniform passes to an overall cut depth not to exceed permitted depths for sand compatibility requirements. The methods necessary to maintain the relative profile and shape of the sand shoal complex to avoid creating deep depressions or pits would be used to the extent practicable.

<u>Navigation Impacts</u>
NASA would require its contractor(s) for the Project to place a notice in the U.S. Coast Guard Local Notice to Mariners regarding the timeframe and location of dredging and construction operations in advance of commencement of dredging.

Marine Pollution Control and Contingency Plan

NASA would require its contractor(s) and subcontractor(s) to prepare for and take all necessary precautions to prevent discharges of oil and releases of waste or hazardous materials that might impair water quality. In the event of such an occurrence, notification and response would be in accordance with applicable requirements of 40 C.F.R. Part 300. All dredging and support operations must be compliant with U.S. Coast Guard regulations and the U.S. Environmental Protection Agency's Vessel General Permit, as applicable.

5.1.1.3 Shoreline (Dune/Beach)

Sediment Quality

Sediment quality for beach fill placement would be assessed as outlined in a QA/QC plan. Any occurrences of unacceptable material would be handled according to the protocols set forth in that plan.

Offshore sources

Offshore sources for sand identified for the project have been investigated through prior core boring and geotechnical analysis (and multiple dredging activities in the case of Canaveral Shoals II). These prior activities have demonstrated that the material is beach quality and meets standards for beach nourishment material established by the State of Florida.

For dredging at Canaveral Shoals II, NASA would report Dredging Quality Management (DQM) data acquired during the Project using procedures jointly developed by the USACE National Dredging Quality Management Data Program Support Center and BOEM. The DQM data would be submitted biweekly to dredgeinfo@boem.gov. A complete DQM dataset, including the x, y, z coordinates, time stamp, elevation and dredge status of the cutterhead arms as applicable, would be submitted within 45 days of completion of the Project. If available, NASA would also submit Automatic Identification System data for vessels qualifying under the International Maritime Organization International Convention for the Safety of Life at Sea.

Upland sources

Fill sediment obtained from upland sources, including upland stockpiles, would be evaluated prior to contracting any given source, for conformance to specified grain size and color requirements. The fill material would be clean sand from a permitted upland source, free of construction debris, asphalt, gravel, rocks, clay balls, branches, leaves and other organics, components prone to cementation, oil, pollutants, and any other non-beach-compatible materials. The sand would be similar to the existing dune or beach sediments in color and texture.

5.1.2 Threatened and Endangered Species

The main biological effect of proposed shoreline protection activities would be disturbance of potential beach habitat in the project area. To limit negative impacts during construction activities, NASA would educate all personnel working in the construction area on recognizing protected species and their likely habitats so that appropriate avoidance and minimization measures could be incorporated into activities.

As applicable, NASA would follow the Terms and Conditions of the Statewide Programmatic Biological Opinion for Shore Protection Activities along the Coast of Florida (Service Log Number: 41910-2011-F-0170) and Terms and Conditions of the NMFS Regional Biological Opinion for Hopper Dredging. NASA would also consult independently with USFWS/NMFS on specific KSC shoreline protection project designs developed established under this EA to establish site specific mitigation measures to avoid, minimize and/or offset impacts to threatened and endangered species.

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APPENDIX A

Historical Shoreline Change

Comparison of historical maps, aerial photographs and survey data indicate a fairly consistent trend in shoreline change along the Kennedy Space Center coastline over the past 140 years, as described below. Approximate mean high water shoreline locations were compared from among the following available data sources:

- 1874-75 (USCGS, from FDEP historical database)
- 1928 (USCGS, from FDEP historical database)
- 1943 (aerial photography, interpreted by R. Schaub (IHA) at 5-m spacing alongshore
- 1948-49 (USCGS, from FDEP historical database)
- 1964 (USCGS, from FDEP historical database)
- 1969-70* (NOS, from FDEP historical database; *not used, as values appear suspect)
- 1969 (aerial photography, interpreted by R. Schaub (IHA) at 5-m spacing alongshore
- 1970* (USGS, from FDEP historical database; *not used, as values appear suspect)
- 1976 (USGS, from FDEP historical database)
- 1999 (Fall) Lidar survey
- 2007 (Fall) Lidar survey
- 2009 (May) USGS Lidar survey
- 2011 (May) Beach profile surveys (UF)
- 2012 (March) Beach profile surveys at FDEP V-monuments (Morgan & Eklund, Inc. (M&E))
- 2014 (Sept.) MHWL and +8' NAVD contour survey, with select beach profile surveys (M&E)

Figure A-1 depicts the long-term historical locations of the high water shoreline along the KSC shoreline relative to the mean high water location in September 2014. The average-annual rate of change in shoreline location, in feet per year, is likewise indicated between the historical shoreline locations and September 2014. The boundaries of KSC are approximately between virtual monument locations V-065.3 and V-098, where each monument is spaced 1000-feet alongshore. These historical data suggest the following, fairly consistent trends:

- V065 – V070/71: Stable to modest accretion
- V070/71 – V086/87: Consistent erosion, particularly severe from V-071 to V-084
- V086/87 – V089: Stable to accretional (immediately north of False Cape)
- V089 – V096: Strongly accretional (immediately along & south of False Cape)
- V096 – V098: Historically accretional tending toward recent stability

By typical standards along Florida's central east coast, the long-term rates of shoreline change over the last century are significant: on the order of -2 to -4 feet per year erosion (V072-V078) and +3 to +5 feet per year accretion (V090-V095).

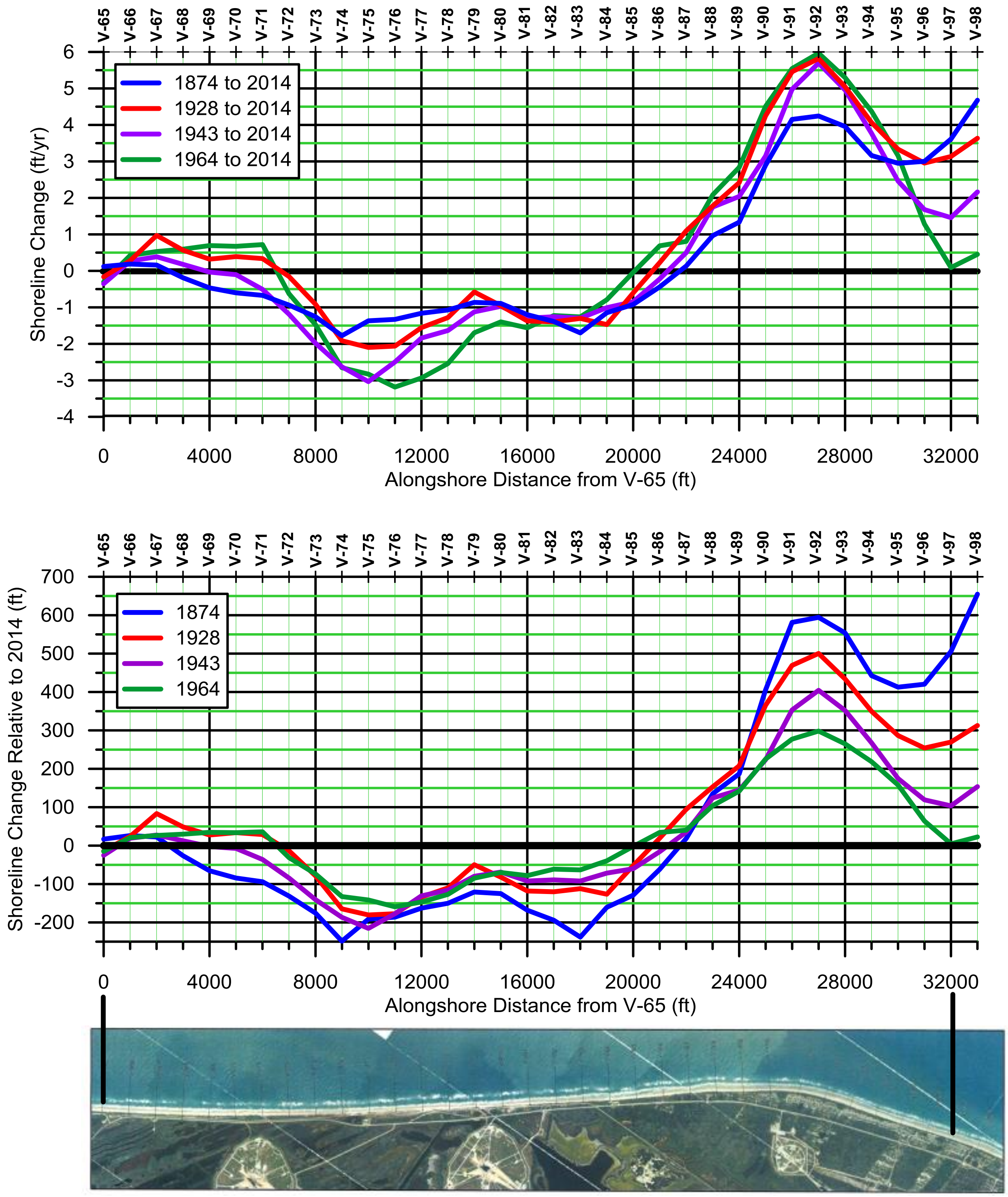


Figure A-1: Historical shoreline locations, and average-annual rates of shoreline change for selected typical intervals, along the KSC coastline from 1874 through September 2014.

Figure A-2 depicts recent locations of the high water shoreline along KSC relative to the 1943 location, specifically including survey data from 1964 through September 2014. The average-annual rates of shoreline change, discerned from these data, are additionally shown for the periods 1943-2014 and 1999-2014. These average-annual rates are based upon regression (linear trend) analysis of the shoreline locations for each year within the given time period, including the years 1943, 1948, 1964, 1969, 1976, 1999, 2007, 2009, 2011, and 2014 as applicable. The shoreline location represents the mean high water shoreline (+0.9 ft NAVD'88) for those recent survey data since 1999. The values were discerned from the data at 1000-ft alongshore spacing; i.e., at the FDEP virtual monuments. Rates of shoreline change using end-point analysis (1943 to 2014, and 1999 to 2014) were also computed. These values are similar to those developed through the regression analysis and are not illustrated.

Figure A-3 similarly depicts the locations of the shoreline and duneline discerned from interpretation of aerial photographs from 1943 through 2009, prepared by R. Schaub (IHA). The results are equivalent to those developed from the survey data as depicted in Figure A-2.

Figure A-4 depicts the change in shoreline location of the mean high water line (MHWL; +0.9 ft NAVD) and toe-of-dune (+8 ft) between May 2011 and September 2014. This includes the effects of Hurricane Sandy in 2012. The lower figure illustrates the change in the MHWL and dune-line over the last 15 years [1999-2014] computed from regression analysis of these contours' locations for the intervening surveys 1999, 2007, 2009, 2011, 2012 and 2014. The computed shoreline change rates of the MHWL and duneline are very similar -- indicating that long-term changes (erosion/accretion) along the dune are similar to those of the MHWL.

The modern shoreline change data depicted in Figures A-2 through A-4 are consistent with the long-term historical shoreline changes described in Figure A-1. This affirms a long-term, chronic response of the KSC shoreline to oceanographic forces, generally consisting of erosion along 3.2 miles north of False Cape (V-070 to V-087) and accretion for 1.7 miles along and south of False Cape (V88 to V-096). Specifically, the prevailing shoreline trends since 1943/1999 include

- moderate stability of the northern 0.9 miles of the KSC shoreline (from V065.3-V070);
- very severe erosion of the north-central 1.9 miles of KSC shoreline between launch pads 39A and 39B (from V070/71 to V080, particularly from V071.5-V078), ranging from at least -2 to -6 ft per year;
- chronic erosion along the central 1.3 miles of KSC shoreline (V080-V087), from Pad 39A to 500-feet north of the Corrosion Test Facility, averaging between -1 and -2 ft/yr;
- mild stability to accretion along 0.2-miles north of False Cape (V087-V088);
- accretion along 1.5-miles at and south of False Cape (V088-V096), extending from False Cape to about 300 feet north of the Beach House; and
- dynamic stability or perhaps developing erosion along the southern 0.4 miles of the KSC shoreline, extending into the north end of CCAFS (V096-V098).

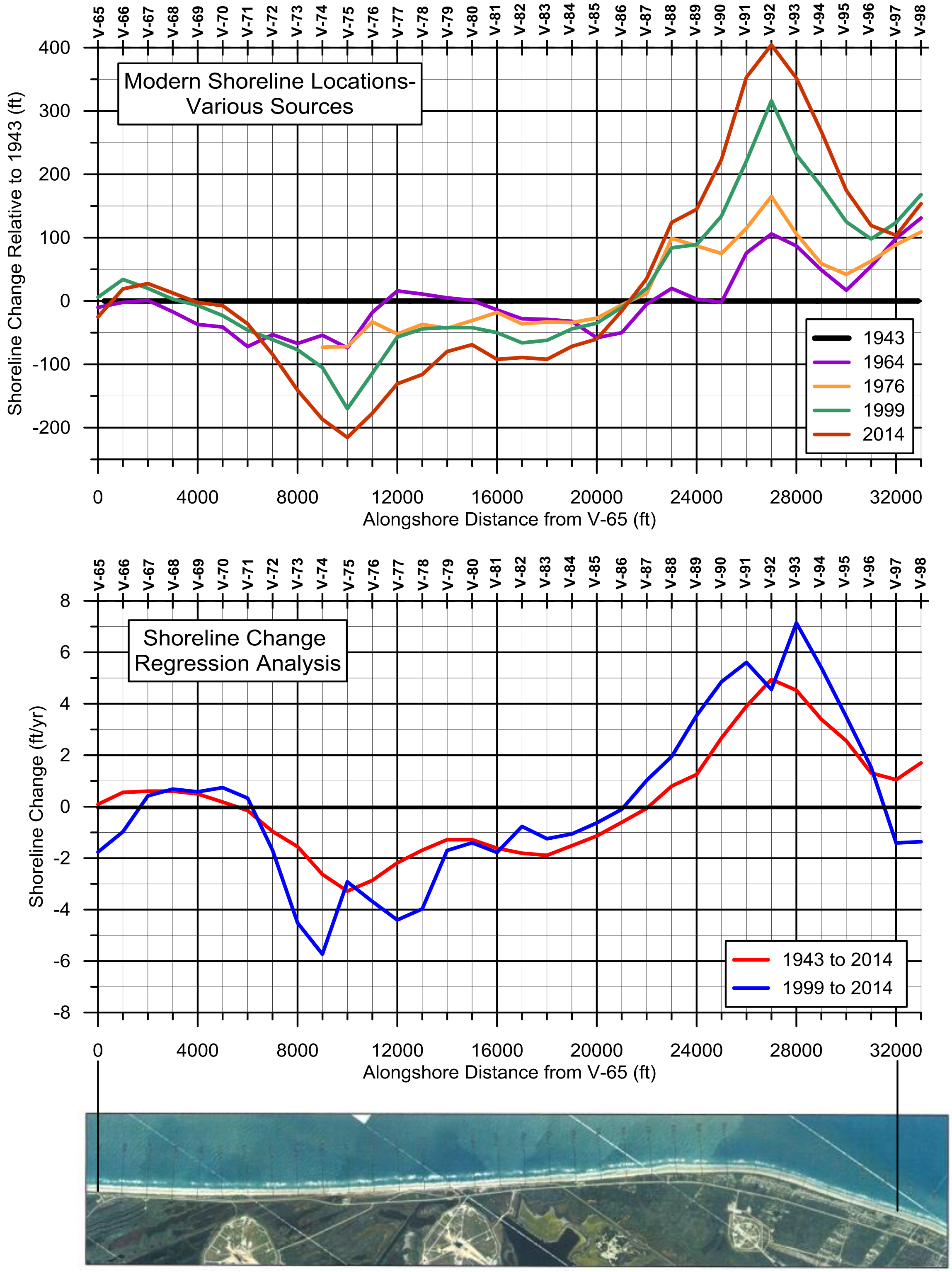


Figure A-2: Recent shoreline locations and average-annual rates of mean high water shoreline change along the KSC coastline from 1943 through September 2014.

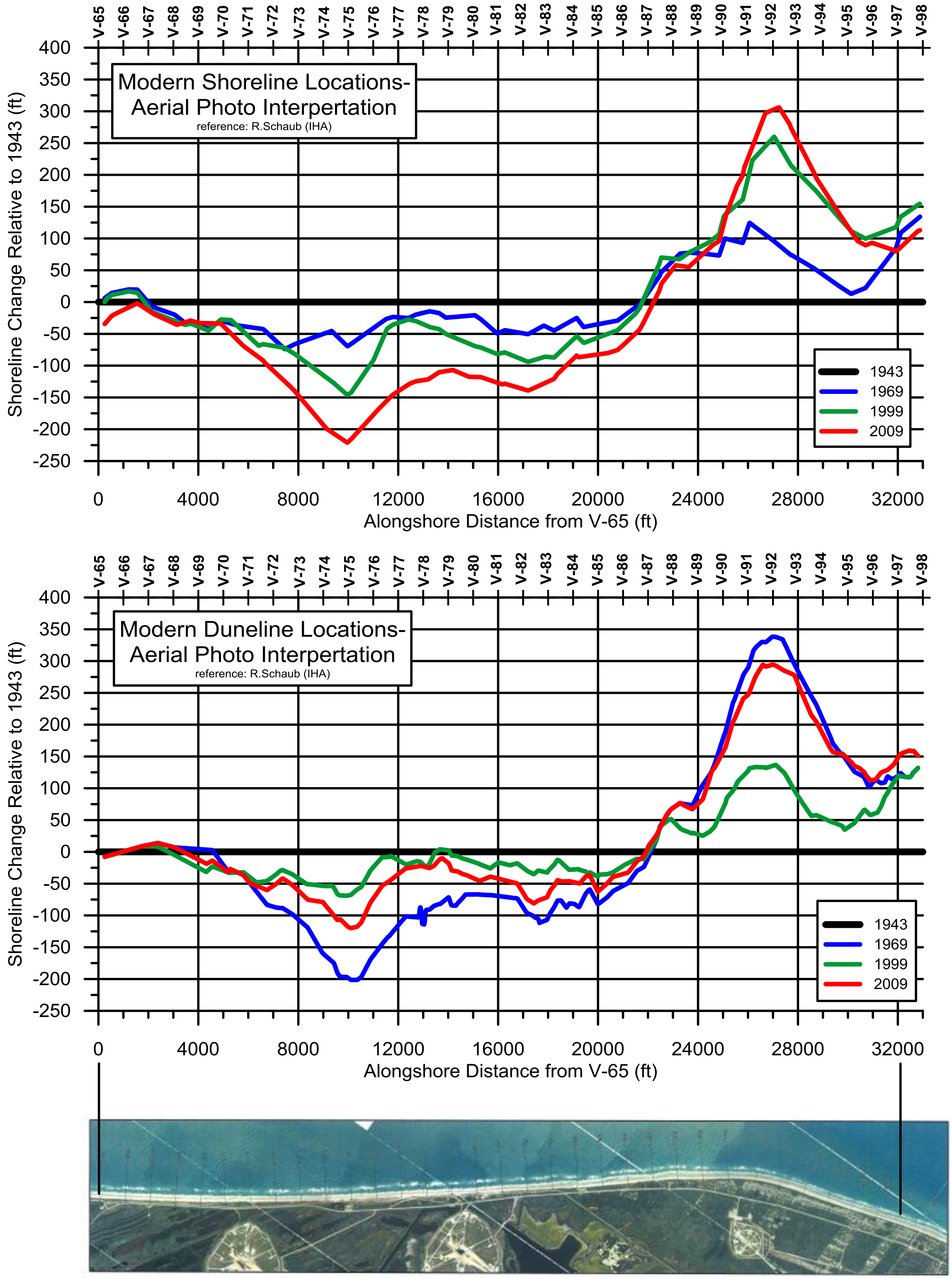


Figure A-3: Recent changes in the shoreline and dune locations interpreted from aerial photography, 1943 to 2011. Adapted from data provided by Ron Schaub (IHA).

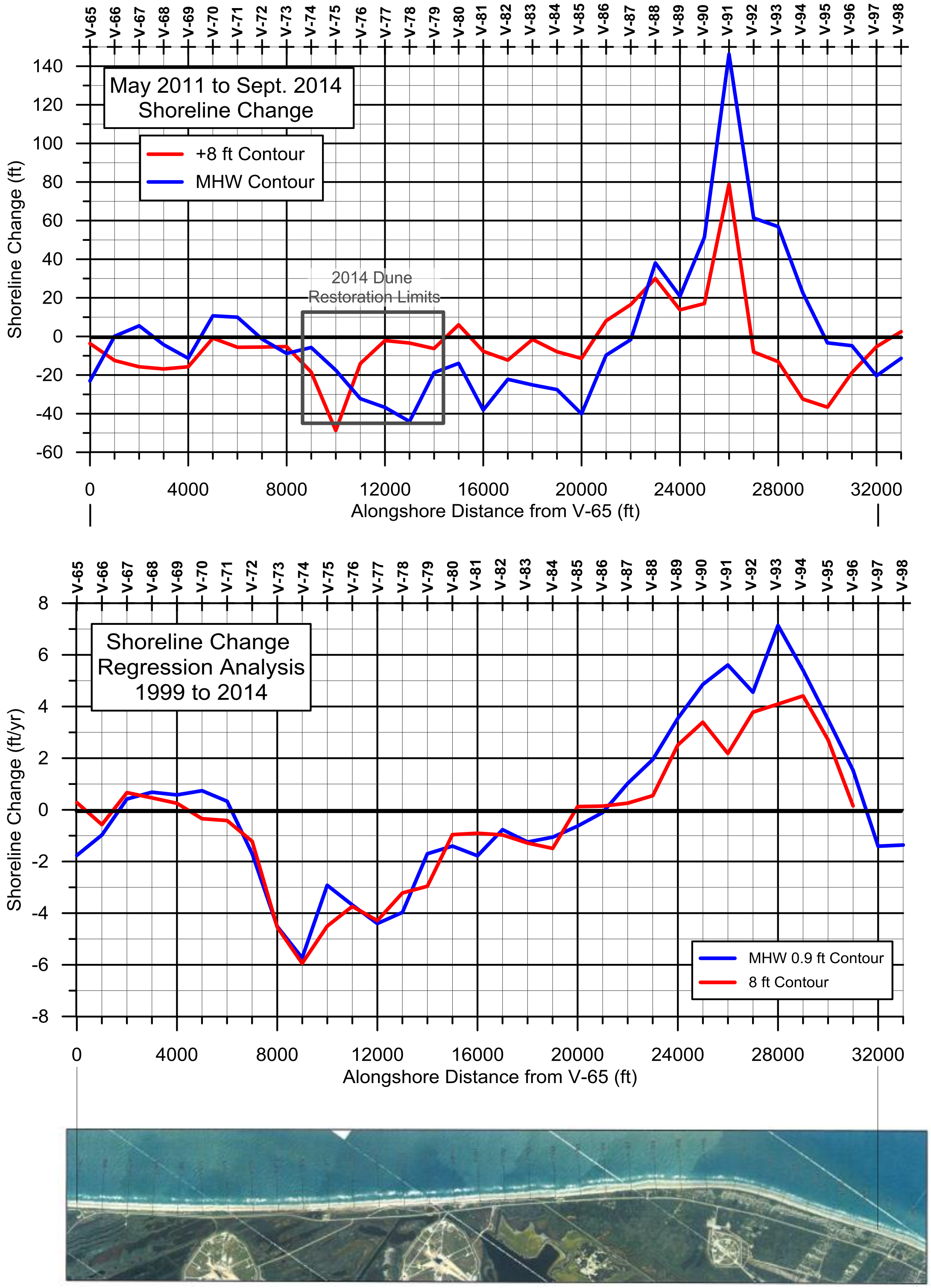


Figure A-4: Change in shoreline location from May 2011 to September 2014 (including Hurricane Sandy impacts in 2012), and average-annual rate of shoreline change computed from Fall 1999 to September 2014, along the mean high water shoreline (+0.9') and toe-of dune (+8', NAVD).

Sufficient beach profile data extending from the dune to depth-of-closure (or at least to -17 ft NAVD) are not known to be available for the purposes of computing, reliable long-term beach volume changes along KSC. **Figure A-5** presents a proxy estimate of beach volume changes along the coastline based upon the historical shoreline changes illustrated in the previous figures. These estimates utilize a Bruun Rule approach that assumes an active vertical beach profile height of 27 feet (from nominal dune elevation of +11 ft to profile toe of -16 ft, NAVD), which suggests a volumetric change of 1 cy/ft per ft alongshore. The figure presents the cumulative alongshore volume change, computed from north to south along the KSC shoreline, using the average-annual shoreline change rates computed for the periods 1874/1928 to 2014 (average value), 1943 to 2014, 1999 to 2011 and 1999 to 2014. Downward-sloping lines indicate erosion; upward-sloping lines indicate accretion.

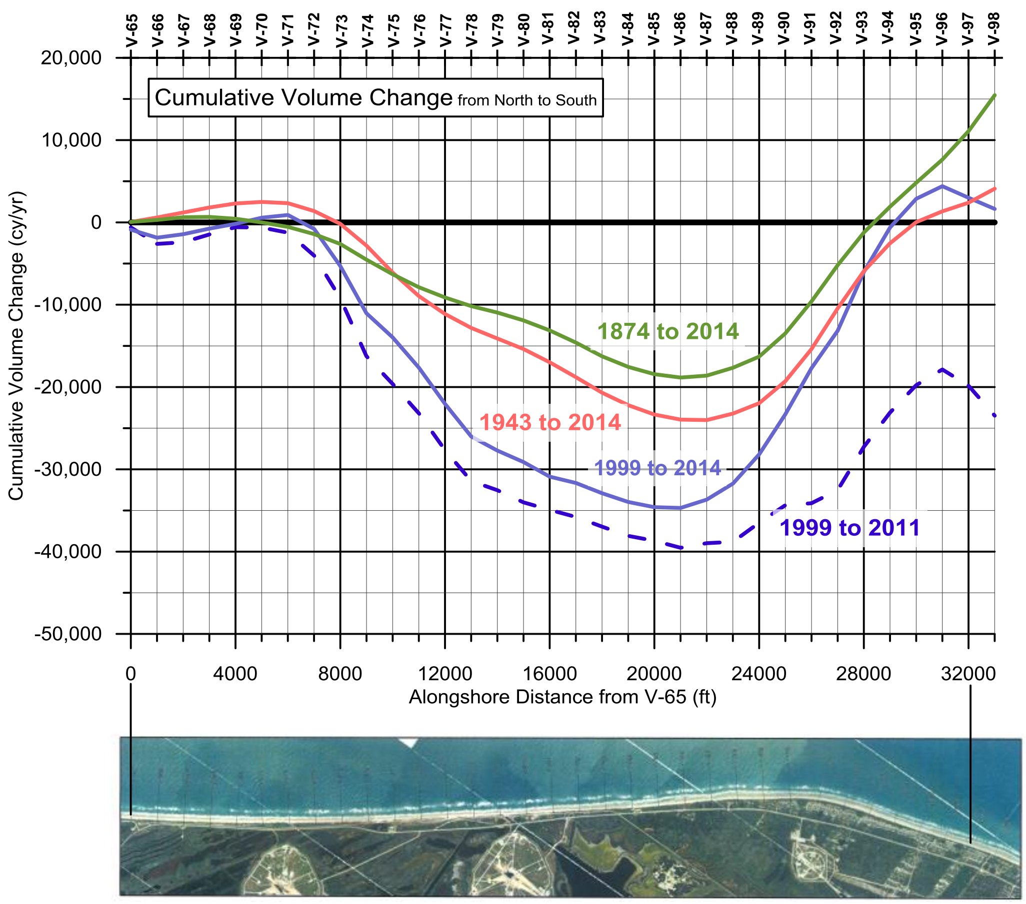


Figure A-5: Cumulative alongshore volume change, computed from north to south along the KSC shoreline, based upon average-annual rates of shoreline change.

From **Figure A-5**, a proxy estimate of the average-annual net rate of beach erosion along the northern 21,000 feet (4 miles) of KSC shoreline, from V-065 to V-086, is -35,000 to -40,000 cubic yards per year since 1999. From 1999-2011, the southern 12,000 feet (2.2 miles) of KSC shoreline, from approximately V-086 to V-098 -- along and south of False Cape – gained about +16,000 cubic yards per year, suggesting a loss of sand along the overall KSC shoreline of on the order of -24,000 cy/yr from 1999-2011. From 1999-2014 (including Hurricane Sandy), the southern 12,000 ft of KSC shoreline may have gained almost 38,000 cy/yr – offsetting the estimated beach profile losses north of False Cape, for an overall apparent net balance.

For the long-term period 1874/1928 to 2014, the estimated volume losses north of False Cape (about -19,000 cy/yr) were more than offset by accretion south of False Cape (about +35,000 cy/yr). For the long-term contemporary periods 1943-2014 and 1999-2014, the estimated net volumetric losses north of False Cape (about -24,000 cy/yr and -35,000 cy/yr, respectively) appear to have been approximately balanced by estimated net volumetric gains south of False Cape. In contrast, for 1999 to 2011, losses north of False Cape (-40,000 cy/yr) exceeded apparent gains south of False Cape (+16,000 cy/yr), for net erosion of about -24,000 cy/yr.

These results suggest that, on temporal average, the rate of beach volume loss along the northern 4 miles of the KSC shoreline has progressively increased over the last century (i.e., from about -19,000 cy/yr in the long-term to between -35,000 and -40,000 cy/yr at present). And, in the present epoch – at least from 1999 to 2011 (excluding Hurricane Sandy), the rate of erosion north of False Cape exceeds the rate of deposition south of False Cape (i.e., by -40,000 cy/yr versus +16,000 cy/yr).

The long-term historical data (from c. 1874/1928 and c. 1943) indicate that False Cape was prograding in the whole toward the south. The recent historical data (c. 1999-2011) suggest that the Cape is continuing to prograde toward the south, however, it is doing so with a slight net loss (erosion) to the overall headland and shoreline. During this period, the northern two-thirds of the KSC shoreline may have eroded at 2.5 times the rate at which the southern one-third of the KSC shoreline accreted. The long-term rate of erosion of the northern two-thirds of the KSC shoreline appears to be accelerating – or, at least, not diminishing – over the last century.

Figure A-5 demonstrates that the most severe shoreline erosion is concentrated between launch pads 39A and 39B (approximately V-071 to V-078), and more broadly from the Corrosion Test Facility to just north of launch pad 39B (approximately V-070 to V-087), or a distance of about 3.2 miles. This latter reach corresponds to that portion of the KSC shoreline that exhibits the lowest and narrowest natural dune ridge that separates the upland from the ocean (i.e., excepting the post-Hurricane Sandy dune repair project constructed in 2013-14). Observation indicates that the dune along parts of this reach is very frequently overwashed by storm tides and waves. These areas (specifically from V-071/072 to V-078) are the areas of highest, long-term shoreline erosion rate. Prior to Hurricane Sandy in 2012, it was anticipated that the minor dune along this area would be eroded, overtopped and breached in the near future – which, indeed, occurred during Hurricane Sandy. Erosion, overtopping, and breaching of the dune in this area can be expected in the future, resulting in significant inundation and/or flooding of the low-elevation uplands that lie immediately landward of the dune ridge.

Figures A-6 and A-7 depict the land elevations of the KSC barrier island complex prior to Hurricane Sandy's impacts in October 2012 and subsequent emergency dune reparations in 2014. Almost all of the inland lies below +5.0 ft NAVD; i.e, the approximate predicted storm water level for a 10-year return period event (USACE 2010, after Dean and Chiu 1986). Much of the complex lies below the normal mean high water elevation, approximately +1 ft NAVD. Along the northern 3.6 miles of the coastline, these low inland areas are separated from the ocean by a narrow dune ridge. Most of this natural ridge is substantially less than +9.6 ft elevation (the predicted 100-yr still water storm level), particularly in the highest chronic erosion areas between launch pads 39A and 39B where the dune is frequently overwashed. A 25-yr return period storm event (such as estimated for Hurricanes Frances or Jeannie, in 2004), with still water surge level of at least +7 ft NAVD -- or a less severe storm – will readily breach the weakest portions of this dune ridge, flood the uplands, and ultimately blow out remaining sections of the dune by flanking and backwash. The potential for this damage will increase annually as the natural beach and dune continues to erode through the chronic erosion stress exhibited by the shoreline history indicated over the last decades and century.

Figure A-8 depicts the maximum dune elevation and the total sediment volume above +7 ft NAVD within 220-ft landward of the mean high water shoreline in existing conditions (Sept. 2014), pursuant to the construction of Post-Hurricane Sandy dune reparations in early 2014. The +7 ft elevation approximately corresponds to the 25-year storm surge level and the natural beach berm elevation; and the 220-ft distance includes the limits of the 2014 dune reparations. Lower dune heights and volumes south of V-089 are associated with the lower-energy, accretional nature of the shoreline area along and south of False Cape, and do not otherwise indicate shoreline vulnerability.

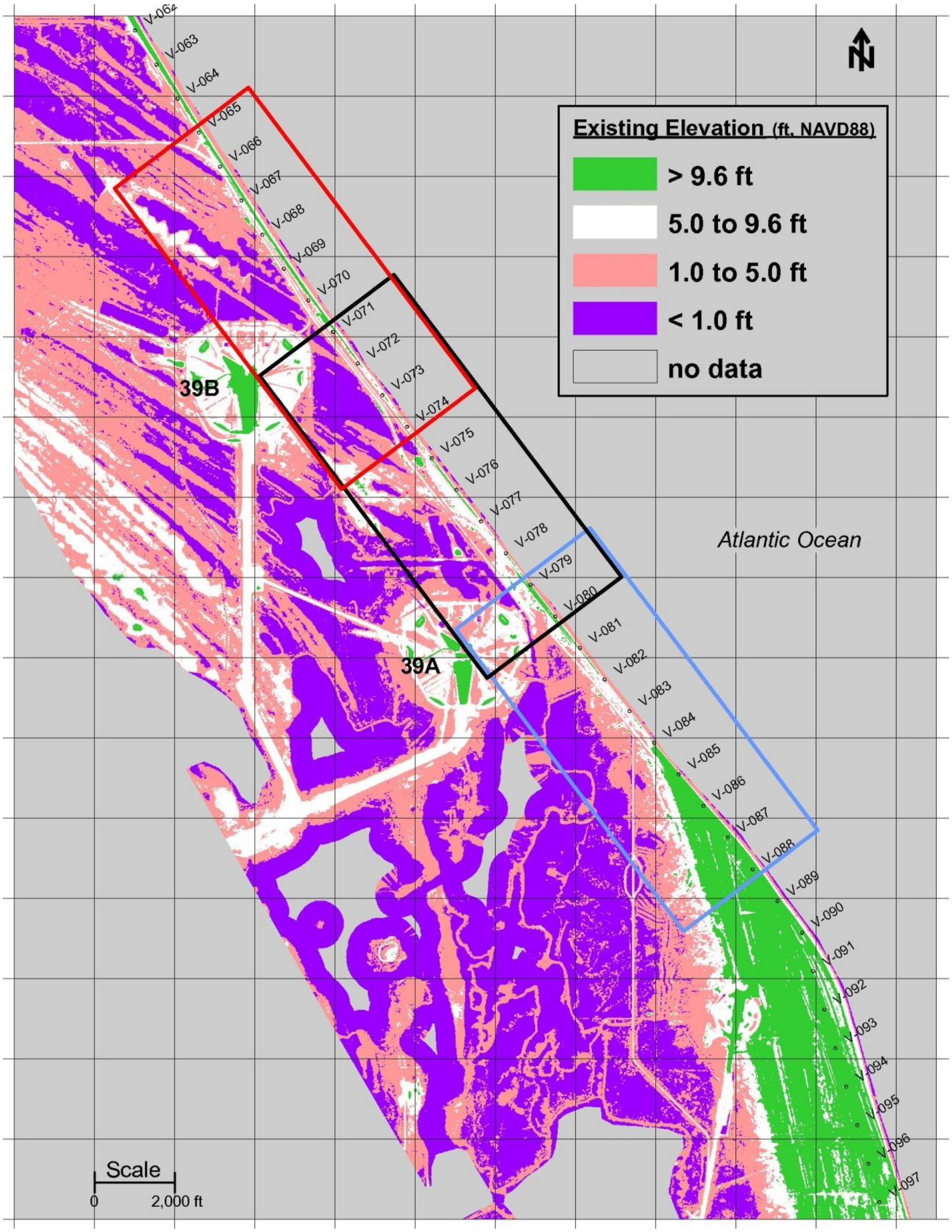


Figure A-6: Upland land elevations along the overall KSC oceanfront (from 2007 Lidar survey). Much of the interior is below Mean High Water elevation, approximately +1 ft (pink), and below +5 ft elevation (purple), separated from the ocean by a narrow ridge above +5 ft (white). Lands higher than the approximate 100-year storm elevation, +9.6 ft (green), include the ocean dune ridge that diminishes in height and width between launch Pads 39A and 39B. Detailed views (box areas) are shown in Figure A-7.

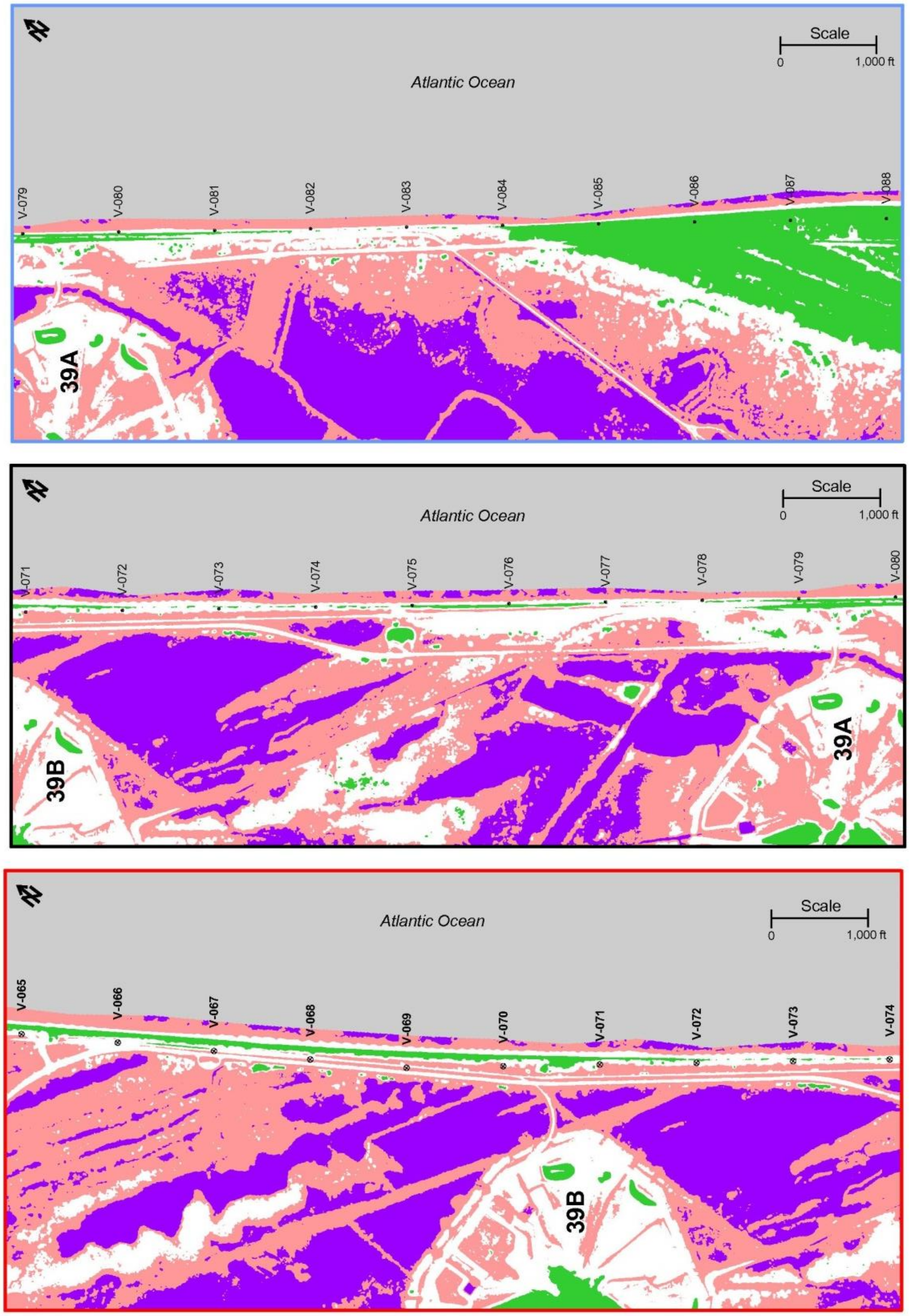


Figure A-7: Detail view of land elevations along the KSC shoreline, north of False Cape (from 2007 Lidar survey). Dunes with elevation above the approximate 100-year still-water storm level (+9.6 ft), indicated in green, are narrow or minimal along the central shoreline, from V071-V-084. Colors indicate land elevations above +9.6 ft (green), between +5 and +9.6 ft (white), below +5 ft (pink), and below +1 ft (purple). Areas in purple are below the approximate Mean High Water elevation.

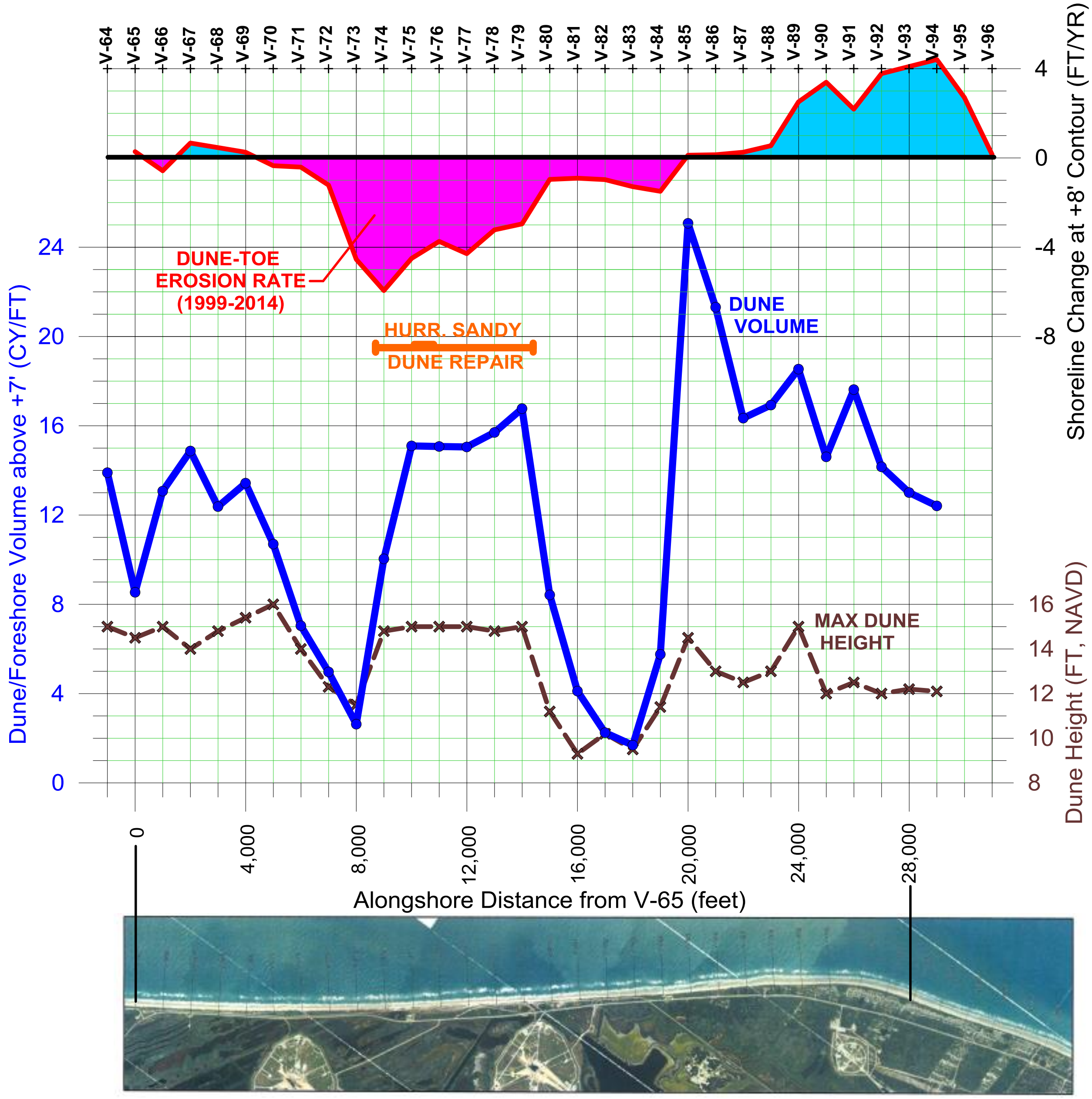


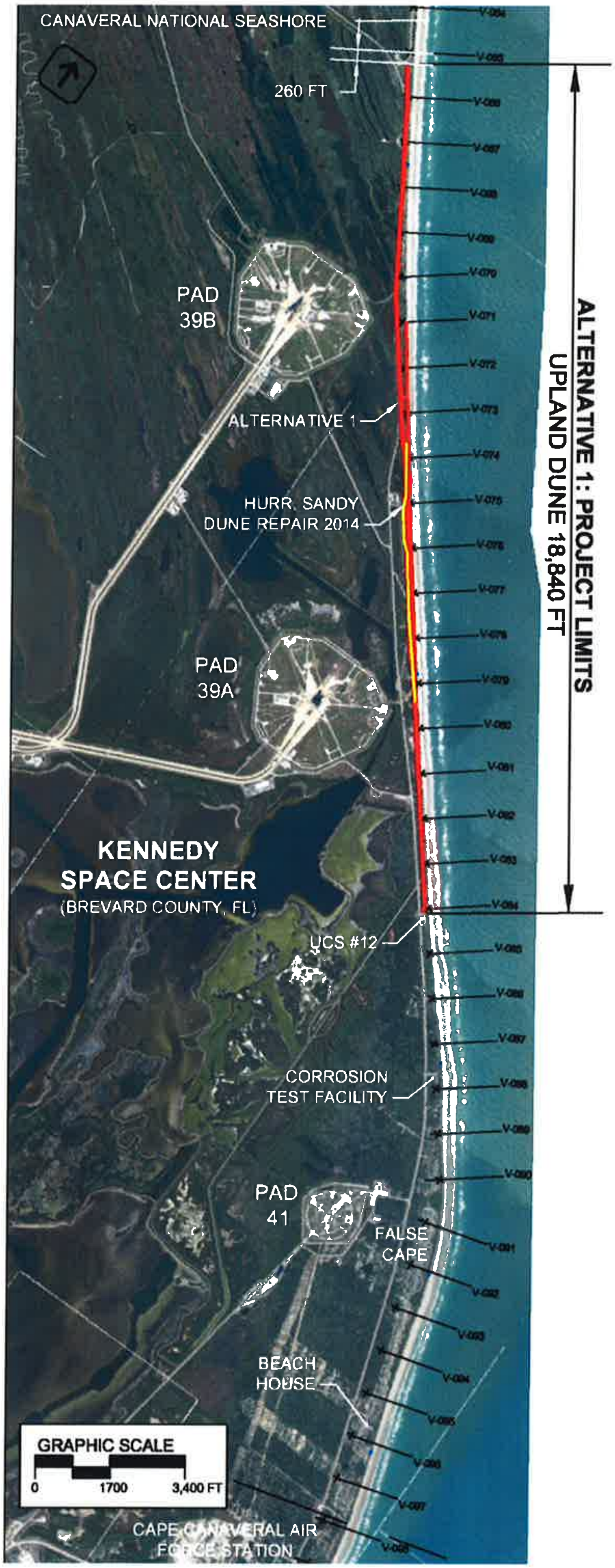
Figure A-8: Existing dune/foreshore sand volume above +7 ft NAVD (blue), and maximum dune height (brown), within 220-ft landward of the mean high water shoreline. The values include conditions measurd in September 2014, pursuant to the Post-Hurricane Sandy dune reparations in Spring 2014. (The 220-ft distance includes the landward limit of the dune reparations above +7 ft NAVD.) The average annual rate of dune erosion, measured along the +8' NAVD contour (red-erosion, blue-accretion), from 1999 through September 2014, is illustrated at the top of the figure.

References:

Dean, R. G. and Chiu, T. Y. 1986. Combined Total Storm tide Frequency Analysis for Brevard County, Florida. Beaches and Shores Resource Center, Inst. Of Science and Public Affairs, Florida State University, Tallahassee, Fl. May 1986.

USACE 2010. Final Integrated General Re-Evaluation Report and Supplemental Environmental Impact Statement; Brevard County, FL Hurricane and Storm Damage Reduction Project, Mid Reach Segment. U. S. Army Corps of Engineers, Jacksonville District. Jacksonville, FL. September 2010.

APPENDIX B



Kennedy Space Center Shoreline Protection

Upland Dune ("Alternative 1")

Planform and Section View Concept Layout, Updated – Nov. 2014

Prepared for

InoMedic Health Applications

and

NASA
Kennedy Space Center, Florida

Prepared by

Olsen Associates, Inc.
Jacksonville, Florida

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Coastal Engineering

14 Nov. 2014

Kennedy Space Center Shoreline Protection
Upland Dune ("Alternative 1")

Planform and Section View Concept Layout
Updated – November 2014

The following sheets (27) update the Planform and Section views of the KSC "Upland Dune" Alternative #1 to reflect 'current' shorefront conditions; i.e., after the Post-Hurricane Sandy dune repairs. The beach profile sections reflect September 2014 survey data (where profile data were collected), else they reflect the prior March 2012 (pre-Sandy) survey data. The beach profile sections are spaced 1000-feet apart, arranged north to south along the shoreline. At those locations where September 2014 profile data were not collected (well north and south of the Hurricane Sandy dune repairs), the earlier March 2012 survey is a reasonable proxy for current conditions – because it appears that there were relatively minor changes to the dune crest and uplands at these locations, between 2012 and 2014, despite the impacts of Hurricane Sandy elsewhere.

The <u>planform drawings</u> (Sheets 1-16) depict the fundamental footprint of the Upland Dune that was originally conceived in 2012. This schematic-level lay-out sought to minimize environmental impact from the dune's construction, avoid the existing roadway, and was mostly aligned atop the railroad bed. This footprint is not changed in the drawings, and is depicted in BLUE. The footprint and crest of the "As-Built" post-Hurricane Sandy dune repairs have been added to the drawings, depicted in YELLOW and RED, respectively.[1]

The <u>section drawings</u> (Sheets 17-27) depict the nominal Upland Dune, located in accordance with the footprint shown in the planform drawings, and drawn in accordance with the general elevations, widths and slopes described for Alternative 1 in the Environmental Assessment. It is depicted in BLUE. The existing beach profile conditions -- measured in March 2012 at every survey monument, and measured in September 2012 at selected monuments – are depicted in BLACK and ORANGE, respectively.

These drawings are not intended as a "construction plan". Instead, they present a schematic-level illustration of the conceptual design of the Upland Dune (Alternative 1) relative to existing conditions. There is no specific accommodation (adjustment) of the Upland Dune location or geometry relative to the existing, post-Hurricane Sandy dune conditions. It is simply a literal geometric translation of the Alternative 1 Upland Dune concept design drawn upon the current shorefront. For example, at monument V-78 (sheet 21), the Alternative 1 dune is shown to overlap the existing Post-Sandy dune by about 5 feet on its landward face. In practice, of course, the Alt. 1 dune would be shifted 5 feet seaward so as not to bury the vegetation on the existing constructed dune. Such accommodations in location and dune geometry would be made in a final design, at such future time when a specific project scope is identified for construction.

A simple measure of the state of the existing dune conditions – relative to the observed rate of dune-toe retreat – is illustrated in Figure A on the following page. This figure depicts current (Post-Hurricane Sandy dune repair) conditions. It does not depict the conditions (i.e., dune volumes) that would result from construction of the Alternative 1 Upland Dune.

---

[1] Where the Sandy dune repairs joined the previously constructed inland dune, the prior dune is shown in ORANGE.)

In Figure A, areas with the least dune volume and height (blue and brown lines) – and with the greatest observed dune erosion (red/pink) – represent shoreline areas of greatest potential vulnerability to storm erosion and overwash. [South of V-86, the smaller dune volumes and heights correspond to historical beach accretion. These represent naturally low & fast-growing dune conditions, and not necessarily areas of high vulnerability.] Prima facie inspection of Figure A suggests that the greatest apparent, immediate need for dune improvement in priority order may be:
(1) V71.5-V75 (2) V79.4-V84 (3) V75-79.4 (4) V65-71.5.

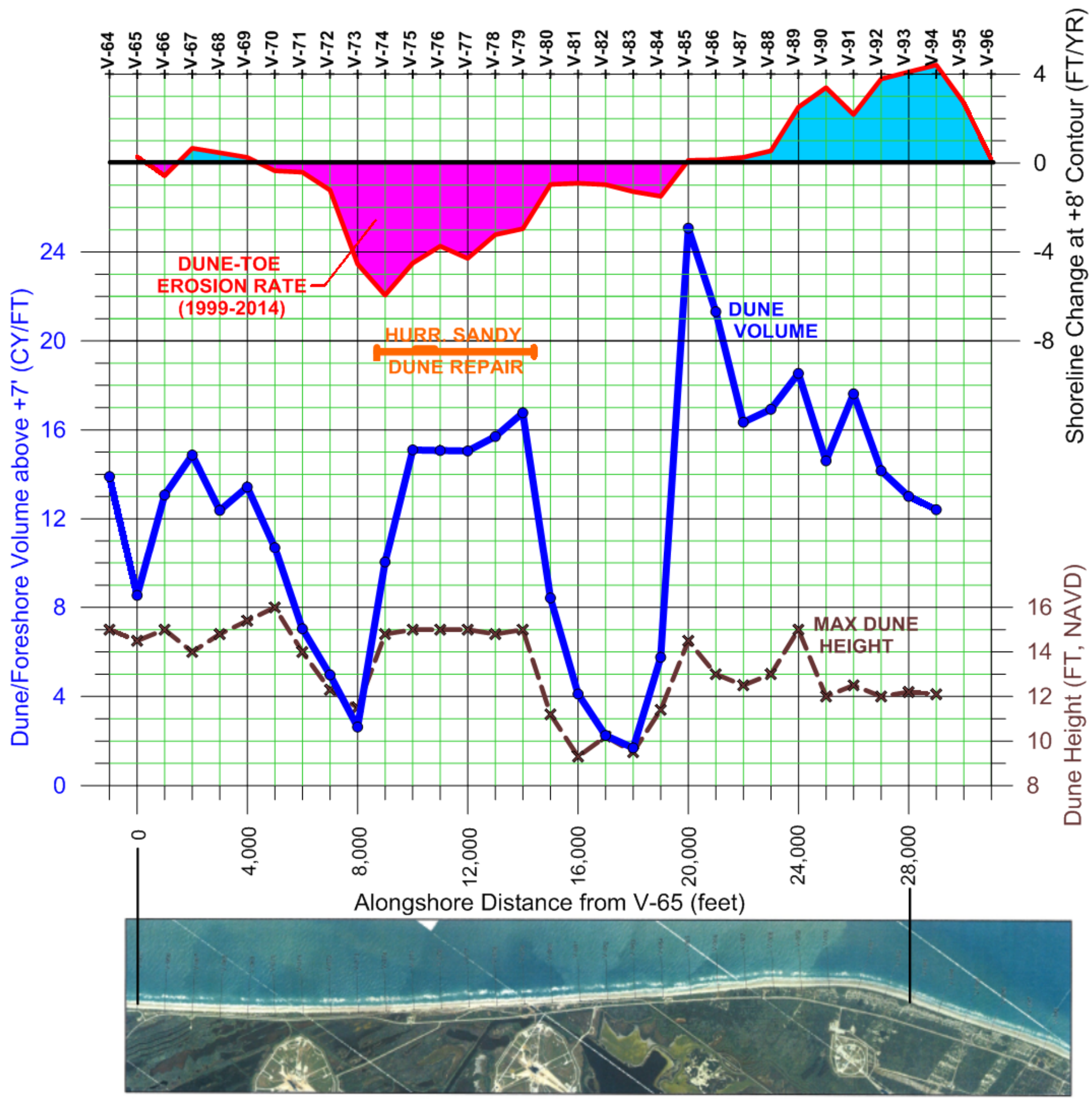
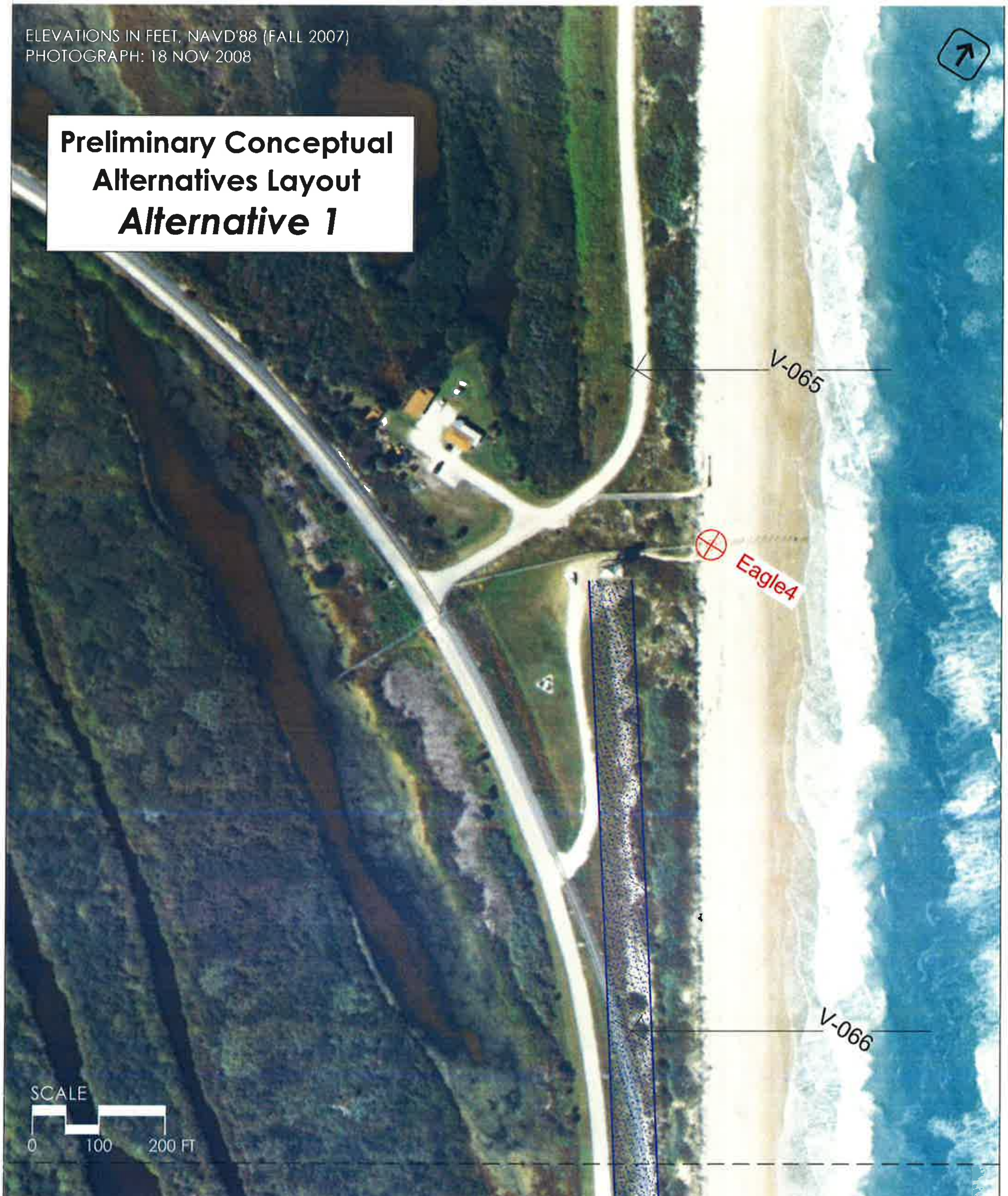


Figure A: Existing dune/foreshore sand volume above +7 ft NAVD (blue), and maximum dune height (brown), within 220-ft landward of the mean high water shoreline. The values include conditions measured in September 2014, pursuant to the Post-Hurricane Sandy dune reparations in Spring 2014. (The 220-ft distance includes the landward limit of the H. Sandy dune reparations above +7 ft NAVD.) The average annual rate of dune erosion, measured along the +8' NAVD contour (red=erosion, blue=accretion), from 1999 through September 2014, is illustrated at the top of the figure.



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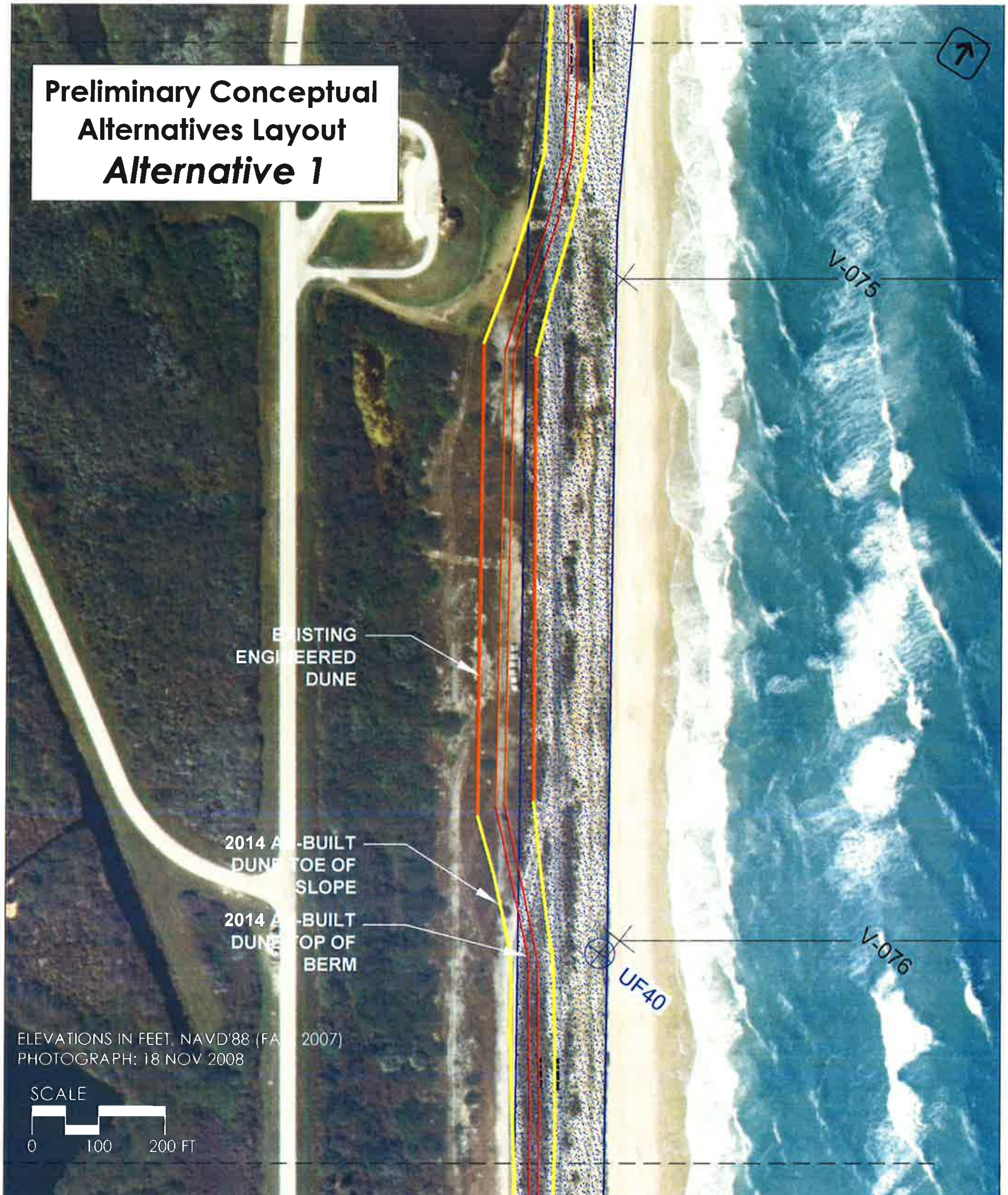

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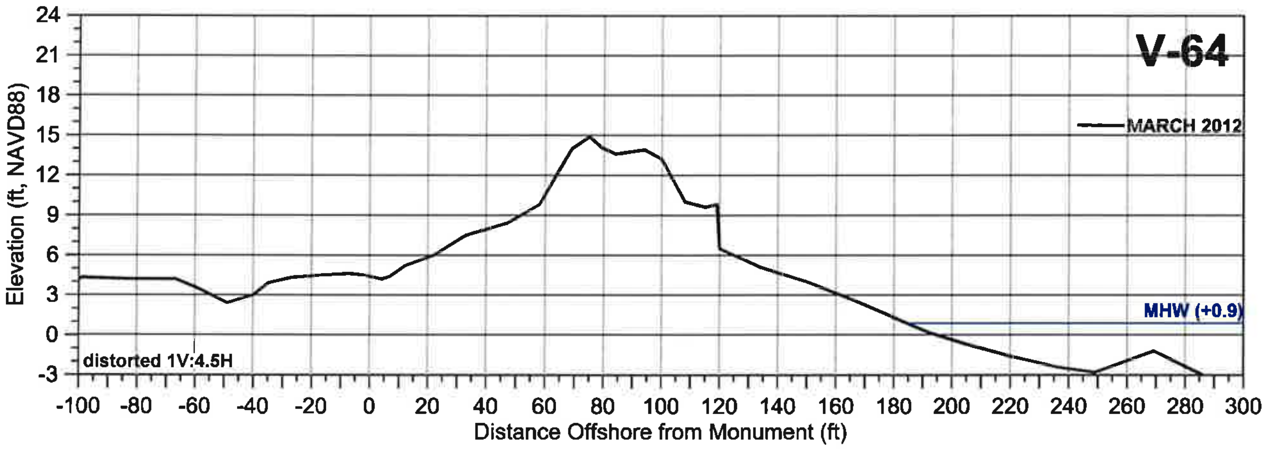

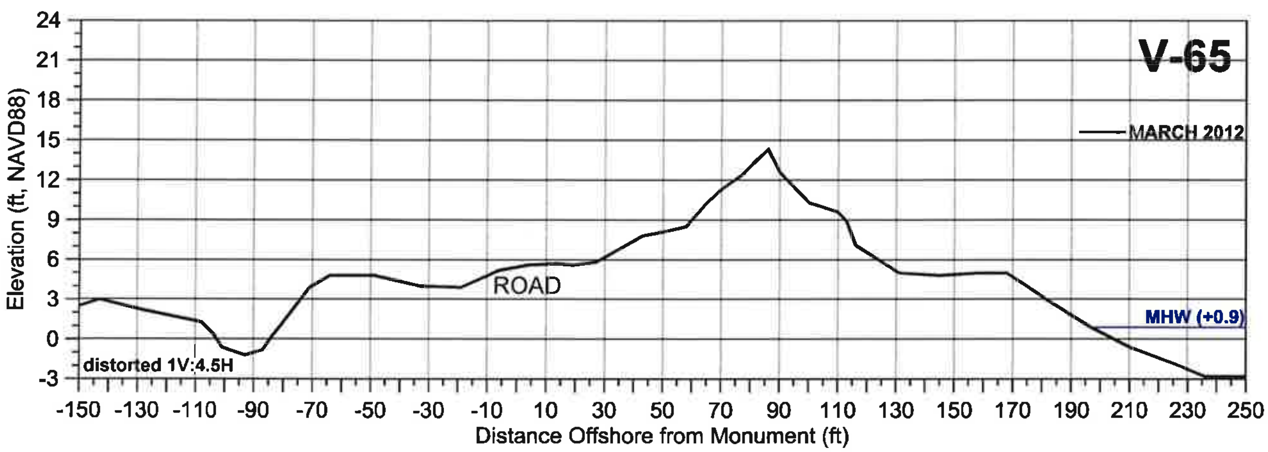

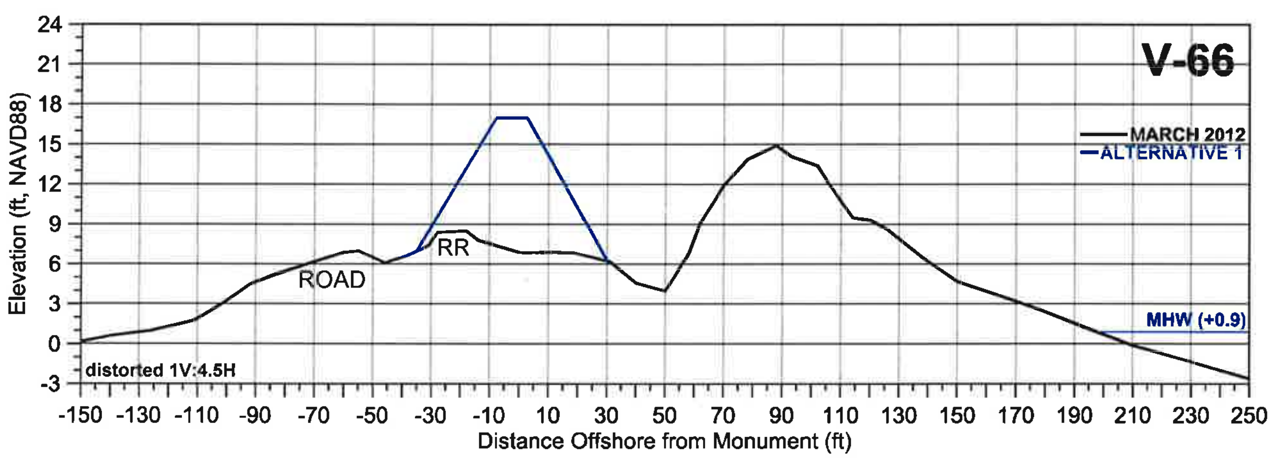

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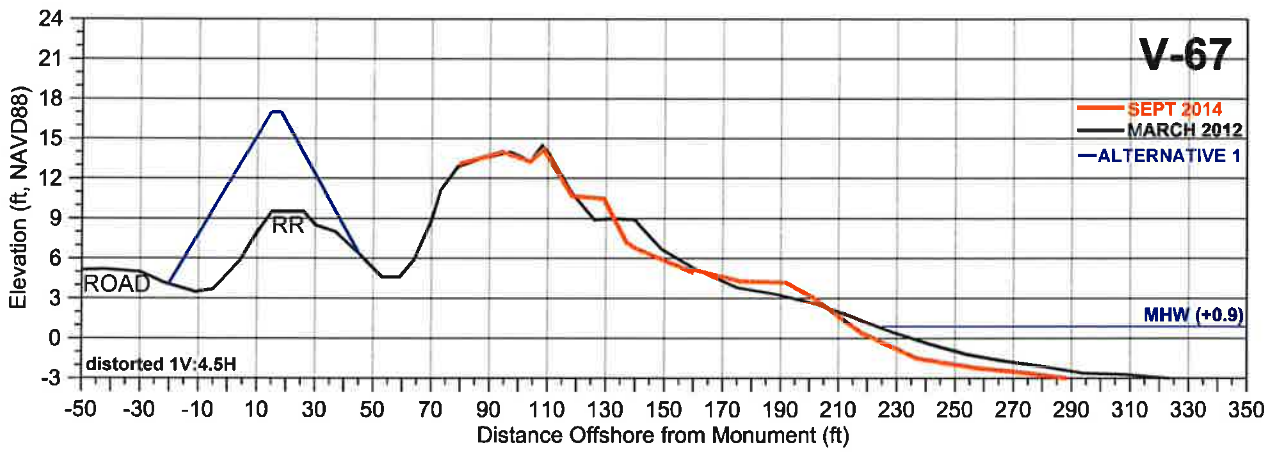

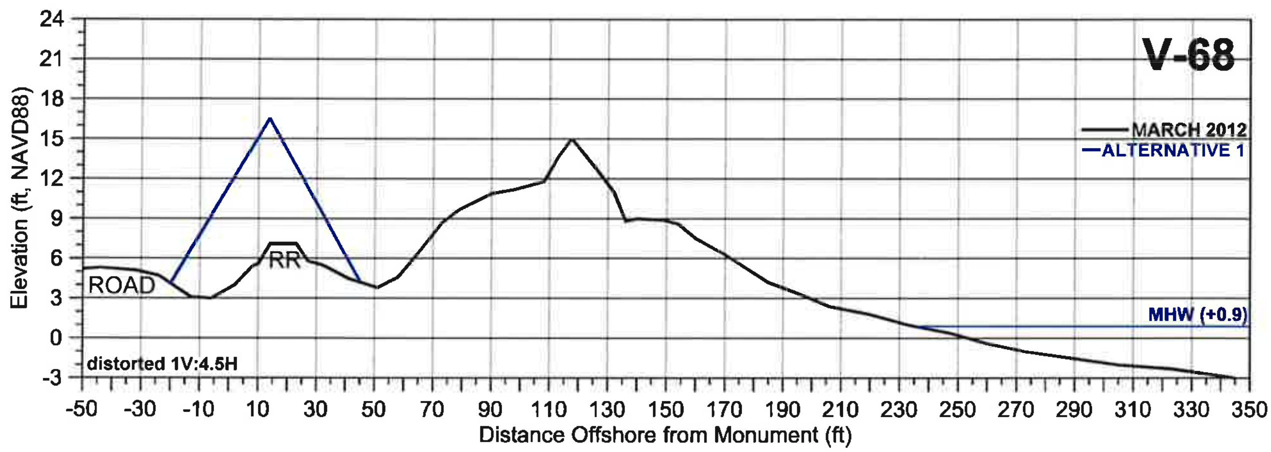

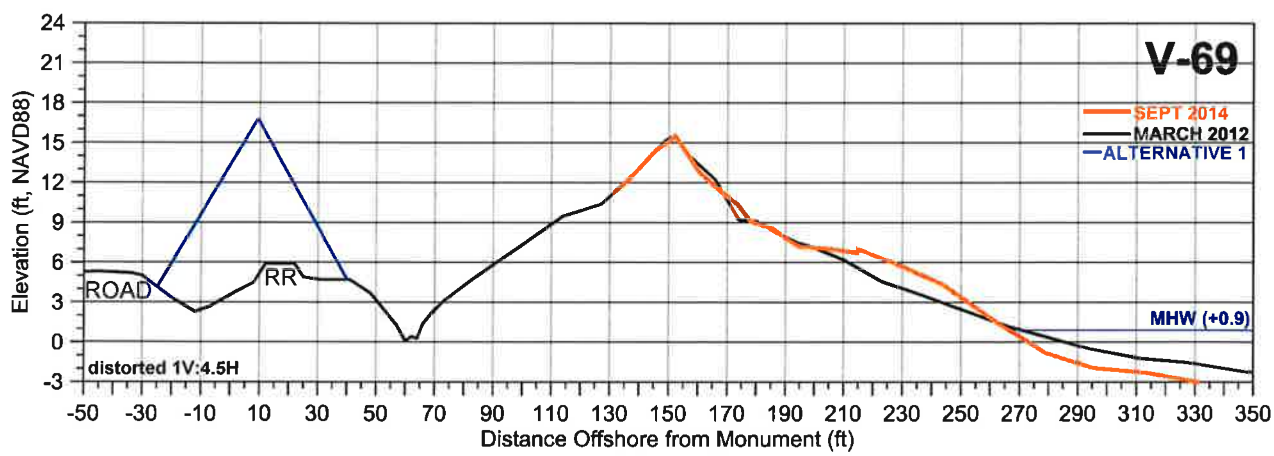

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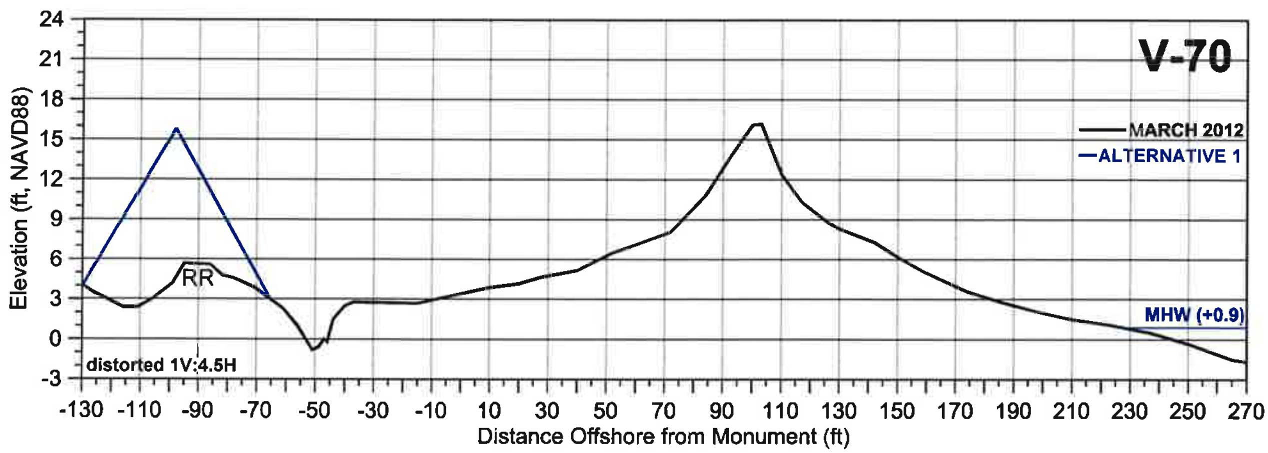

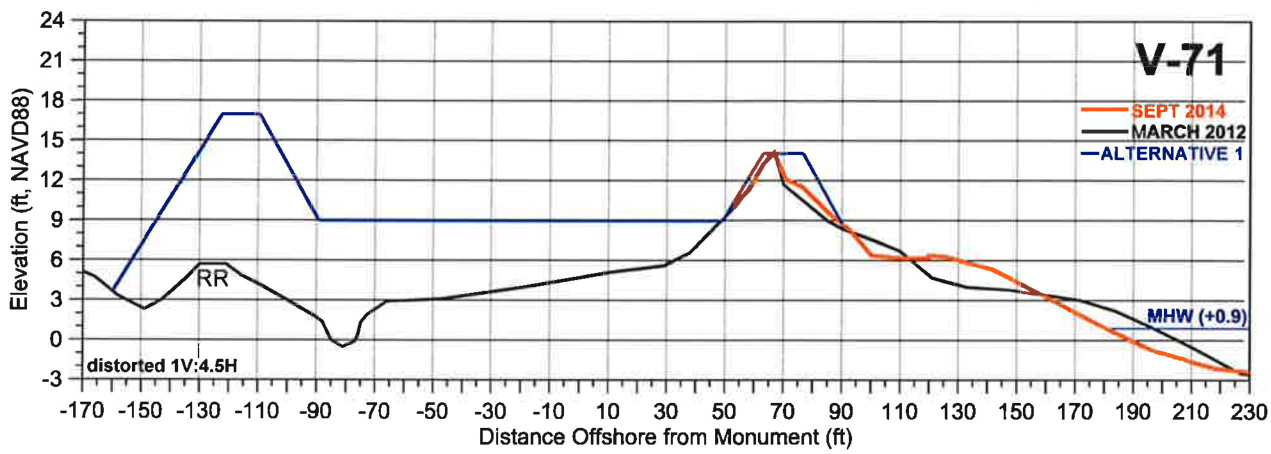

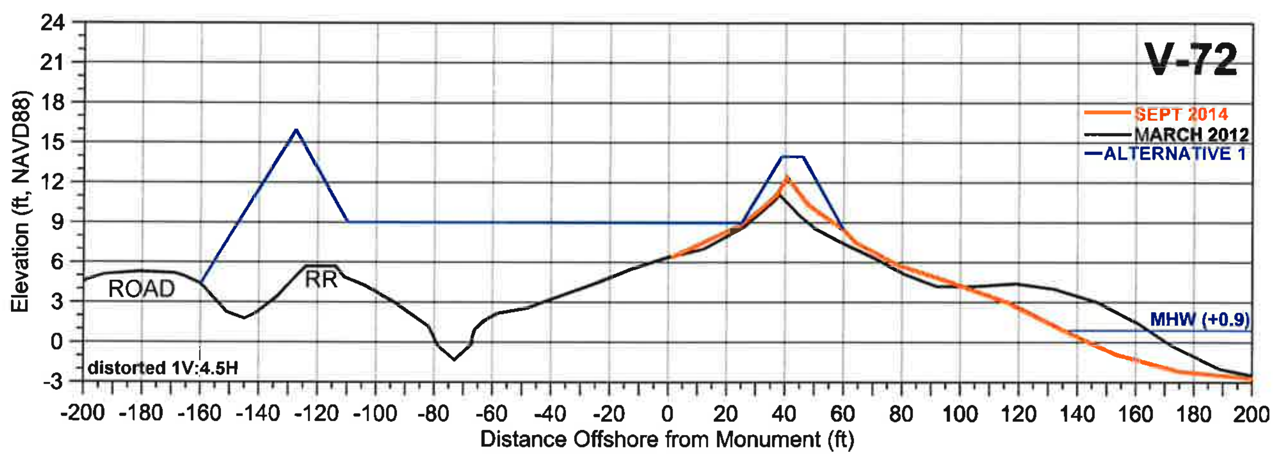

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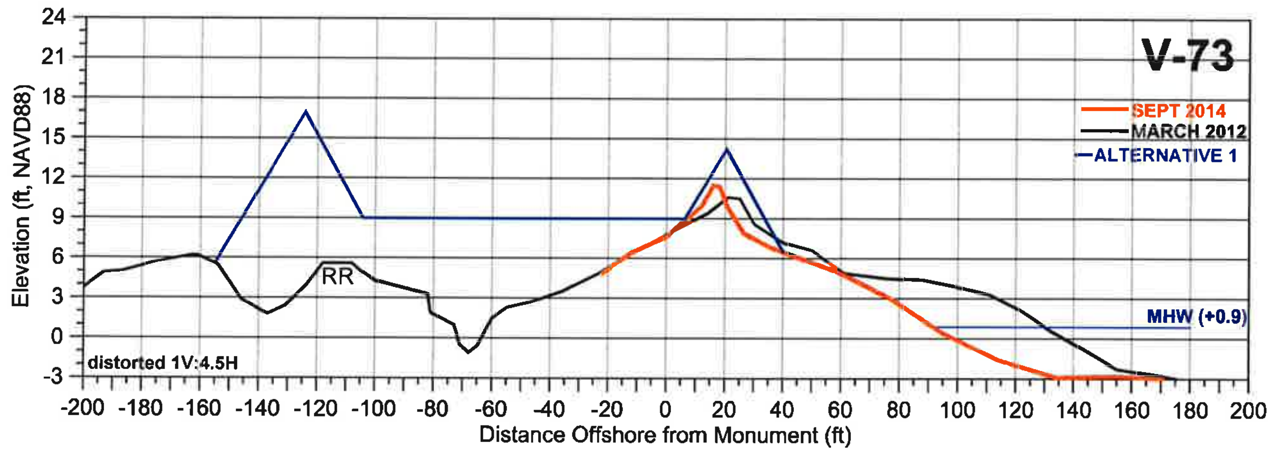

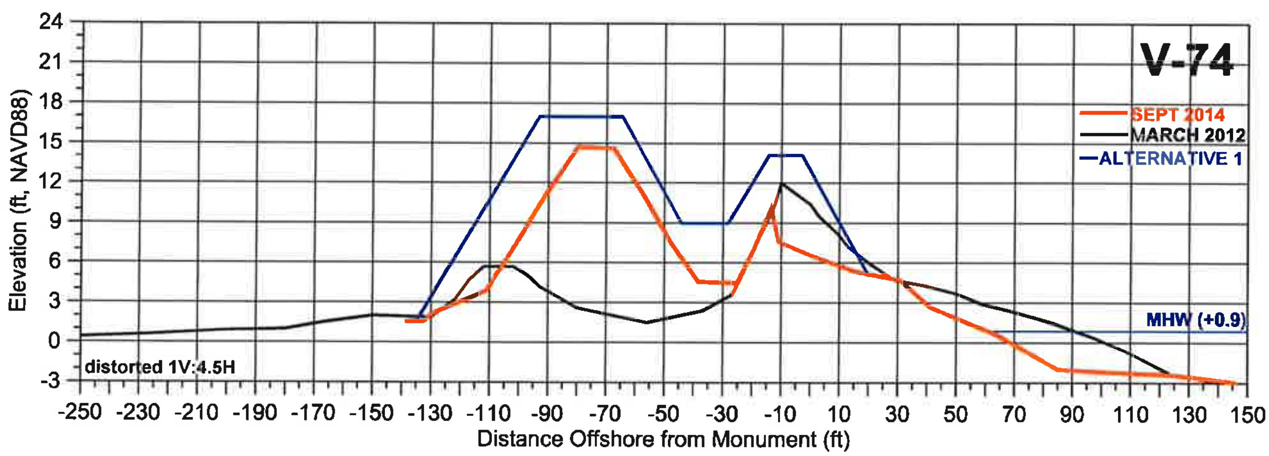

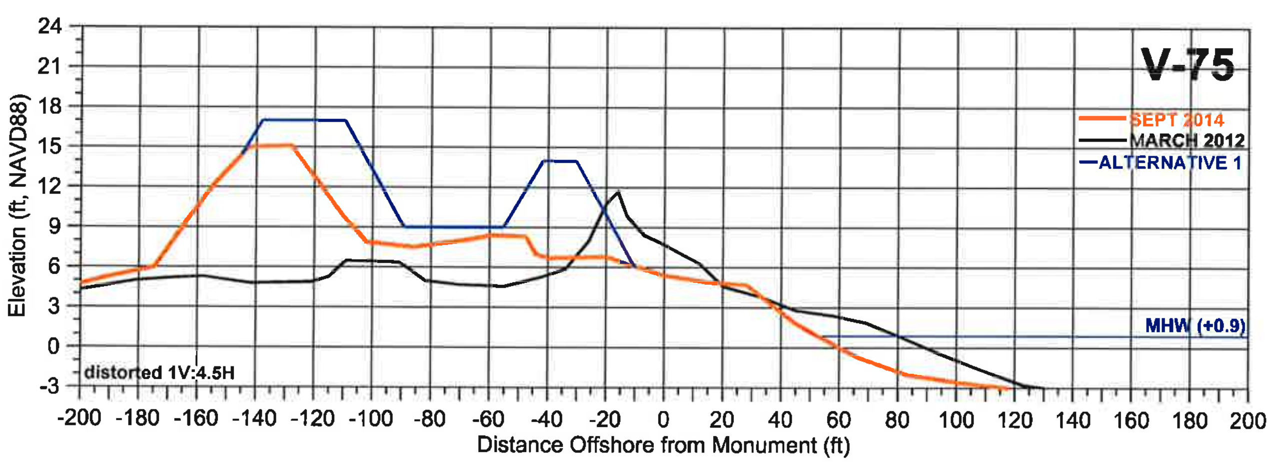

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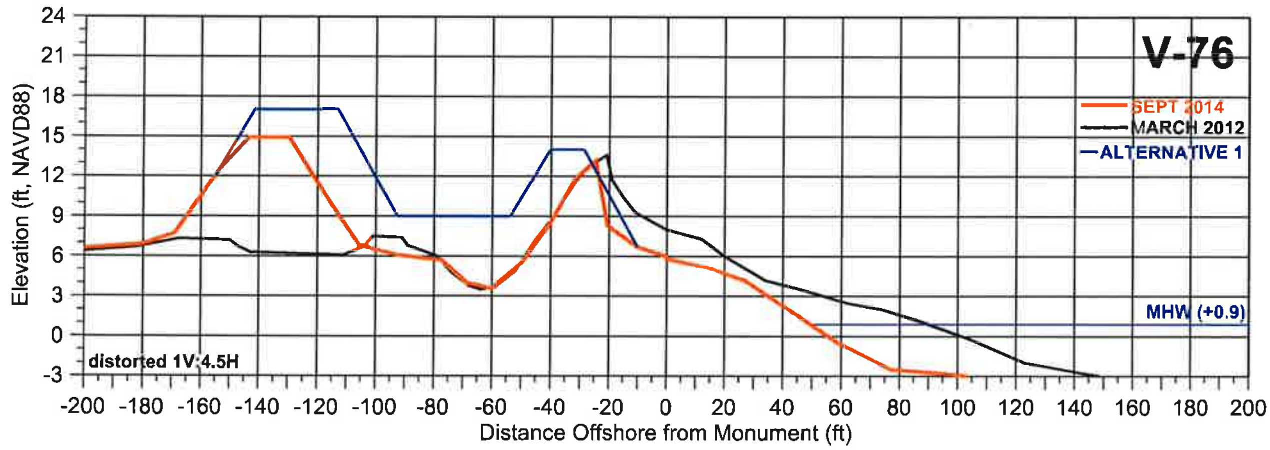

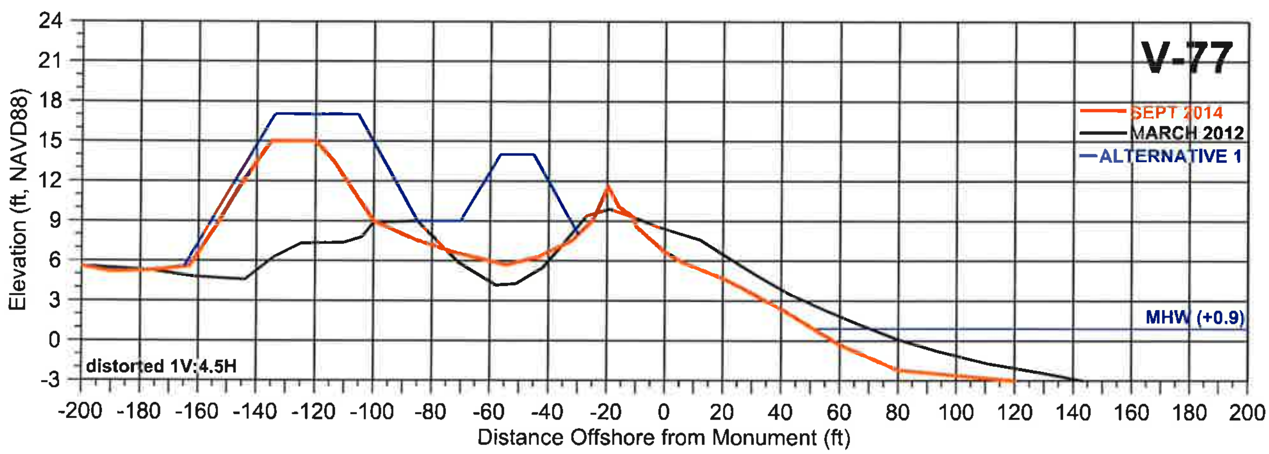

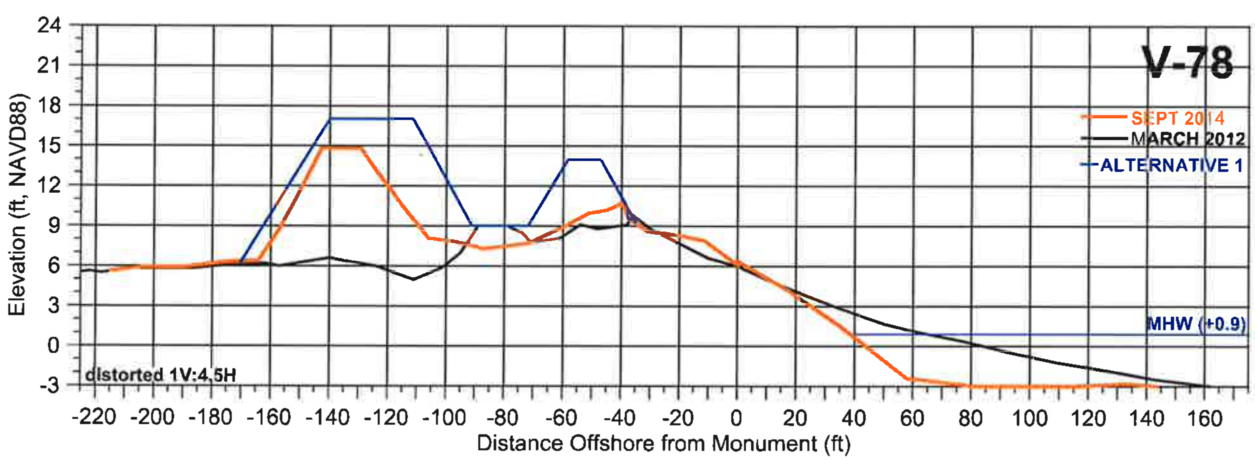

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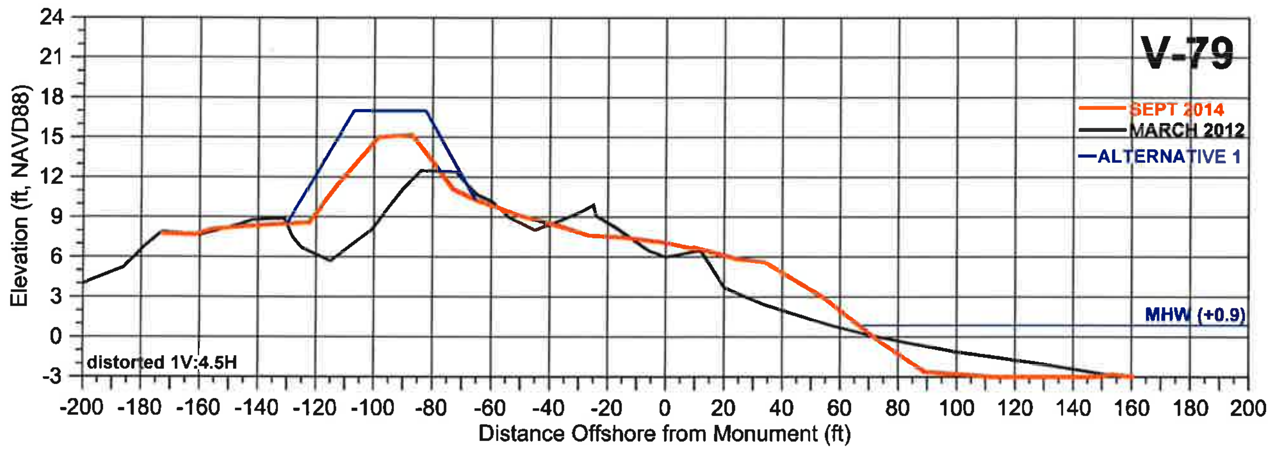

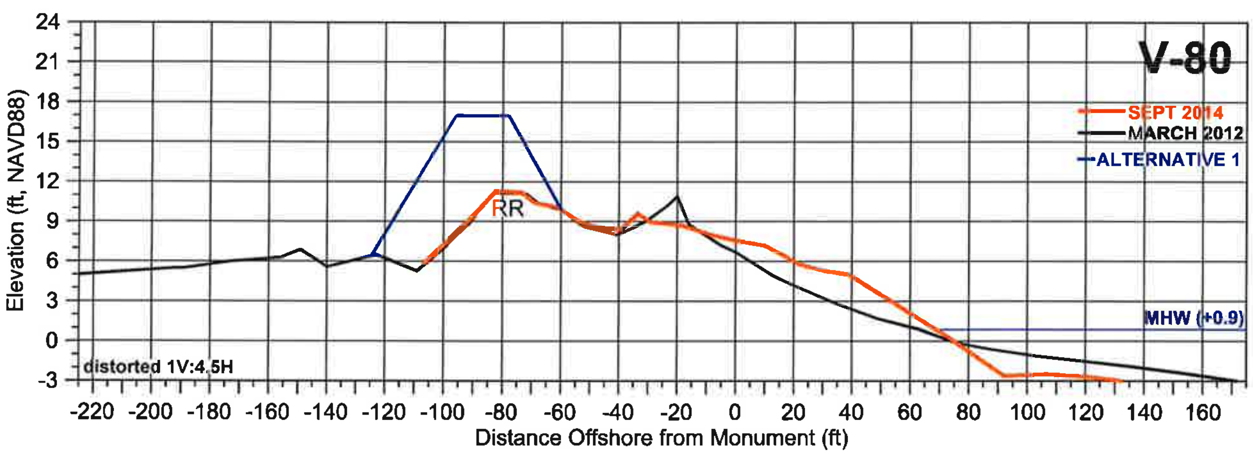

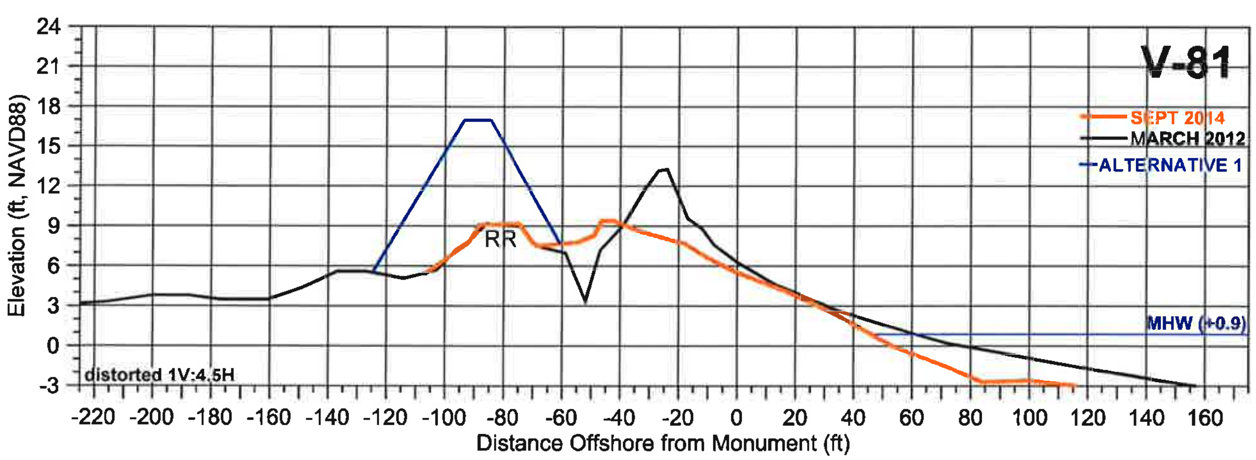

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ALTERNATIVE 1
POST-SANDY DUNE REPAIR

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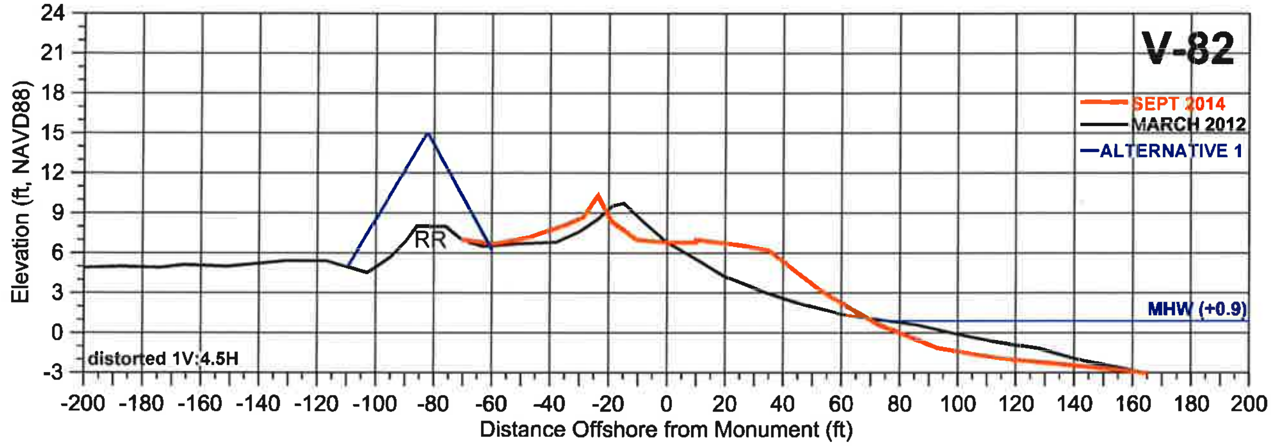

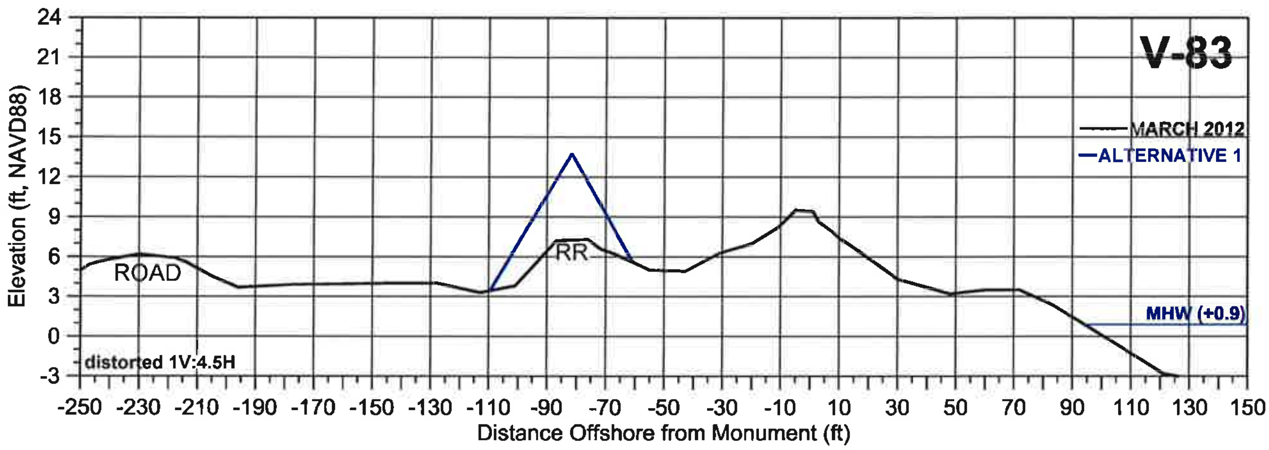

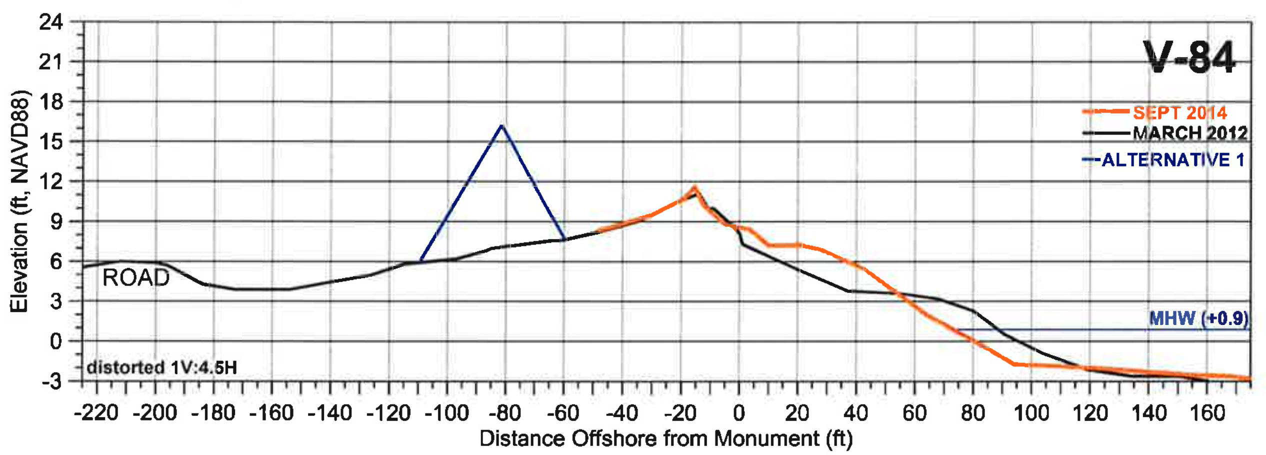

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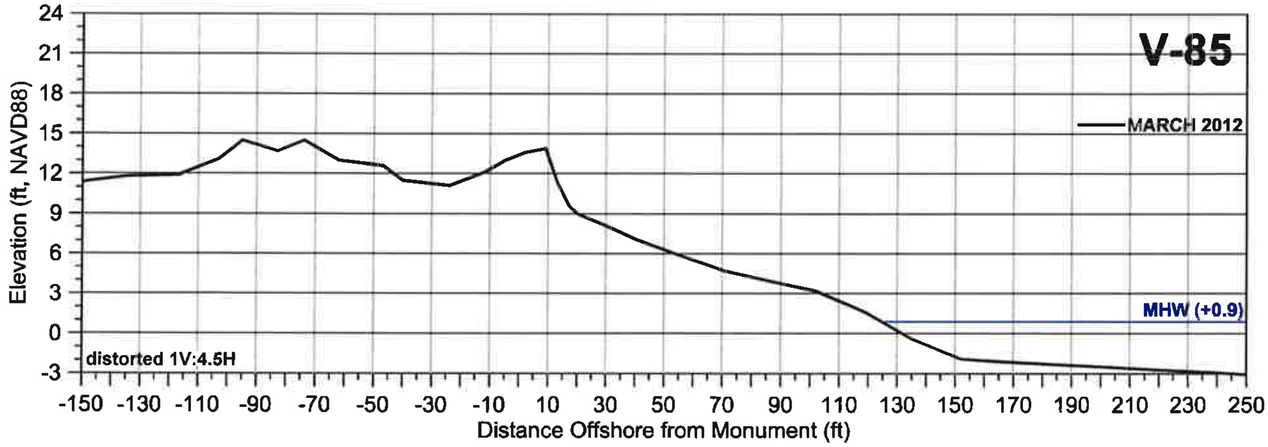

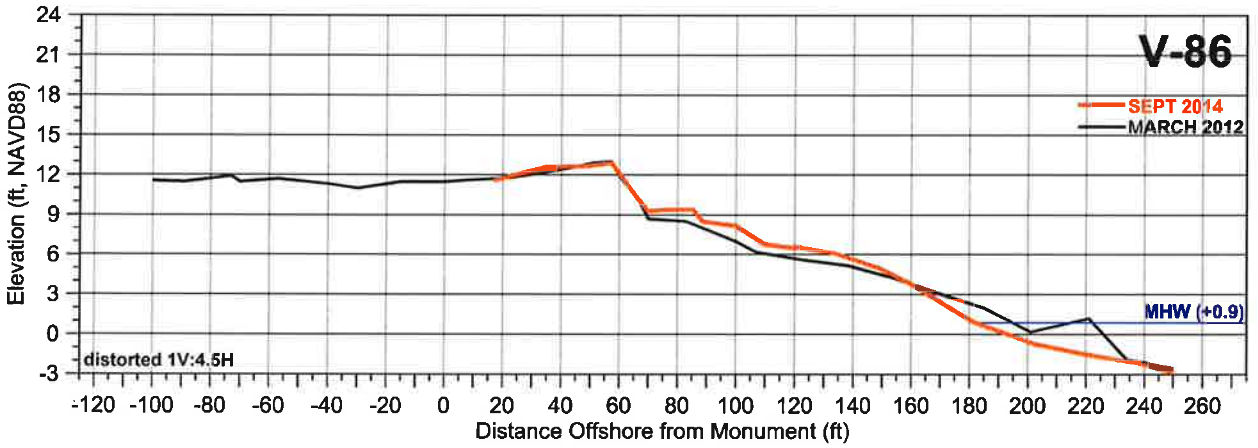

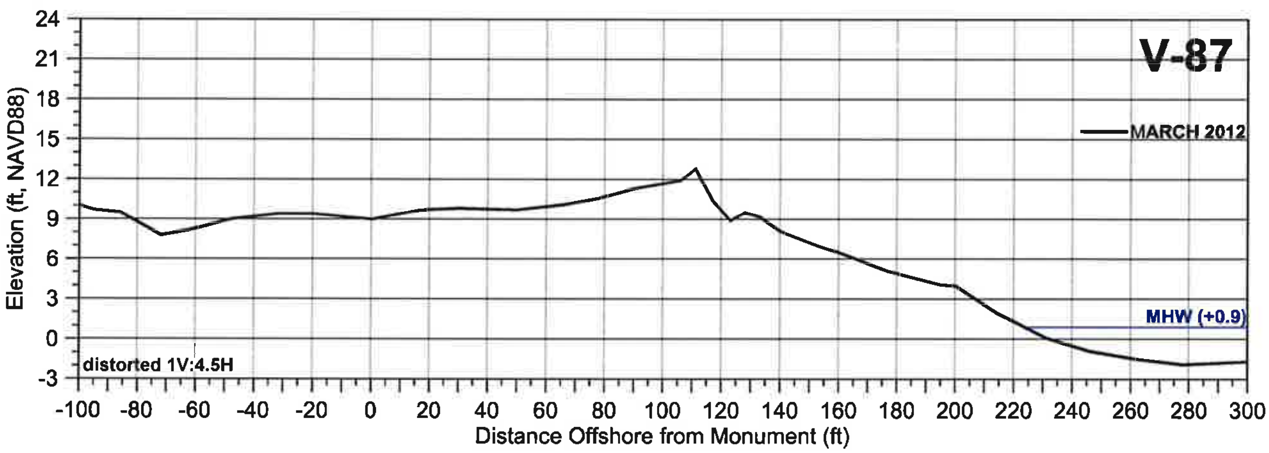

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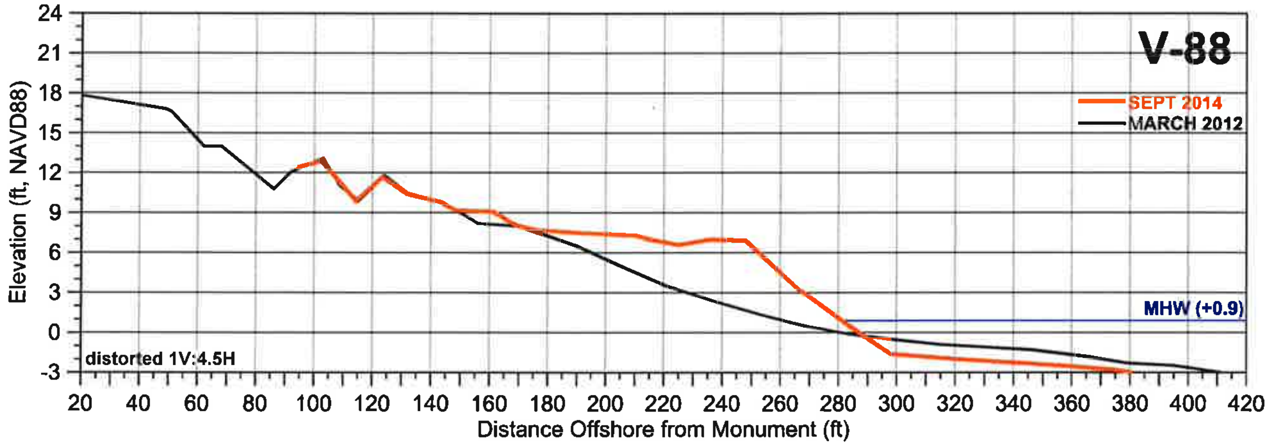

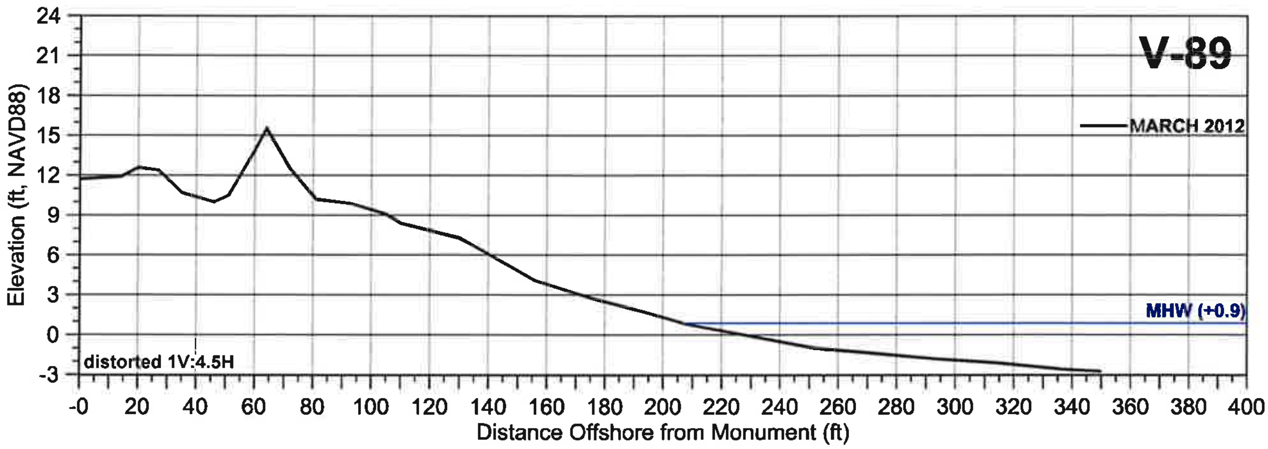

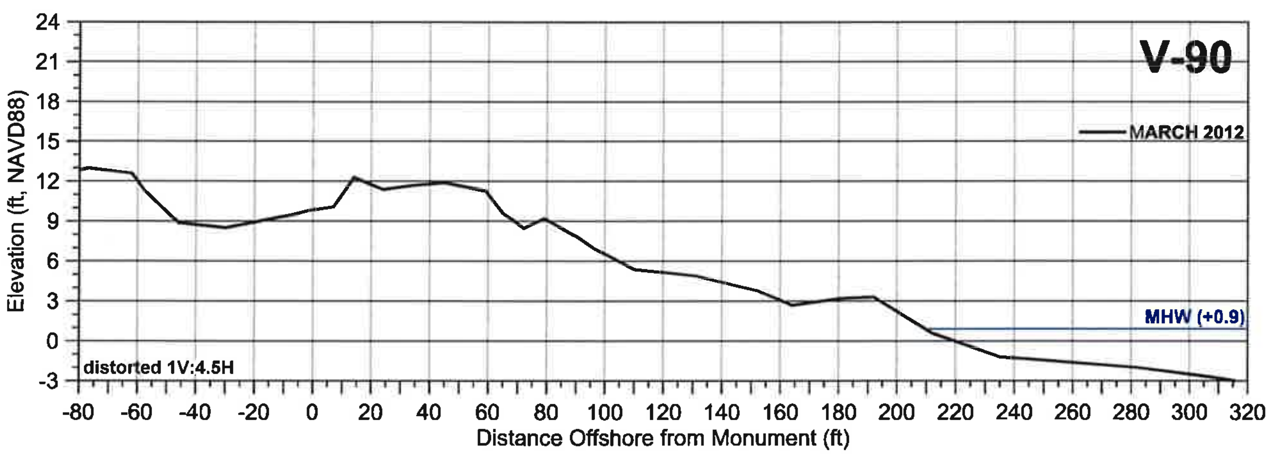

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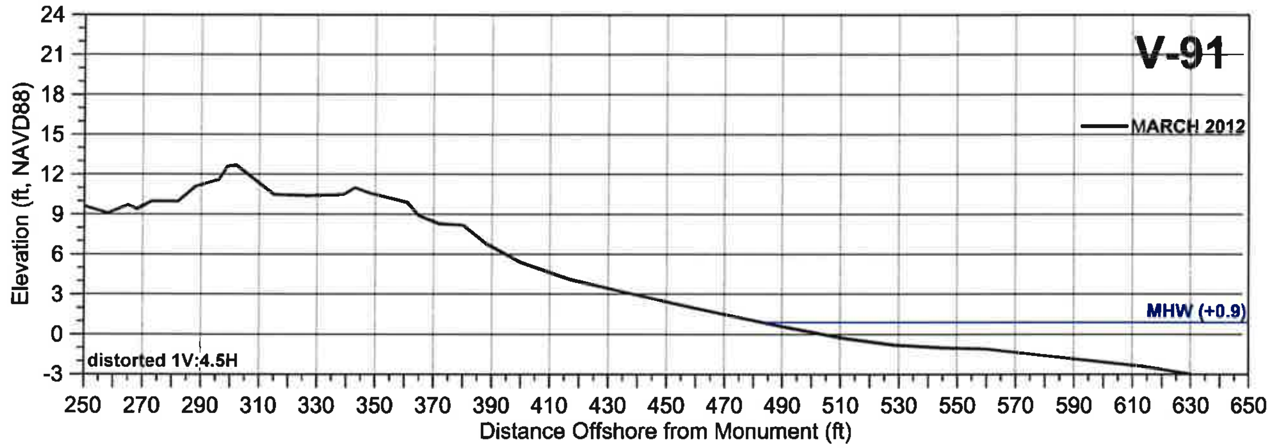

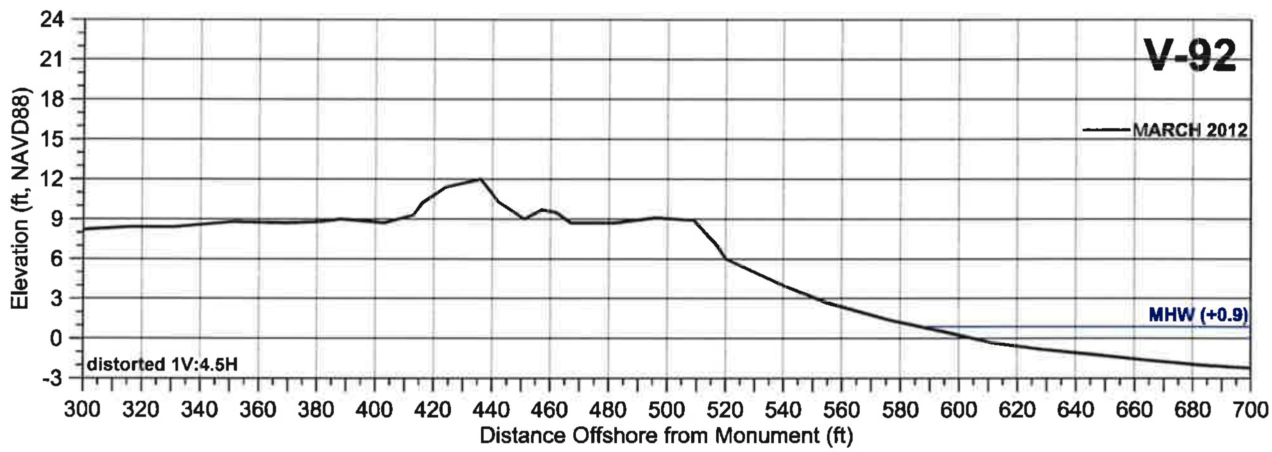

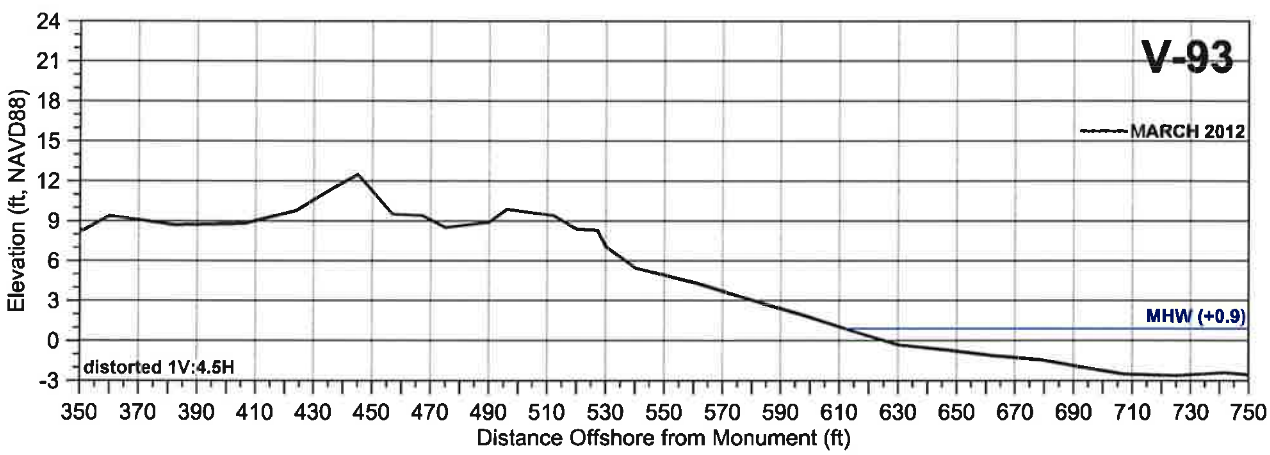

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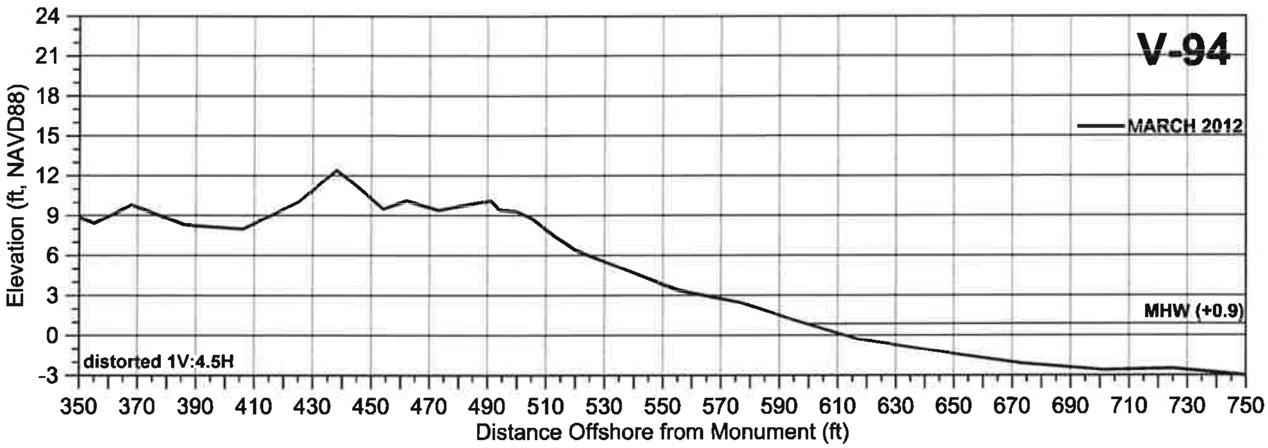

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APPENDIX C

Sand Sources for Shore Protection along Kennedy Space Center, Florida

Prepared for:
InoMedic Health Applications

and

Kennedy Space Center
National Aeronautics and
Space Administration
Kennedy Space Center, FL 32899

Prepared by:
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JANUARY 2015

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coastal engineering

Sand Sources for Shore Protection along Kennedy Space Center, Florida

Kevin R. Bodge, Ph.D., P.E. and William Reilly, P.E.
Olsen Associates, Inc. (OAI)

January 2015

1.0 INTRODUCTION

This report describes potential borrow areas for beach-compatible sediment in the vicinity of the Kennedy Space Center (KSC) at Cape Canaveral in Brevard County, Florida. Specific description is given of (1) the native dune and beach sediments at KSC, (2) existing offshore borrow areas previously permitted and used for beach nourishment in Brevard County, (3) upland borrow areas previously permitted and used for dune restoration in Brevard County, and (4) the potential for new offshore borrow areas that may be developed in the immediate proximity of KSC. Description of the compatibility (overfill ratio) of the existing borrow area sediments and native beach sediments is likewise provided. This report updates the prior, original version of the report dated June 2012.

2.0 NATIVE BEACH SEDIMENTS

For purposes of both environmental (habitat) protection and proper physical performance, sediment placed to the beach system should be compatible with the native (natural) beach sediments; i.e., generally similar in granularmetric distribution, color, and mineralogic composition, and free of debris or contaminants that are inconsistent with natural beaches. In Florida, beach compatible sediment is typically described by the State of Florida "sand rule" [FAC 62B-41.007(2)(j)]. And, along federal property such as the KSC where there is no coastal construction control line, sediment placed to the beach seaward of the mean high water line, in State waters, must demonstrate beach-compatibility as defined by the "sand rule".

To identify the characteristics that define the native beach sediment along KSC, physical samples were collected and analyzed by OAI in March 2012. Data describing the samples, summary statistics, and compatibility/overfill ratio (with respect to permitted offshore borrow areas) is presented in **Section 5** of this report. A brief description of the native beach sediment investigation is presented below.

Ten beach sand samples were collected along each of three transects -- V-68, V-77, and V-86 – across the KSC dune/beach and nearshore seabed (see ***Figure 2-1***). The 30 samples were

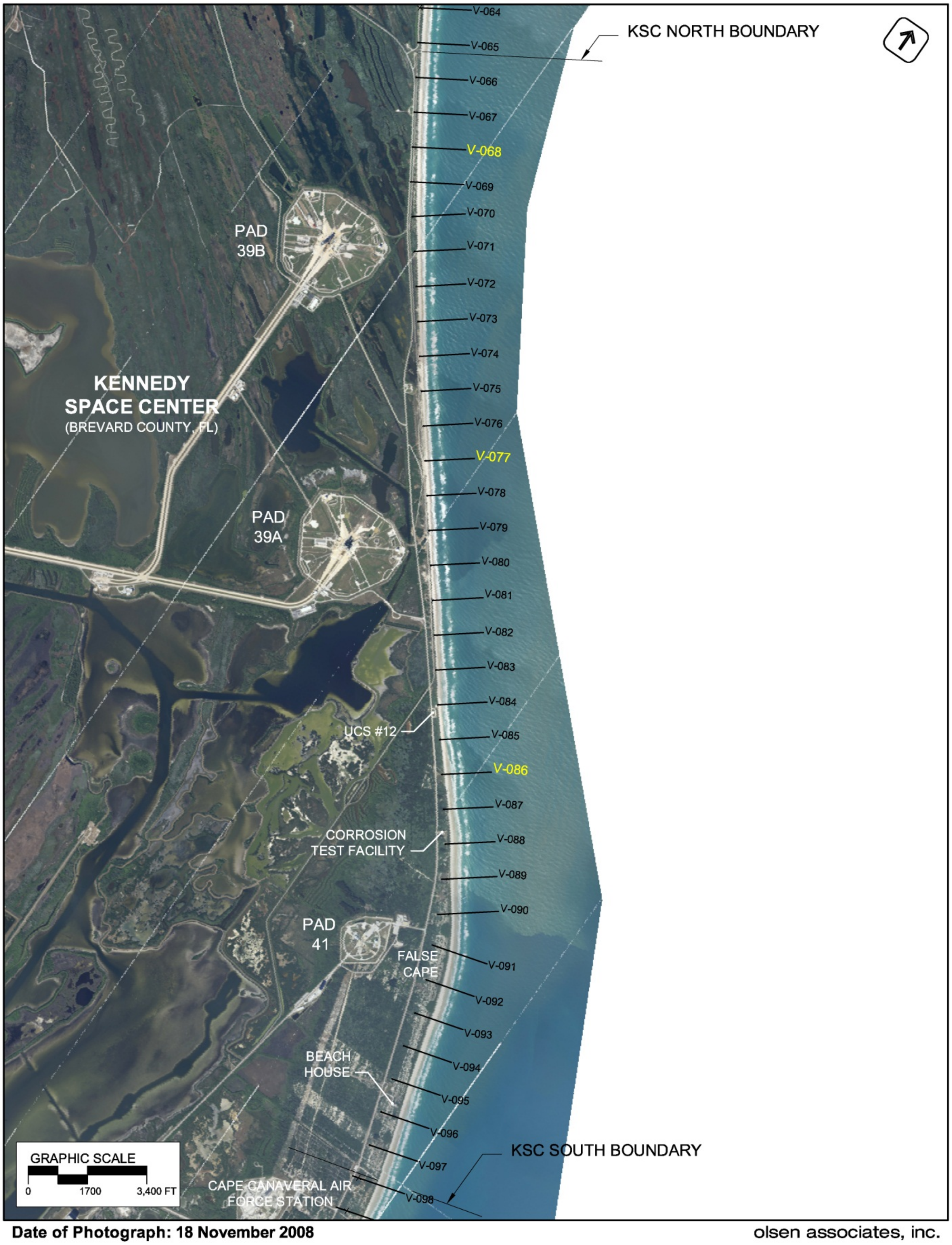

Figure 2-1: Kennedy Space Center, Florida ocean shoreline. Native beach sediment samples were collected along transect locations V-068, V-077, and V-086.

collected by Morgan & Eklund of Wabasso, FL, and analyzed for grain size distribution, carbonate content and color by Scientific Environmental Applications, Inc. (SEA) of Melbourne, FL. Along each transect, sand samples were collected along seven general elevations: (1) dune, (2) berm, (3) high water line, (4) low water line, (5) -8 ft, (6) -13 ft, and (7) -18 ft NAVD88 contours. [1] Two samples each were collected at the dune, berm and high water line, and each pair was then averaged to characterize the dune, berm and high water line.

As detailed in **Section 5** near the end of this report, composite grain size distributions were formed for each profile (i.e., average of the seven sampled elevations from the dune to -18' depth for each individual profile) as well as for each elevation (i.e., average for each of the seven elevations among the three profiles). The upper beach composite was formed by averaging the dune, berm and high water line composites. The overall native composite was formed by averaging the three profile composites -- or by averaging the seven elevation composites (the resultant overall native composite curve is identical for each method). **Figure 2-2** depicts the composite grain size distributions for the native beach sediments, developed in this manner.

Listed below are the sediment characteristics of the native beach determined from this investigation. The grain size statistics are computed from the overall native composite distribution. The overall mean and standard deviation were computed using formulas outlined in the Coastal Engineering Manual (CEM, 2008).

- USCS Classification: SP (one sample was SW)
- Median (d_{50}): 0.20 mm -- *range 0.11 to 0.54 mm*
- Mean: 0.22 mm -- *range 0.12 to 0.49 mm*
- Standard Deviation: 1.02 φ -- *range 0.41 to 1.28 φ*
- Fines Content (passing #230): 1.0% -- *range 0.1 to 1.5%*
- Gravel Content (retained on #4): less than 0.1% -- *range 0.0 to 0.2%*
- Carbonate Content: 15.1% -- *range 5.3 to 37.9%*
- Munsell Color (moist): typical 10YR 7.5/1.0 -- *range 10YR 7.0/1.0 to 10YR 8.5/1.5*

[1] The NAVD88 datum is about 3.3 ft above Mean Lower Low Water, such that the latter three samples are from about -4.7, -9.7, and -14.7 ft MLLW; i.e., the active nearshore seabed. The typical depth of profile closure for average-annual conditions, based upon annual changes between surveyed beach profiles in Brevard County is about -17.4 ft NAVD, or -14.1 ft MLLW.

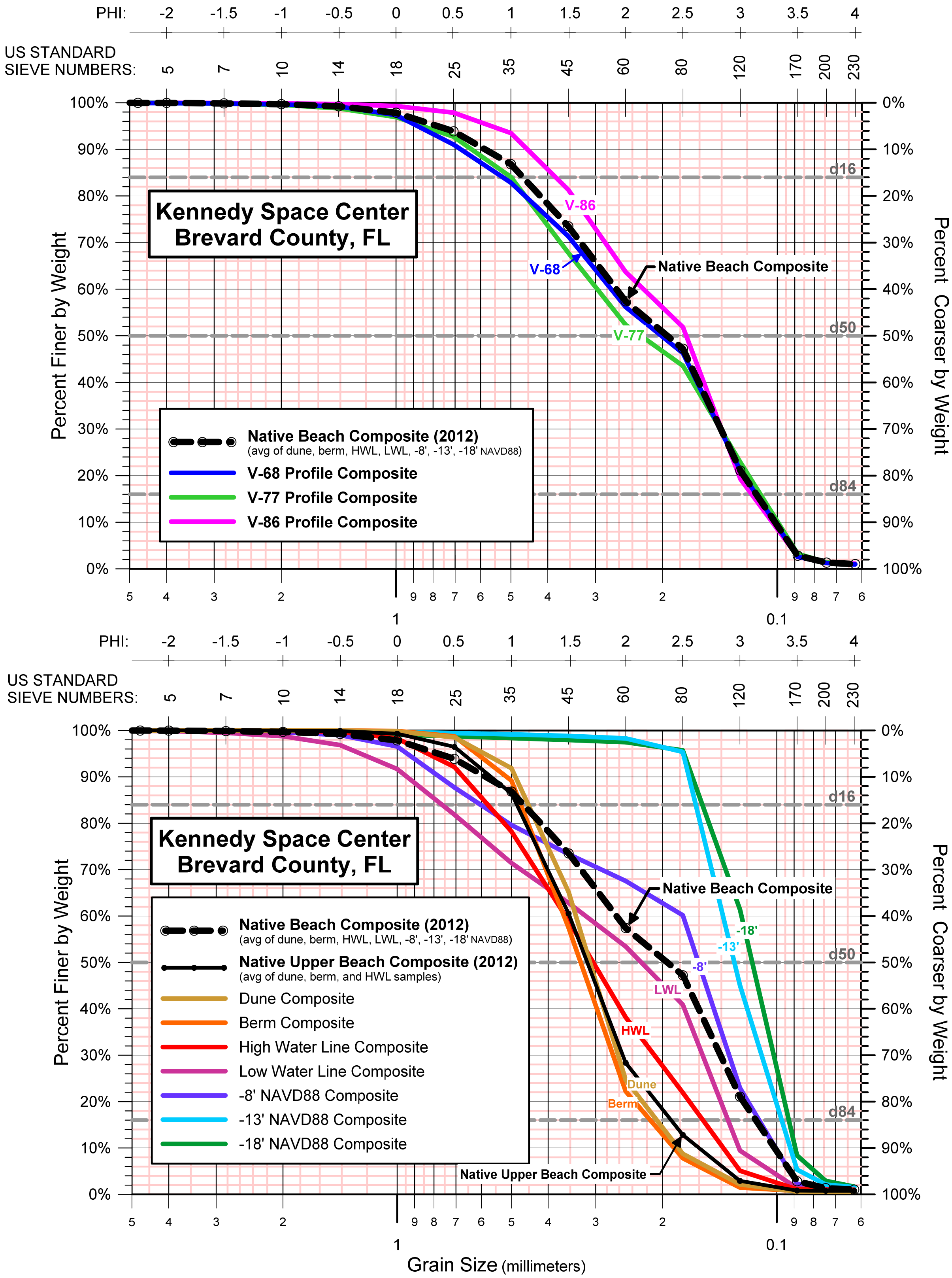

Figure 2-2: Summary native beach grain size distribution, Kennedy Space Center, FL.

3.0 OFFSHORE BORROW AREAS

The nearshore seabed in the vicinity of the Kennedy Space Center presents abundant potential for economical, beach-compatible sand borrow areas – probably the greatest along Florida's entire coastline. See ***Figures 3-1 and 3-2***, below. There are two existing, permitted sand borrow areas within about 16 nautical miles of KSC -- Canaveral Shoals I and II – located southeast of Cape Canaveral. ***Figure 3-3*** depicts the locations of these two borrow areas relative to KSC and the Brevard coastline.

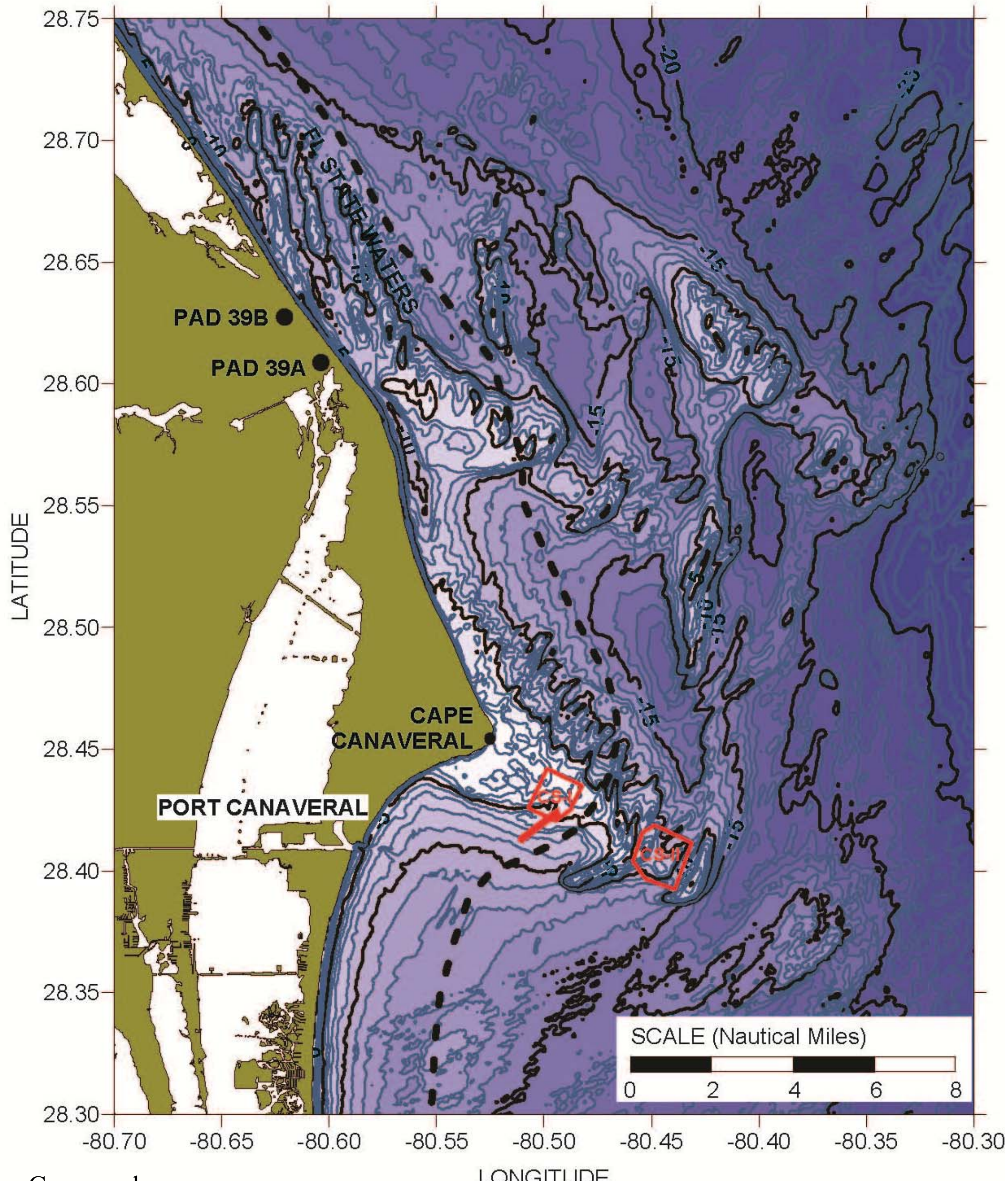

Figure 3-1:
Seabed bathymetry, Canaveral
Shoals I and II borrow areas, and locations of KSC
Launch pads 39A and 39B. Depths in meters, MLLW; various data sources.

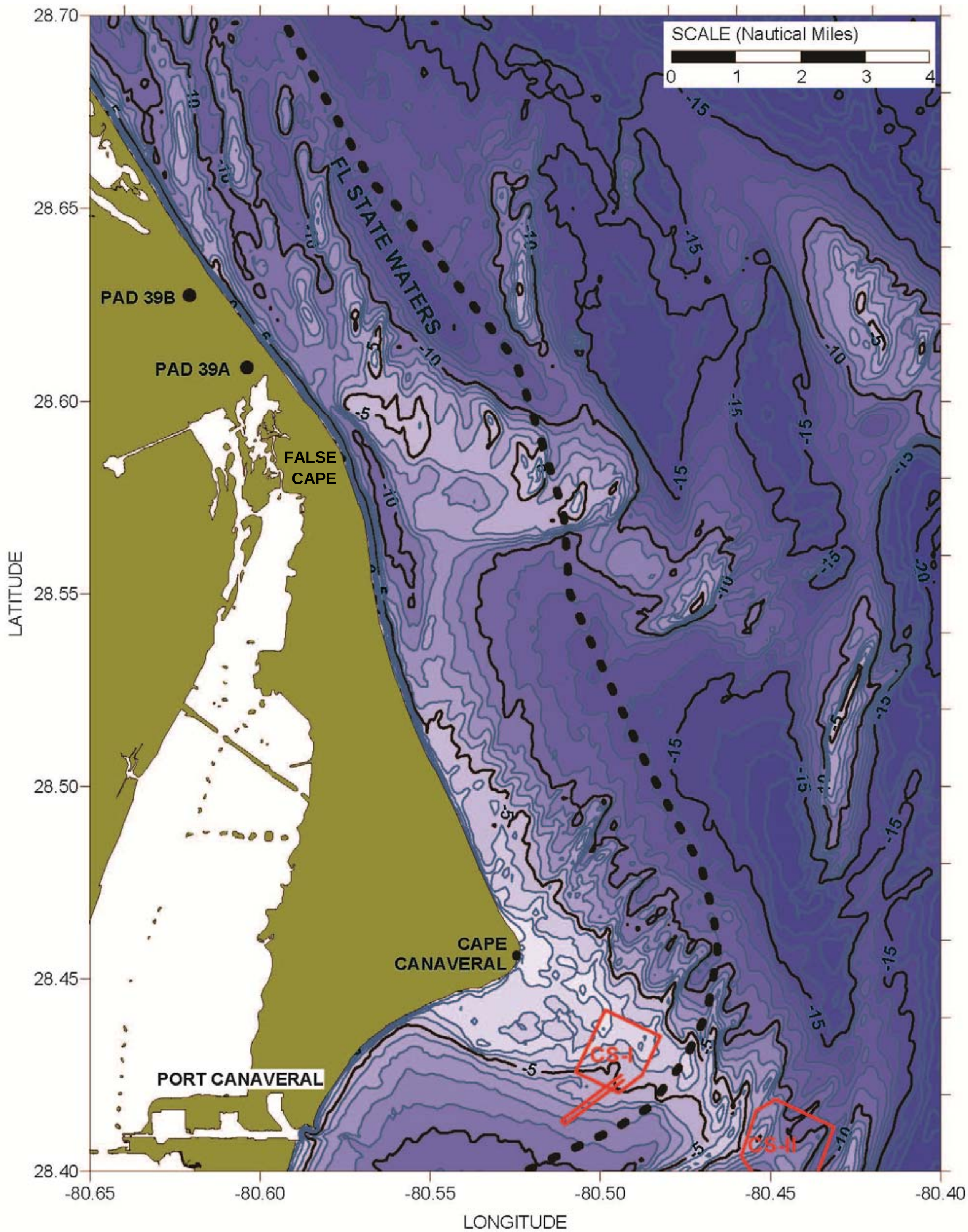

Figure 3-2: Approximate nearshore bathymetry in vicinity of Kennedy Space Center; depths in meters, MLLW. Canaveral Shoals I and II borrow areas indicated at bottom of figure. The locations of launch pads 39A and 39B are indicated at KSC.

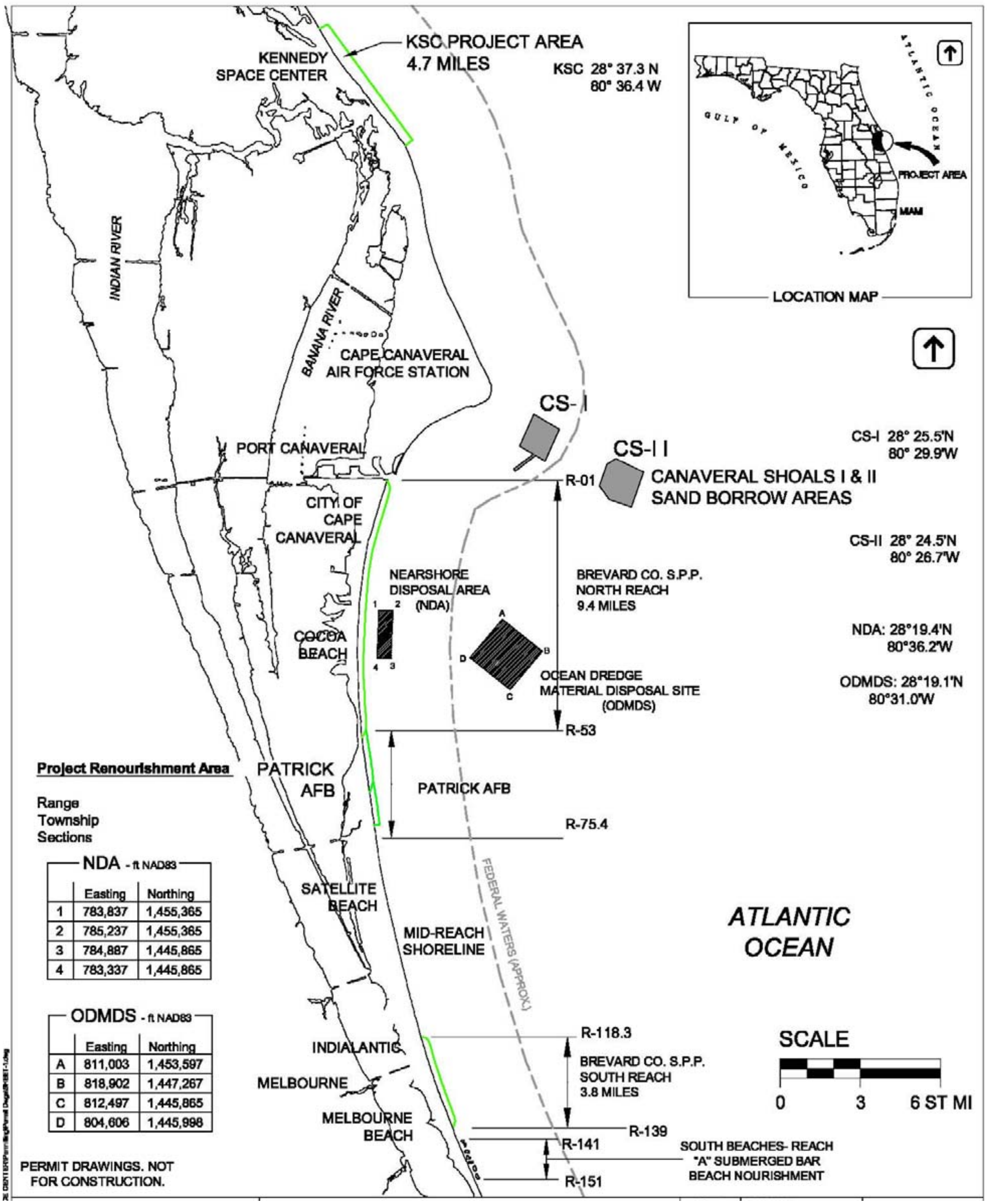

Figure 3-3: Location of CS-I and CS-II borrow areas, nearshore disposal area, and ODMDS.

3.1 Canaveral Shoals II Borrow Area

The Canaveral Shoals II (CS-II) borrow area is located in federal waters on the Outer Continental Shelf (OCS), approximately 5 nautical miles southeast of the tip of Cape Canaveral. It is about 15.5 nautical miles south-southeast of the KSC project area shoreline, or about 17 nautical miles by one-way sailing distance. **Figure 3-4** delineates the CS-II borrow area.

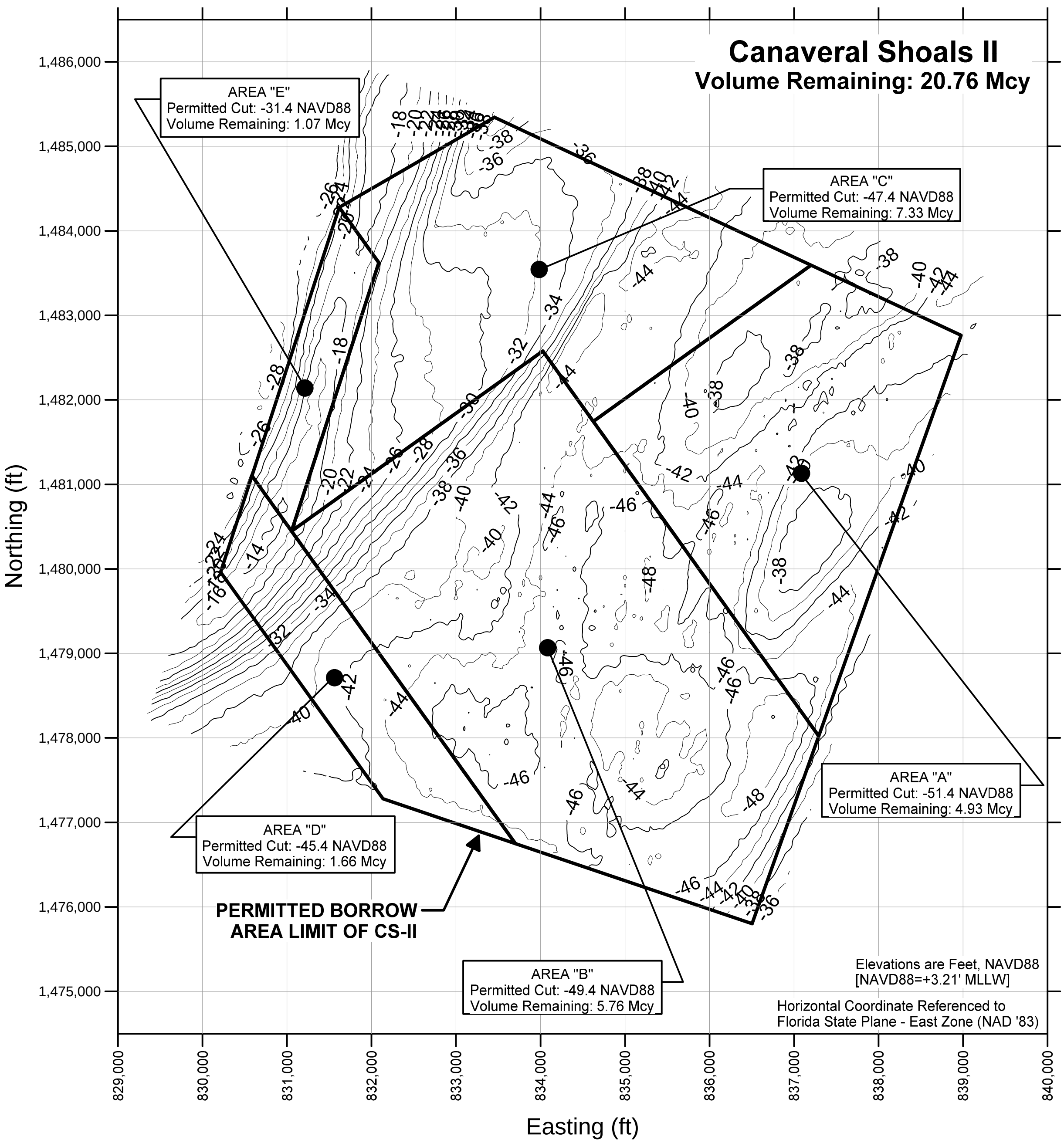

Figure 3-4: Canaveral Shoals II (CS-II) permitted offshore borrow area. May 2014 survey, subsequent to 2013/14 dredging for Brevard County Shore Protection Project renourishment.

Figure 3-5 compares the pre- and post-dredging bathymetry of the CS-II borrow area associated with the 2013/14 renourishment of the Brevard County Federal Shore Protection Project. The post-dredging bathymetry illustrates that the overall structure and rugosity of the seabed is equivalent to or greater than that of the pre-dredging bathymetry (OAI, 2014).

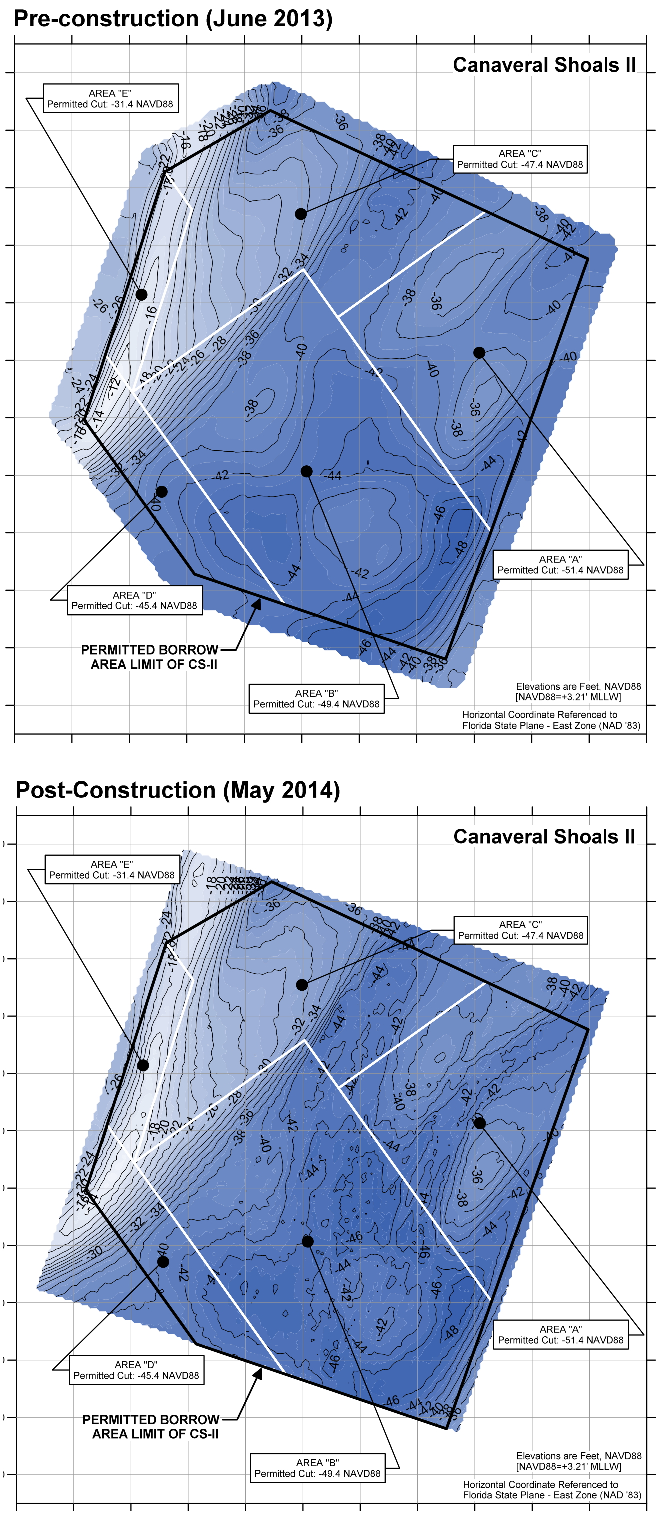

Figure 3-5: Bathymetry of the CS-II seabed prior to and after the most recent dredging of the borrow area for the 2013/14 renourishment of the Brevard County Federal Shore Protection Project. Contours in 2-ft intervals relative to NAVD'88.

Ambient seabed depths across CS-II range from about -13 ft to -45 ft, MLLW[2]. The limits of the borrow area, approximately 1233.4 acres in overall size, are divided into five sub-regions with varying dredge (cut) depths of -31.4 to -51.4 feet, NAVD88. Following the most recent dredging of CS-II in Nov 2013-April 2014, there is approximately 20.76 million cubic yards (15,884,000 m^3) of sediment remaining within the permitted excavation limits (OAI, 2010, 2014). Approximately 9.3 million cubic yards of sediment has been dredged from the CS-II borrow area for purposes of beach nourishment in Brevard County on multiple prior occasions since the borrow area's development in 1998-99. These dredge events include the

- initial construction of the Brevard County Federal Shore Protection Project (BCSPP) North Reach in 2000-01 and South Reach in 2002-03,
- initial construction of Patrick AFB shore protection in 2000-01,
- renourishment of the BCSPP and Patrick AFB in 2005,
- renourishment of the BCSPP South Reach in 2010, and
- renourishment of the BCSPP North and South Reach in 2013-14.

For each of these projects, lease or similar agreements for the use of sand from CS-II were executed between the Bureau of Ocean Energy Management (BOEM, formerly Minerals Management Service) and the U. S. Army Corps of Engineers, Brevard County, and/or 45th Space Wing United States Air Force (45SW/USAF). Use of the CS-II borrow area by the KSC will require a similar lease or memorandum-of-agreement between BOEM and NASA/KSC, similar to the two-party agreements between BOEM and the 45SW/USAF.

The CS-II borrow area was investigated for cultural resources by the USACE during its initial development (Watts 2001) and most recently updated in 2014 (Panamerican 2014). From the latter, no magnetic anomalies and no sonar contacts were located in the previous or updated surveys that represent potentially significant cultural resources in the form of shipwrecks. The most recent (2014) survey identified four (4) magnetic anomalies and targets to be avoided within the CS-II borrow area, thought to potentially represent rocket cylinders. In 2014, the USACE updated its identified dredge exclusion areas in CS-II, to be described by a 200-ft radial buffer around the following four (4) coordinates:

Table 3-1: Canaveral Shoals II Magnetic Anomalies (2014)

ID	Easting (ft, NAD83)	Northing (ft, NAD83)
m35	836,039	1,482,530
m47	837,485	1,480,862
m57	831,766	1,482,563
m61	832,730	1,481,664
MAINTAIN 200 FT AVOIDANCE RADIUS ABOUT EACH POINT.		

[2] The CS-II area was developed in 1998 by OAI for Brevard County, after OAI pointed out that the CS-I borrow area developed by the Corps for the Brevard Shore Protection Project was too far offshore for a cutterhead dredge and too shallow for a hopper dredge. OAI developed the access lane to CS-I at the same time as the CS-II area.

From core boring data and inspection of the sand placed onto Brevard County's beaches since 2000, the sediment contained in the CS-II borrow area is of consistent, excellent compatibility with the KSC beach and broader Brevard coastline. Comparison of the typical (average) grain size distribution of sediment from CS-II and the native KSC beach is shown in **Figure 3-6**. The median grain size of the CS-II borrow area ranges from about 0.3 to 0.4 mm (about 0.34 mm on composite-average). The mean grain size typically ranges from about 0.4 to 0.45 mm (three-point mean) but may locally vary between about 0.3 and 0.55 mm. Fine sediment content is low, typically less than 2% finer than the #200 and #230 sieves. The coarse fraction is less than 5% (retained on #4 sieve). The typical carbonate content is about 30% and with individual samples generally ranging between about 20% and 48%. The Munsell color (value/hue) is typically 6.5/1 to 7/1.

The overfill ratio is used to estimate the volume of additional sand that should be placed with the beach fill to compensate for textural differences between the borrow (fill) sediments and the native beach sediments. The overfill ratio computed for the CS-II borrow area relative to the KSC beach is 1.00 (perfect) – meaning that the borrow material is as coarse or coarser than the native beach; i.e., losses due to "finer-sediments" content are negligible. This reflects both the SPM/J-K method (Krumbein and James, 1965; James 1974, 1975) and the Dean method (Dean 1974), using the approaches outlined in the CEM (2008) and Bodge (2006), respectively.

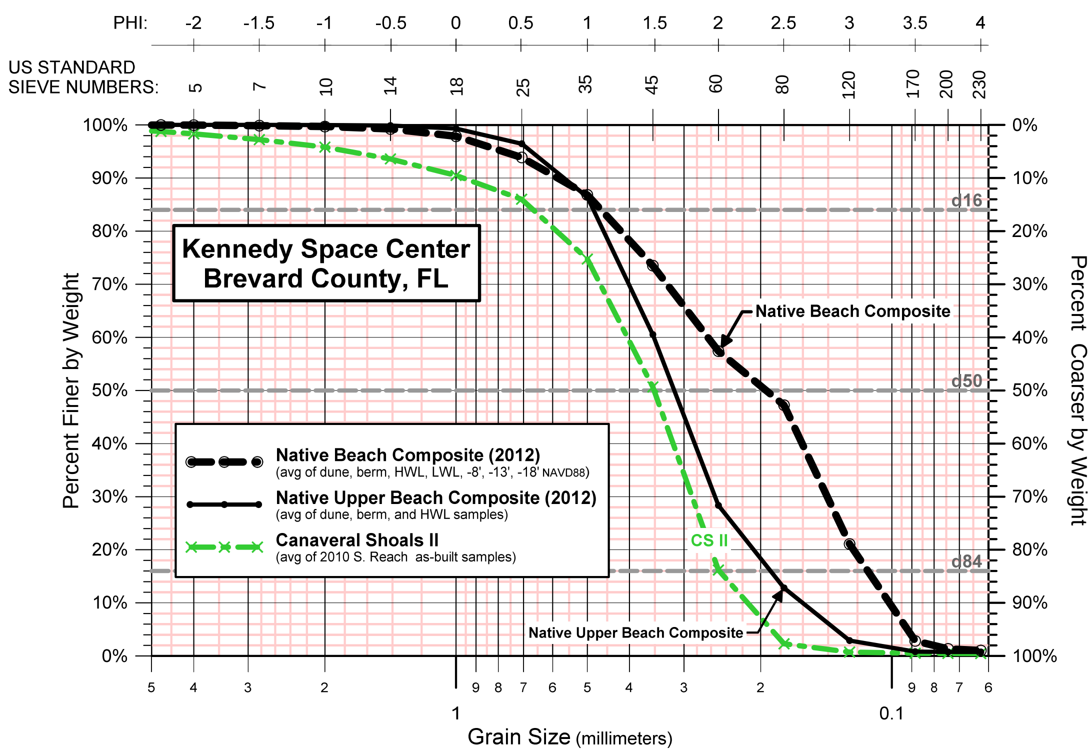

Figure 3-6: Comparison of the average (composite) sediment grain size data from CS-II offshore borrow area and native KSC beach.

OAI (2014) compared the weighted-composite grain size distributions of the sediments remaining within the CS-II borrow area limits between pre-dredge conditions (1998) and the most recent post-dredge conditions (May 2014). Despite the removal of 9.3 Mcy of sediment from the borrow area since the original 1998 composite, the comparison indicated negligible change in the computed overall grain size distribution of the remaining sediment as of May 2014. This was attributed to the observations that (i) the prior excavations affected less than 30% of the borrow area volume, and (ii) the sediment within the borrow area appears to be fairly uniform (OAI 2014).

3.2 Canaveral Shoals I Borrow Area

The Canaveral Shoals I borrow area is located approximately 2.5 nautical miles southeast of the tip of Cape Canaveral. While it appears closer to KSC than CS-II by 2 or 3 miles, CS-I is actually the same sailing distance from KSC – about 17 nautical miles, one-way – because of the need to navigate around the shallow shoals that define False Cape and Cape Canaveral. **Figure 3-7** details the permitted limits of the CS-I borrow area and access lane.

Ambient seabed depths across CS-I range from about -8 to -18 ft MLLW. The borrow area limits, approximately 1 square nautical mile in size, are divided into five sub-regions with varying dredge (cut) depths of about -22.3 to -30.3 ft. Because of the shallow ambient depths of the borrow area, a 5300-ft long by 500-ft wide dredge access lane has been identified for this site. The total size of the CS-I borrow area and access lane is 889.1 acres. The access lane has been permitted for excavation to -30.3 ft NAVD'88 (-27 ft MLLW). Sediment dredged from the access lane above -26.3 ft is proposed for beach fill (if compatible and containing and less than 5% fines), or nearshore disposal (if containing less than 20% fines), or otherwise offshore disposal to the Canaveral Offshore Dredge Material Disposal Site (ODMDS).

A total of approximately 16 million cubic yards (12,242,000 m^3) of sand is available from within the permitted limits of the CS-I borrow area. This borrow area has not been previously dredged. Use of CS-I to construct shore protection at KSC would be incorporated to the project through State and federal permits issued by FDEP and USACE, and a State Lands easement to KSC from FDEP. Because CS-I has not been previously dredged (unlike CS-II), it has been suggested by National Marine Fisheries Service (NMFS) that some baseline pre-dredge survey for infauna/biota at the site may be appropriate, prior to the first use of CS-I.

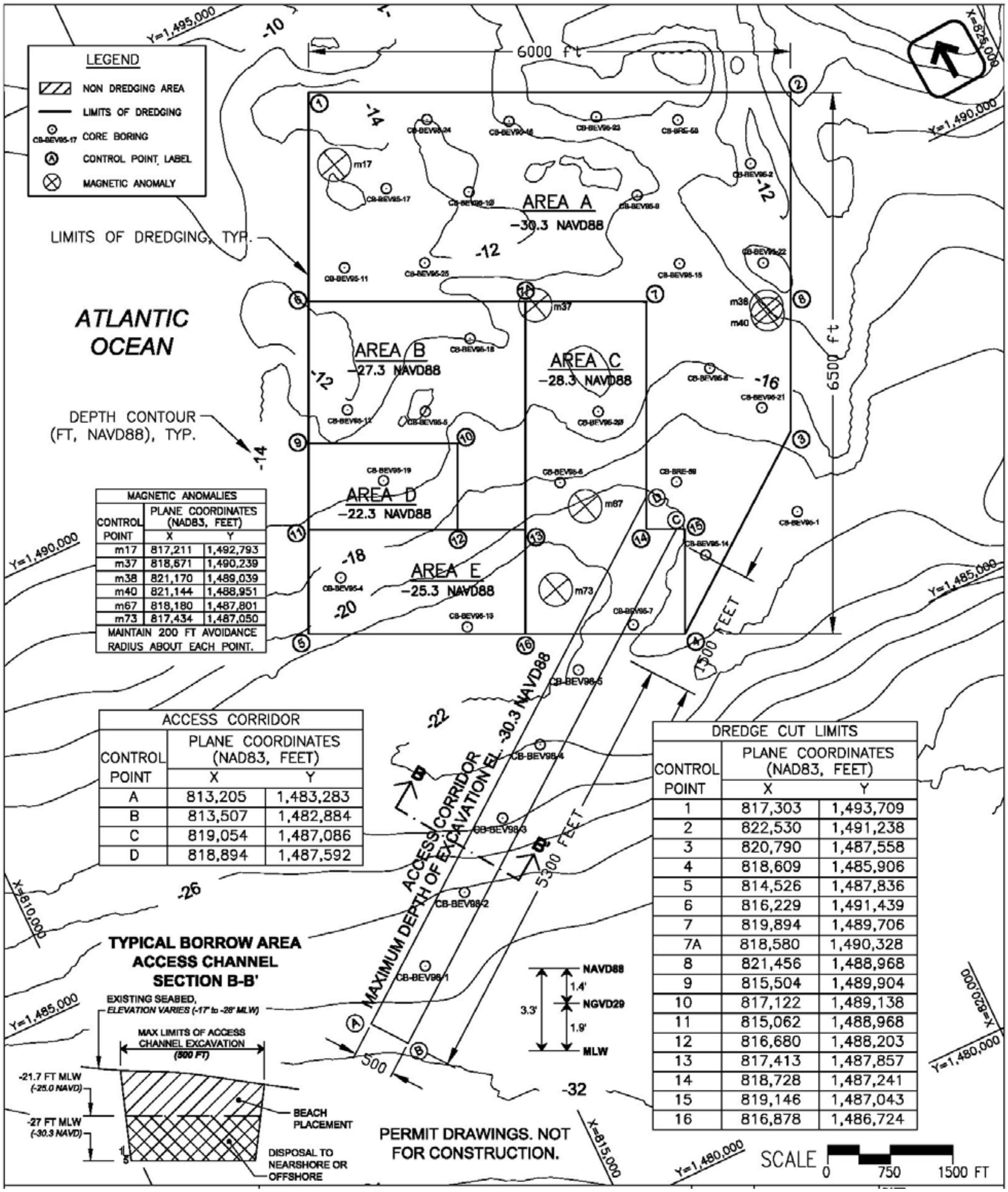

Figure 3-7: Canaveral Shoals I (CS-I) permitted offshore borrow area.
[From Brevard County Shore Protection Project, North Reach: FDEP Permit 0134869-009-JC]

The CS-I borrow area and access lane was investigated for cultural resources by the USACE during its initial development (Watts 2001) and most recently updated in 2014 (Panamerican 2014). From the latter, no magnetic anomalies and no sonar contacts were located in the previous or updated surveys that represent potentially significant cultural resources in the form of shipwrecks. The most recent (2014) survey identified six (6) magnetic anomalies and targets to be avoided within the CS-I borrow area, thought to potentially represent rocket cylinders. In 2014, the USACE identified dredge exclusion areas in CS-I described by a 200-ft radial buffer around the following six (6) coordinates:

Table 3-2: Canaveral Shoals I Magnetic Anomalies (2014)

ID	Easting (ft, NAD83)	Northing (ft, NAD83)
m17	817,211	1,492,793
m37	818,671	1,490,239
m38	821,170	1,489,039
m40	821,144	1,488,951
m67	818,180	1,487,801
m73	817,434	1,487,050
MAINTAIN 200 FT AVOIDANCE RADIUS ABOUT EACH POINT.		

The median grain size of the CS-I borrow area ranges from about 0.18 to 0.3 mm (about 0.27 mm on composite-average). The mean grain size is about 0.33 mm (three-point average). Fine sediment content is variable but typically less than 5% to 3% finer than the #200 and #230 sieves, respectively. The coarse fraction is less than 5% (retained on #4 sieve). Comparison of the composite grain size distribution of sediment from CS-I and the native KSC beach is shown in **Figure 3-8**. Specific Munsell color values and carbonate content from the CS-I borrow area core samples, collected by the Corps of Engineers in 1995-98, are not available.

The overfill ratio computed for the CS-I borrow area relative to the KSC beach is between 1.00 and 1.02, for the Dean and James-Krumbein methods respectively – meaning that the borrow material is basically as coarse or coarser than the native beach, and that only 0% to 2% allowance for losses due to "finer-sediments" is recommended. Both the CS-I and CS-II material is coarser than the overall native beach sediment. While the CS-II material is *coarser* than the native berm/upper beach, the CS-I material is *slightly finer* than the native berm/upper beach. This suggests that both the CS-I and CS-II borrow area sediments are compatible with the native beach and berm, but that the CS-II sediment may exhibit *slightly greater stability* (resistance to erosion) than the CS-I borrow area sediment.

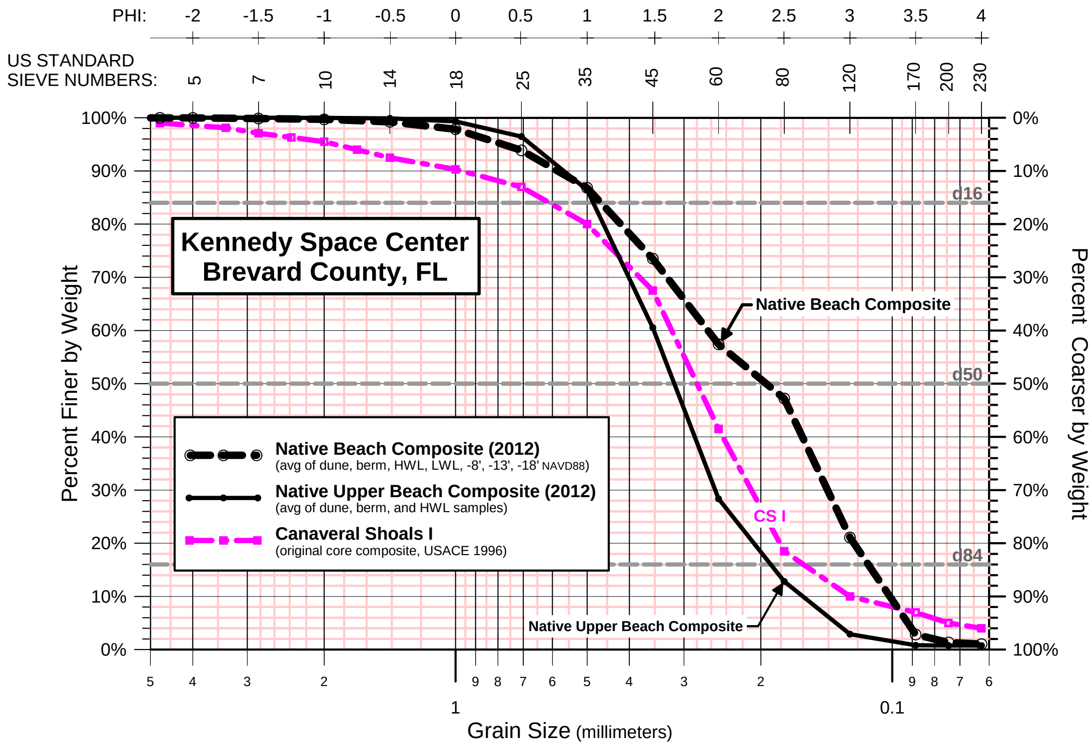

Figure 3-8: Comparison of the average (composite) sediment grain size data from CS-I offshore borrow area and native KSC beach.

Nearshore and Offshore Disposal Areas. Use of the CS-I offshore borrow area may require dredging of the CS-I access channel (see prior pages 11-12). Material dredged from the access channel that contains less than 5% fine sediment and is otherwise beach-compatible may be placed as beach fill. Dredged material that contains less than 20% fine sediment may be placed to an existing nearshore disposal area (NDA) offshore of Cocoa Beach, subject to FDEP and USACE permit. Dredged material that contains more than 20% fine sediment must be placed to an offshore disposal area: specifically the Canaveral Offshore Dredge Material Disposal Site (ODMDS) subject to approval by the USEPA and the Corps of Engineers. The latter requires a Section 103 evaluation prepared for the USEPA and incorporation of the approval and conditions for dredge-disposal to the ODMDS in the Department of the Army (USACE) permit for the project. The locations of the NDA and ODMDS are indicated in ***Figure 3-3***, previous page 7.

3.3 Other Offshore Borrow Areas

The only other offshore borrow area developed and permitted for dredging and beach nourishment in the general vicinity of KSC is the Space Coast Shoals II borrow area, located southeast of Patrick AFB. This area was dredged for construction of the BCSPP South Reach in 2002, exhausted of sediment, and is no longer available as a sand source.

There appear to be numerous potential opportunities to develop offshore sand sources in the immediate vicinity of the Kennedy Space Center shoreline. Reference to ***Figure 3-2***, on page 6 of this report, indicates abundant shoals that are located *within 1.5 to 2.5 nautical miles* of the KSC shoreline where beach/dune erosion is most severe; i.e., between launch pads 39A and 39B. If beach-compatible sediment of at least several feet thickness is found to reside in these areas – which is likely -- this represents the potential for very significant savings in construction costs. Specifically, a borrow area within less than about 3 to 3.5 miles of the shoreline is a ready candidate for an oceangoing cutterhead/pipeline dredge[3]. In contrast, use of the existing Canaveral Shoals I or II borrow areas requires the use of a hopper dredge, with a round-trip sail-distance of 34 nautical miles per load.

The unit cost to move sand by a cutterhead/pipeline dredge (or a hopper dredge) from within a few miles of shore may likely be at least one-third to one-half less than the unit cost of a hopper dredge from Canaveral Shoals. Assuming a fill project of about 1,400,000 cubic yards, a semi-uniform mobilization cost of about \$2.9M (regardless of the borrow area), and a unit cost of about \$11.50/cy, the hopper dredge cost using Canaveral Shoals may be on the order of about \$19M. The same project using a borrow area within a few miles of KSC may be on the order of about \$13.2M to \$14.2M – or a third less than Canaveral Shoals – saving on the order of \$5M.

The cost to develop and permit a new offshore borrow area is typically about \$0.7M to \$1M. So, even during the first use of the new borrow area, the net savings can be very significant – in this example, being on the order of \$4M net cost-savings for a \$1M investment in developing the borrow area. There is, of course, risk that a borrow area cannot be developed because of inadequate sediment or cultural resources; but in this instance, it is highly likely that suitable borrow areas exist that can be used without significant adverse impact to the seabed, shore or resources. The greater risk is the use of the cutterhead dredge in open seas, far from the Port Canaveral harbor, in non-summer months – for which some economic cost (risk) is borne.

A practical borrow area must be in ambient depths of at least 6 to 10 meters MLLW (for cutterhead and hopper dredge access, respectively) and of adequate bank-cut thickness and physical sailing size (for cutterhead dredges and hopper dredges, respectively) to be useful and economical. These considerations are made during proper engineering investigation and

[3] A borrow area greater than 3+ miles away can also be cut by cutterhead, but usually requires a booster pump.

development of a new borrow area. Development of a borrow area within 3 nautical miles of shore may be preferred in order to keep the site within State of Florida waters. This appears possible at the KSC location. Siting the borrow area within State waters can obviate some costly, time-consuming restrictions on the development, permitting, and use of the borrow area that are otherwise associated with the use of borrow areas in federal waters.[4]

4.0 UPLAND SAND SOURCES

Upland sand sources for dune construction may include commercial quarries and other available, permitted sites that contain sediment demonstrated to be of compatible quality with the native KSC dune and beach, and to meet the State of Florida "sand rule" FAC 62B-41.007(2)(j) if sand will be placed below the Mean High Water Line at KSC. The availability and quality of upland sources vary with time because existing sources are mined and new sources and excavation projects continually arise. Accordingly, upland sources for project implementation should be specifically identified and evaluated for suitability prior to construction.

In the recent past, upland sources for beach and dune nourishment in Brevard County have included numerous sites, each of which have successfully resulted in placement of beach-compatible material. A partial list of these sources includes the following.

1. Port Canaveral Cruise Terminal Excavation – Source of beach nourishment placed along the City of Cape Canaveral in 1993. This source was depleted after construction of the cruise terminals; however, it is typical of local excavation projects that periodically produce beach-quality sand.
2. Poseidon Dredge Material Management Area (Port Canaveral/CCAFS) – Source of beach and dune nourishment placed along PAFB in 1998. This site is currently depleted and not available. The site is proposed for continued future use of dredge disposal for Canaveral Harbor and the US Navy, and for possible stockpiling of sand from offshore borrow areas by the USACE for transfer to the Brevard County Mid-Reach shoreline; however, that sand stockpile will not be available to KSC.
3. Fischer Sand 77th Street (Indian River County) – Commercial mining operation that has provided beach quality sand for 2005 Brevard County dune restoration and other projects conducted by Indian River County and Sebastian Inlet Tax District.

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[4] Sand and other mineral borrow areas in federal waters (Outer Continental Shelf, or OCS) are managed by the Department of Interior, Bureau of Ocean Energy Management (BOEM). Despite cooperative effort and recent initiatives by BOEM, there are numerous federal requirements for OCS borrow sites that do not apply in State of Florida waters. For instance, exploratory coring and surveys to identify and develop the sand borrow area require prior federal approval (versus none in State waters). Use of the borrow area requires an EA developed in cooperation with BOEM and a lease agreement with BOEM.

4. Pence Pit 6 (Palm Bay) – Commercial sand mine.
5. Cape Canaveral Air Force Station (CCAFS) - Upland beach north of Canaveral Harbor jetty. This on-beach source is permitted and was used as a sand source for beach/dune restoration at PAFB (2011 and 2014) as sand bypassing southward across the Canaveral Harbor Entrance. It is probably not available as a "backpassing" source for KSC, unless agreed by 45SW. [The sand along this beach, below the high water line, is periodically dredged and placed to the City of Cape Canaveral shoreline, by the USACE, as the Canaveral Harbor Sand Bypass Project.]
6. Port Canaveral Widening – Widening and deepening of the Canaveral Harbor Entrance channel to 46+2 ft is underway in 2014 and is anticipated to generate potentially beach-compatible material (from above -4.9 m [-16 ft] mean low water cut depth) for which disposal sites have not yet been confirmed.
7. Titan Road stockpile, CCAFS – Approximately 90,000 cy of sand stockpiled from an upland excavation project. The sand was used to construct post-Hurricane-Sandy dune repairs along KSC in Spring 2014. This source is depleted.
8. Central Sand Tico Pit (Titusville) – Principal source of dune restoration material placed by Brevard County in 2005 and 2006.
9. Fischer Sand Mine 99th Street (Indian River County) – Commercial sand mine, utilized in Brevard County 2009 dune restoration.
10. Ranch Road (82nd Avenue, Indian River County) – Commercial sand mine, utilized in Brevard County 2009 dune restoration.
11. Brian Davis Mine (7200 84th Ave., Vero Beach) – Commercial sand mine that provided sand for Brevard County 2014 dune restoration.
12. Rock Solid Rock, LLC Broadway Pits (Brevard County) – Commercial sand mine, utilized in Brevard County 2009 dune restoration.
13. Huntington Pit (JP Donovan). Stormwater pond excavation at Huntington Lakes II in City of Rockledge, FL; used by Brevard County for 2014 dune reparations. This source is depleted.
14. Cemex Gator Mine, Lake Wales Sand Mine, Davenport Sand Mine (Davenport and Lake Wales, FL) – Commercial sand mines.

Sand sources 8 through 14 were most recently included on FDEP's approved list of sand sources for dune restoration in Brevard County, south of Canaveral Harbor, as of Spring 2014 (as itemized in the Sediment Quality Assurance/Quality Control [QA/QC] Plan for FDEP Permit BE-1307 issued to Brevard County in August 2013.) Some, but not all, of these sources have been used by the County. Brevard County's dune restoration projects have used sand from sources 8 through 13, in addition to other storm-water excavation sites from which sand is no longer available. Numerous other sources are available, including additional commercial mines not listed above. Other sand sources are added to the list of approved sources for dune/beach fill placement, for use by Brevard County, pursuant to review and approval by FDEP, as opportunities and needs arise.

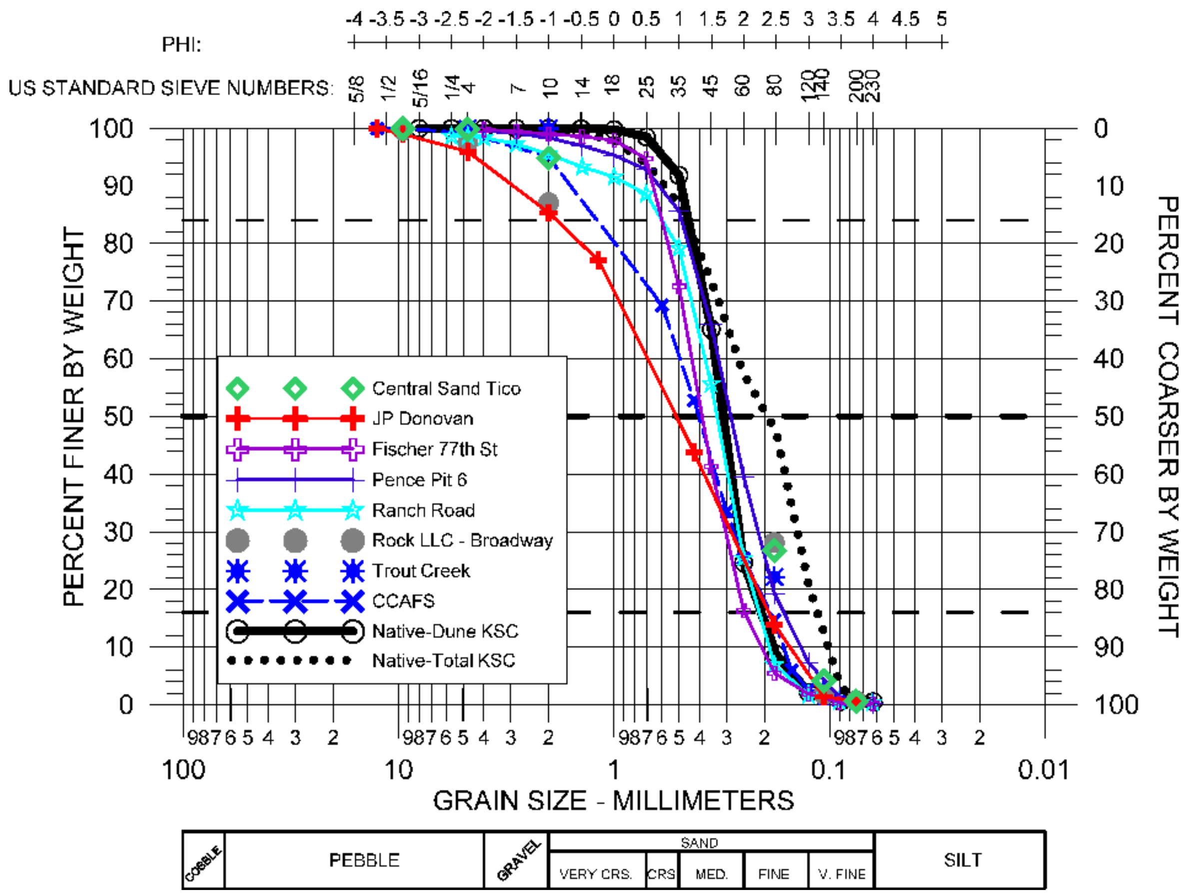

Figure 4-1: Typical grain size data from upland sand sources used in Brevard County, FL.

As noted, specific investigation of candidate upland borrow areas must be made just prior to initiating/soliciting construction of a project – due to the dynamic nature of sand supplies. The overfill ratio of the sources described above is typically about 1.0, but again, conditions vary and must be re-assessed for each candidate sand source and each specific project objective. Quality assurance & control measures must be prescribed and implemented for the import and placement of any sediment fill to the project area.

5.0 GRANULARMETRIC DATA (DETAIL)

The following pages summarize the grain size distribution (granularmetric) data describing the native beach sediments along Kennedy Space Center, the borrow area sediments of Canaveral Shoals I and II, and the overfill ratio of the borrow area sediments relative to the native KSC beach.

A comprehensive summary of the geotechnical data collected at Canaveral Shoals I and II, prepared by the US Army Corps of Engineers (USACE), is presented in the original version of this report dated June 2012 (OAI 2012). These data – including a brief narrative description, core boring logs, and grain size analysis from core samples – are routinely included in the USACE construction plans and specifications for the Brevard County Shore Protection Project, including those dated 18 September 2009 (Solicitation/Project: W912EP-09-B-0021).

Figure 5-1: Native Beach Samples (2012)

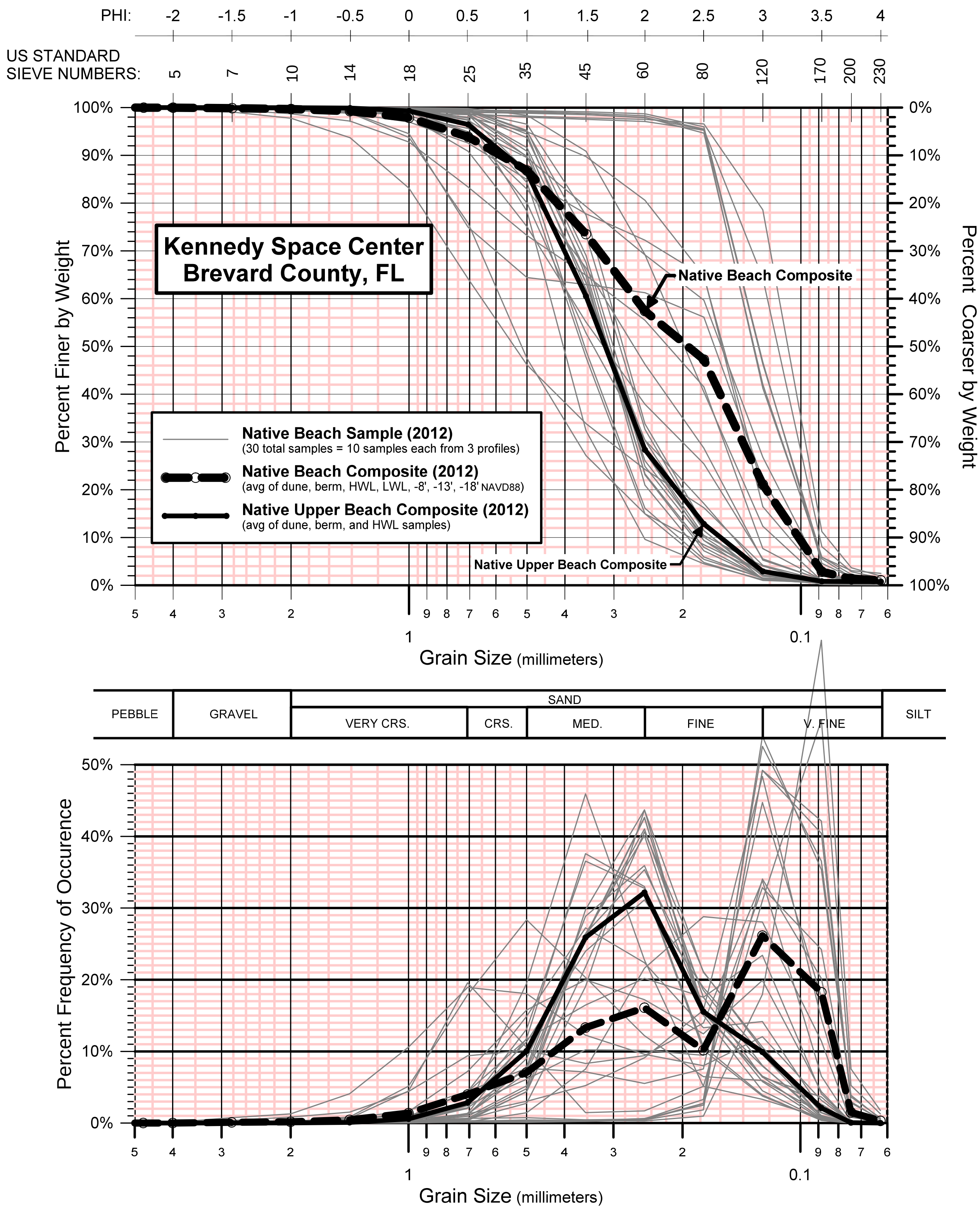

Figure 5-2: Native Beach Profile Composites

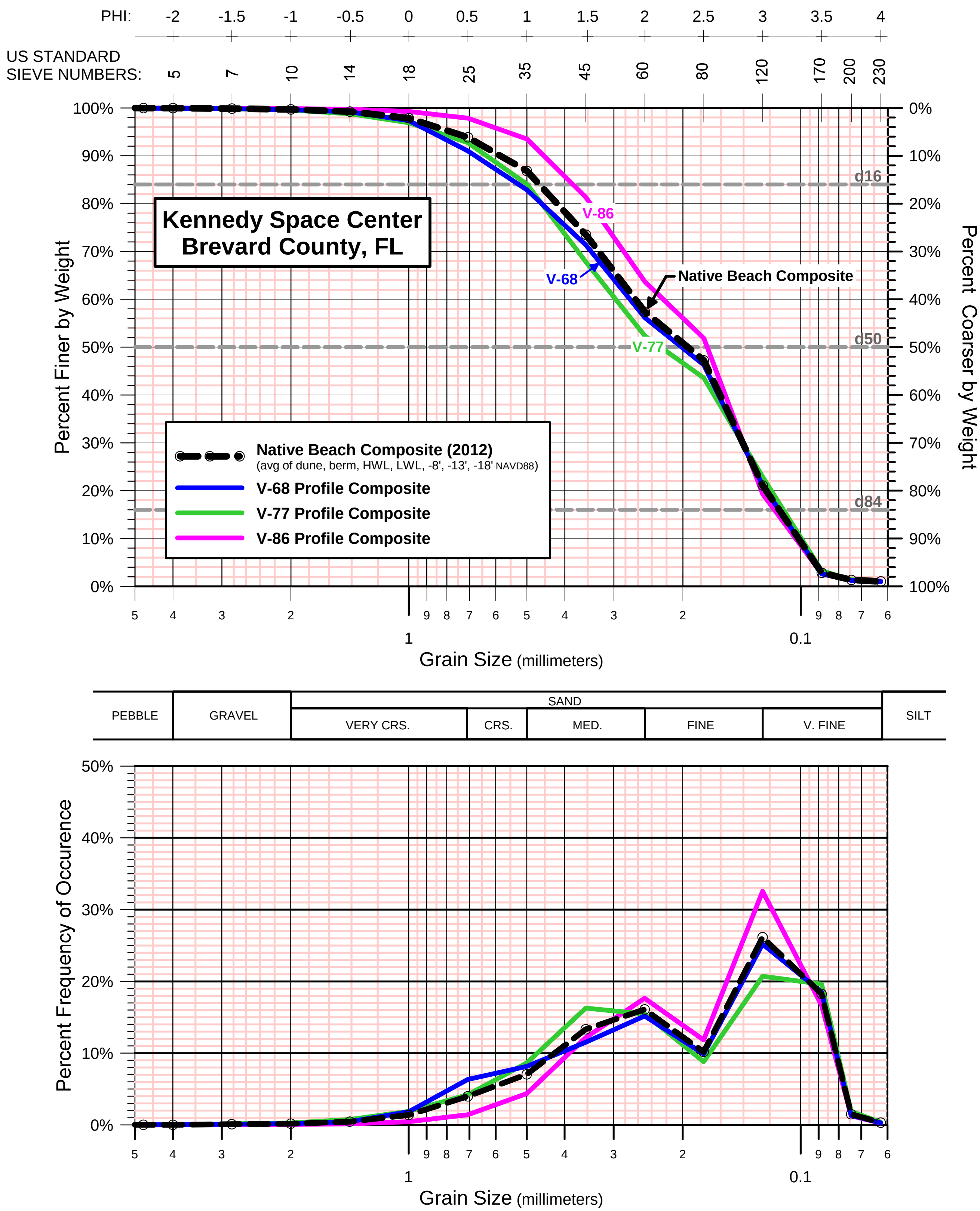

Figure 5-3: Native Beach Elevation Composites

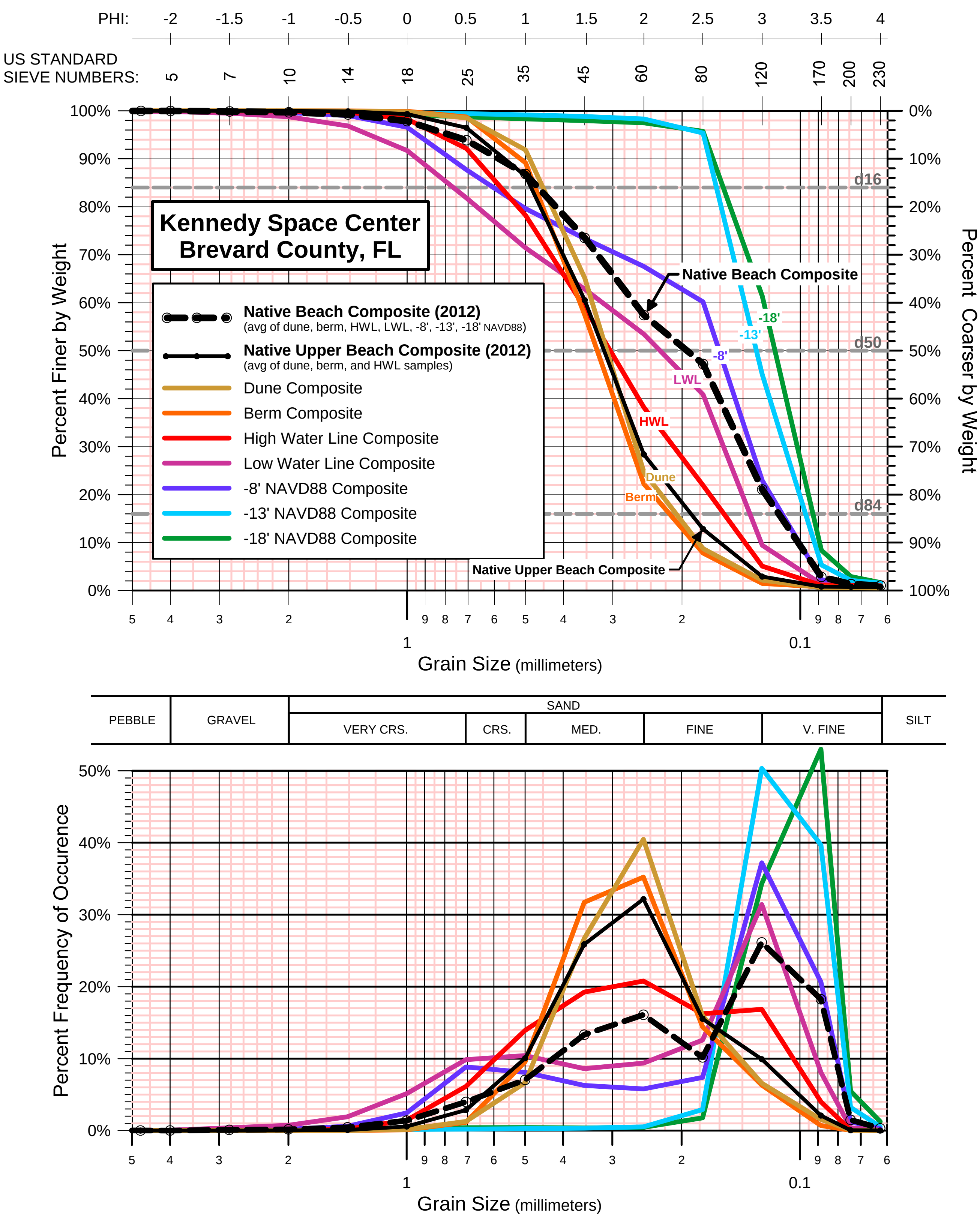

Figure 5-4: Native Beach and Borrow Area Composites

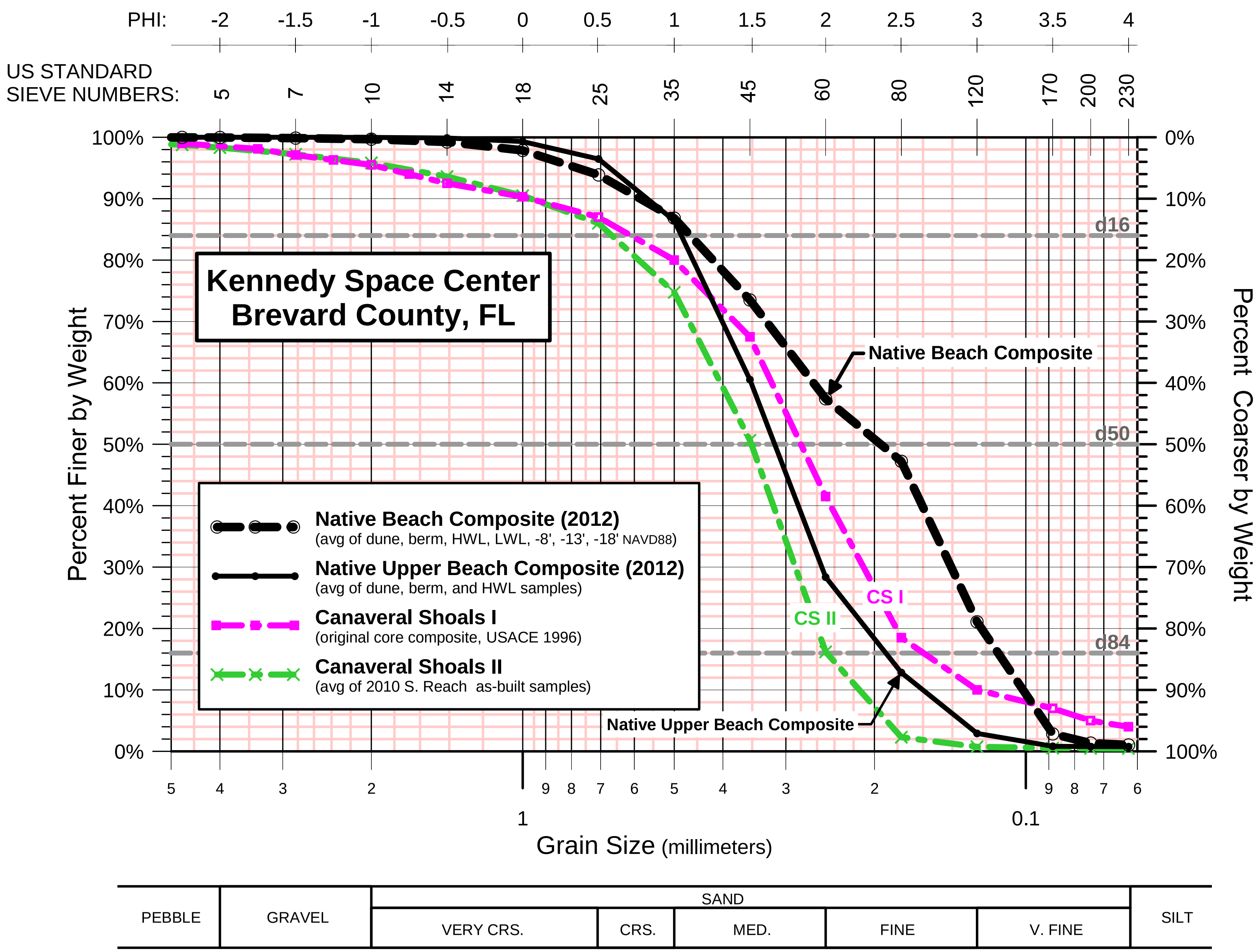

Table 5-1: Native Beach and Borrow Area Grain Size Distributions

Native Beach Composite (2012) (avg of dune, berm, HWL, LWL, -8, -13, -18' NAVD88)				
Sieve	**Size (in)**	**Size (mm)**	**Size (ϕ)**	**% By Weight Coarser Than**
5/16"	0.315	8.000	-3.0	**0.00**
3.5	0.223	5.657	-2.5	**0.01**
4	0.187	4.757	-2.25	**0.03**
5	0.157	4.000	-2.0	**0.04**
7	0.111	2.828	-1.5	**0.14**
10	0.079	2.000	-1.0	**0.31**
14	0.056	1.414	-0.5	**0.76**
18	0.039	1.000	0.0	**2.15**
25	0.028	0.707	0.5	**6.13**
35	0.020	0.500	1.0	**13.18**
45	0.014	0.354	1.5	**26.50**
60	0.010	0.250	2.0	**42.60**
80	0.007	0.177	2.5	**52.77**
120	0.005	0.125	3.0	**78.92**
170	0.003	0.088	3.5	**97.17**
200	0.003	0.074	3.75	**98.66**
230	0.002	0.063	4.0	**98.97**

Native Upper Beach Composite (2012) (avg of dune, berm, and HWL samples)				
Sieve	**Size (in)**	**Size (mm)**	**Size (ϕ)**	**% By Weight Coarser Than**
5/16"	0.315	8.000	-3.0	**0.00**
3.5	0.223	5.657	-2.5	**0.00**
4	0.187	4.757	-2.25	**0.00**
5	0.157	4.000	-2.0	**0.00**
7	0.111	2.828	-1.5	**0.01**
10	0.079	2.000	-1.0	**0.03**
14	0.056	1.414	-0.5	**0.12**
18	0.039	1.000	0.0	**0.69**
25	0.028	0.707	0.5	**3.54**
35	0.020	0.500	1.0	**13.59**
45	0.014	0.354	1.5	**39.48**
60	0.010	0.250	2.0	**71.64**
80	0.007	0.177	2.5	**87.18**
120	0.005	0.125	3.0	**97.09**
170	0.003	0.088	3.5	**99.19**
200	0.003	0.074	3.75	**99.24**
230	0.002	0.063	4.0	**99.25**

Canaveral Shoals I Offshore Borrow Area (original core composite, USACE 1996)				
Sieve	**Size (in)**	**Size (mm)**	**Size (ϕ)**	**% By Weight Coarser Than**
4	0.187	4.757	-2.25	**1.00**
6	0.132	3.364	-1.75	**1.90**
7	0.111	2.828	-1.5	**2.90**
8	0.094	2.378	-1.25	**3.70**
10	0.079	2.000	-1.0	**4.50**
12	0.066	1.682	-0.75	**6.00**
14	0.056	1.414	-0.5	**7.50**
18	0.039	1.000	0.0	**9.70**
25	0.028	0.707	0.5	**13.00**
35	0.020	0.500	1.0	**20.00**
45	0.014	0.354	1.5	**32.50**
60	0.010	0.250	2.0	**58.50**
80	0.007	0.177	2.5	**81.50**
120	0.005	0.125	3.0	**90.00**
170	0.003	0.088	3.5	**93.00**
200	0.003	0.074	3.75	**95.00**
230	0.002	0.063	4.0	**96.00**

Canaveral Shoals II Offshore Borrow Area (avg of 2010 S. Reach as-built samples)				
Sieve	**Size (in)**	**Size (mm)**	**Size (ϕ)**	**% By Weight Coarser Than**
7/16"	0.445	11.314	-3.50	**0.07**
5/16"	0.315	8.000	-3.00	**0.39**
3.5	0.223	5.657	-2.5	**0.96**
4	0.187	4.757	-2.25	**1.23**
5	0.157	4.000	-2.0	**1.69**
7	0.111	2.828	-1.50	**2.77**
10	0.079	2.000	-1.0	**4.18**
14	0.056	1.414	-0.5	**6.40**
18	0.039	1.000	0.0	**9.52**
25	0.028	0.707	0.5	**13.99**
35	0.020	0.500	1.0	**25.26**
45	0.014	0.354	1.5	**49.34**
60	0.010	0.250	2.0	**83.81**
80	0.007	0.177	2.5	**97.71**
120	0.005	0.125	3.0	**99.26**
170	0.003	0.088	3.5	**99.48**
200	0.003	0.074	3.75	**99.52**
230	0.002	0.063	4.0	**99.54**

Table 5-2: **Native Beach and Borrow Area – Overfill Calculation**

Native Beach Composite (2012) (avg of dune, berm, HWL, LWL, -8', -13', -18' NAVD88)						
	phi-05	phi-16	phi-50	phi-84	phi-95	
Grain Size Distribution	0.37	1.11	2.35	3.14	3.45	phi
Mean	2.20	phi				
Standard Deviation	1.02	phi				

Canaveral Shoals I (original core composite, USACE 1996)						
	phi-05	phi-16	phi-50	phi-84	phi-95	
Grain Size Distribution	-0.95	0.74	1.83	2.64	3.79	phi
Mean	1.74	phi				
Standard Deviation	1.27	phi				
(Mb-Mn)/Sn	-0.45					
Sb/Sn	1.24					
J-K Overfill Factor (R_A)	**1.02**					
(Mb-Mn)/Sb	-0.37					
Dean Overfill Factor (K)	**1.00**					

Canaveral Shoals II (avg of 2010 S. Reach as-built samples)						
	phi-05	phi-16	phi-50	phi-84	phi-95	
Grain Size Distribution	-0.86	0.59	1.50	2.00	2.43	phi
Mean	1.36	phi				
Standard Deviation	0.90	phi				
(Mb-Mn)/Sn	-0.82					
Sb/Sn	0.88					
J-K Overfill Factor (R_A)	**1.00**					
(Mb-Mn)/Sb	-0.93					
Dean Overfill Factor (K)	**1.00**					

Table 5-3a: Granularmetric Data for Native Beach Samples along KSC shoreline (V-068).

Sieve	Size (in)	Size (mm)	Size (ϕ)	Percent By Weight									
				V-68									
				Dune (11')	Dune (9')	Berm (7')	Berm (5')	HWL (1')	HWL (0')	LWL (-3')	-8'	-13'	-18
5/16"	0.315	8.000	-3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.5	0.223	5.657	-2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.11
4	0.187	4.757	-2.25	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.07	0.00	0.07
5	0.157	4.000	-2.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00
7	0.111	2.828	-1.5	0.00	0.00	0.00	0.00	0.13	0.02	0.34	0.07	0.03	0.16
10	0.079	2.000	-1.0	0.00	0.02	0.01	0.00	0.16	0.07	0.83	0.14	0.09	0.14
14	0.056	1.414	-0.5	0.02	0.09	0.02	0.02	0.85	0.25	1.53	0.66	0.16	0.19
18	0.039	1.000	0.0	0.15	0.42	0.12	0.05	5.14	1.60	4.40	4.47	0.14	0.12
25	0.028	0.707	0.5	1.27	2.13	1.15	0.51	17.89	7.21	9.39	19.57	0.12	0.22
35	0.020	0.500	1.0	6.96	7.52	9.00	4.37	28.37	15.78	10.17	10.54	0.11	0.21
45	0.014	0.354	1.5	25.88	26.41	26.44	21.78	20.32	19.98	8.32	1.46	0.23	0.28
60	0.010	0.250	2.0	42.60	40.09	35.36	40.63	12.18	17.21	9.41	1.71	0.43	0.64
80	0.007	0.177	2.5	15.91	15.39	18.53	21.15	6.48	12.45	13.96	5.13	2.72	2.50
120	0.005	0.125	3.0	5.79	6.44	8.03	10.23	5.94	19.91	33.83	34.06	49.22	31.04
170	0.003	0.088	3.5	0.48	0.64	0.74	0.88	1.42	4.38	6.55	20.17	42.15	56.25
200	0.003	0.074	3.75	0.03	0.03	0.02	0.04	0.02	0.11	0.23	0.82	2.96	5.25
230	0.002	0.063	4.0	0.01	0.01	0.00	0.01	0.00	0.01	0.04	0.14	0.52	1.29
Total				99.10	99.19	99.42	99.67	98.90	98.98	99.14	99.08	98.88	98.47

Sieve	Size (in)	Size (mm)	Size (ϕ)	Percent By Weight Coarser Than									
				V-68									
				Dune (11')	Dune (9')	Berm (7')	Berm (5')	HWL (1')	HWL (0')	LWL (-3')	-8'	-13'	-18
5/16"	0.315	8.000	-3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.5	0.223	5.657	-2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.11
4	0.187	4.757	-2.3	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.07	0.00	0.18
5	0.157	4.000	-2.0	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.14	0.00	0.18
7	0.111	2.828	-1.5	0.00	0.00	0.00	0.00	0.13	0.02	0.48	0.21	0.03	0.34
10	0.079	2.000	-1.0	0.00	0.02	0.01	0.00	0.29	0.09	1.31	0.35	0.12	0.48
14	0.056	1.414	-0.5	0.02	0.11	0.03	0.02	1.14	0.34	2.84	1.01	0.28	0.67
18	0.039	1.000	0.0	0.17	0.53	0.15	0.07	6.28	1.94	7.24	5.48	0.42	0.79
25	0.028	0.707	0.5	1.44	2.66	1.30	0.58	24.17	9.15	16.63	25.05	0.54	1.01
35	0.020	0.500	1.0	8.40	10.18	10.30	4.95	52.54	24.93	26.80	35.59	0.65	1.22
45	0.014	0.354	1.5	34.28	36.59	36.74	26.73	72.86	44.91	35.12	37.05	0.88	1.50
60	0.010	0.250	2.0	76.88	76.68	72.10	67.36	85.04	62.12	44.53	38.76	1.31	2.14
80	0.007	0.177	2.5	92.79	92.07	90.63	88.51	91.52	74.57	58.49	43.89	4.03	4.64
120	0.005	0.125	3.0	98.58	98.51	98.66	98.74	97.46	94.48	92.32	77.95	53.25	35.68
170	0.003	0.088	3.5	99.06	99.15	99.40	99.62	98.88	98.86	98.87	98.12	95.40	91.93
200	0.003	0.074	3.8	99.09	99.18	99.42	99.66	98.90	98.97	99.10	98.94	98.36	97.18
230	0.002	0.063	4.0	99.10	99.19	99.42	99.67	98.90	98.98	99.14	99.08	98.88	98.47

	Dune (11')	Dune (9')	Berm (7')	Berm (5')	HWL (1')	HWL (0')	LWL (-3')	-8'	-13'	-18
USCS Classification	SP	SP	SP	SP	SP	SP	SP	SP	SP	SP
Median (d50,mm)	0.31	0.31	0.31	0.29	0.51	0.32	0.11	0.22	0.17	0.13
Mean (μ,mm)	0.31	0.32	0.31	0.29	0.48	0.31	0.12	0.29	0.27	0.13
Standard Deviation (σ,ϕ)	0.53	0.57	0.58	0.54	0.83	0.89	0.55	1.13	1.28	0.42
Skewness (α,ϕ)	0.00	-0.15	0.06	0.10	0.46	-0.09	-5.08	-0.79	-0.53	-3.64
Kurtosis (β,ϕ)	3.57	3.81	2.98	3.09	3.07	2.20	42.39	2.77	1.72	32.74
% Fines (passing #230)	0.90	0.81	0.58	0.33	1.10	1.02	1.53	0.86	0.92	1.12
% Gravel (retained on #4)	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.14	0.07	0.00
% Carbonate	15.34	17.67	18.70	14.90	33.31	22.61	7.08	25.16	12.32	5.29
Munsell Color (moist)	10YR 8.0 / 10	10YR 7.5 / 15	10YR 8.0 / 10	10YR 8.0 / 10	10YR 7.5 / 15	10YR 7.5 / 10	10YR 7.0 / 10	10YR 7.5 / 10	10YR 7.0 / 10	10YR 7.0 / 10

Sample elevations are in feet NAVD88

Table 5-3b: Granularmetric Data for Native Beach Samples along KSC shoreline (V-077).

Sieve	Size (in)	Size (mm)	Size (ϕ)	Percent By Weight									
				V-77									
				Dune (11')	Dune (9')	Berm (7')	Berm (5')	HWL (1')	HWL (0')	LWL (-3')	-8'	-13'	-18
5/16"	0.315	8.000	-3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.5	0.223	5.657	-2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00
4	0.187	4.757	-2.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.157	4.000	-2.0	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.02
7	0.111	2.828	-1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.03	0.04	0.28
10	0.079	2.000	-1.0	0.01	0.00	0.00	0.00	0.02	0.01	1.28	0.16	0.11	0.25
14	0.056	1.414	-0.5	0.02	0.01	0.01	0.02	0.05	0.13	4.08	0.54	0.18	0.37
18	0.039	1.000	0.0	0.04	0.15	0.09	0.14	0.64	0.92	10.59	1.11	0.21	0.24
25	0.028	0.707	0.5	0.33	2.43	1.18	2.05	4.38	4.34	18.93	2.53	0.24	0.33
35	0.020	0.500	1.0	4.40	13.12	7.87	19.50	14.90	11.70	18.06	6.11	0.26	0.33
45	0.014	0.354	1.5	26.17	36.55	28.85	45.93	27.23	16.47	12.27	10.22	0.43	0.36
60	0.010	0.250	2.0	41.04	32.77	35.93	22.75	22.37	20.18	9.59	10.15	0.59	0.30
80	0.007	0.177	2.5	17.56	10.19	15.97	5.13	13.30	17.56	8.01	9.46	3.29	0.97
120	0.005	0.125	3.0	6.39	3.76	7.96	3.31	14.16	23.42	12.06	32.85	52.57	17.95
170	0.003	0.088	3.5	3.64	0.44	1.06	0.76	1.85	4.07	3.18	24.22	36.56	67.37
200	0.003	0.074	3.75	0.05	0.03	0.07	0.01	0.04	0.05	0.05	1.43	3.88	7.56
230	0.002	0.063	4.0	0.02	0.00	0.01	0.00	0.01	0.01	0.01	0.35	0.60	1.75
Total				99.67	99.45	99.00	99.60	98.95	98.86	99.06	99.16	98.96	98.08

Sieve	Size (in)	Size (mm)	Size (ϕ)	Percent By Weight Coarser Than									
				V-77									
				Dune (11')	Dune (9')	Berm (7')	Berm (5')	HWL (1')	HWL (0')	LWL (-3')	-8'	-13'	-18
5/16"	0.315	8.000	-3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.5	0.223	5.657	-2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00
4	0.187	4.757	-2.3	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00
5	0.157	4.000	-2.0	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.02
7	0.111	2.828	-1.5	0.00	0.00	0.00	0.00	0.00	0.00	0.95	0.03	0.04	0.30
10	0.079	2.000	-1.0	0.01	0.00	0.00	0.00	0.02	0.01	2.23	0.19	0.15	0.55
14	0.056	1.414	-0.5	0.03	0.01	0.01	0.02	0.07	0.14	6.31	0.73	0.33	0.92
18	0.039	1.000	0.0	0.07	0.16	0.10	0.16	0.71	1.06	16.90	1.84	0.54	1.16
25	0.028	0.707	0.5	0.40	2.59	1.28	2.21	5.09	5.40	35.83	4.37	0.78	1.49
35	0.020	0.500	1.0	4.80	15.71	9.15	21.71	19.99	17.10	53.89	10.48	1.04	1.82
45	0.014	0.354	1.5	30.97	52.26	38.00	67.64	47.22	33.57	66.16	20.70	1.47	2.18
60	0.010	0.250	2.0	72.01	85.03	73.93	90.39	69.59	53.75	75.75	30.85	2.06	2.48
80	0.007	0.177	2.5	89.57	95.22	89.90	95.52	82.89	71.31	83.76	40.31	5.35	3.45
120	0.005	0.125	3.0	95.96	98.98	97.86	98.83	97.05	94.73	95.82	73.16	57.92	21.40
170	0.003	0.088	3.5	99.60	99.42	98.92	99.59	98.90	98.80	99.00	97.38	94.48	88.77
200	0.003	0.074	3.8	99.65	99.45	98.99	99.60	98.94	98.85	99.05	98.81	98.36	96.33
230	0.002	0.063	4.0	99.67	99.45	99.00	99.60	98.95	98.86	99.06	99.16	98.96	98.08

	Dune (11')	Dune (9')	Berm (7')	Berm (5')	HWL (1')	HWL (0')	LWL (-3')	-8'	-13'	-18
USCS Classification	SP	SP	SP	SP	SP	SP	SP	SP	SP	SP
Median (d50,mm)	0.30	0.36	0.31	0.40	0.34	0.27	0.54	0.16	0.13	0.11
Mean (μ,mm)	0.29	0.36	0.31	0.39	0.33	0.28	0.49	0.20	0.13	0.12
Standard Deviation (σ,ϕ)	0.56	0.54	0.57	0.53	0.74	0.82	1.13	0.93	0.47	0.59
Skewness (α,ϕ)	0.52	0.24	0.23	0.77	0.11	-0.33	0.12	-1.02	-3.47	-5.05
Kurtosis (β,ϕ)	3.68	3.47	3.15	4.39	2.46	2.35	2.39	3.46	27.17	35.35
% Fines (passing #230)	0.33	0.55	1.00	0.40	1.05	1.14	0.94	0.84	1.04	1.92
% Gravel (retained on #4)	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00
% Carbonate	14.34	21.63	16.10	22.45	21.66	20.28	37.91	14.55	6.00	7.31
Munsell Color (moist)	10YR 8.5 / 10	10YR 8.0 / 10	10YR 8.0 / 10	10YR 8.0 / 10	10YR 7.5 / 10	10YR 7.5 / 10	10YR 7.0 / 10	10YR 7.0 / 10	10YR 7.0 / 10	10YR 7.0 / 10

Sample elevations are in feet NAVD88

Table 5-3c: Granularmetric Data for Native Beach Samples along KSC shoreline (V-086).

Sieve	Size (in)	Size (mm)	Size (ϕ)	Percent By Weight									
				V-86									
				Dune (11')	Dune (9')	Berm (7')	Berm (5')	HWL (1')	HWL (0')	LWL (-3')	-8'	-13'	-18
5/16"	0.315	8.000	-3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.5	0.223	5.657	-2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.187	4.757	-2.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
5	0.157	4.000	-2.0	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00
7	0.111	2.828	-1.5	0.02	0.01	0.00	0.00	0.00	0.00	0.07	0.26	0.00	0.01
10	0.079	2.000	-1.0	0.01	0.04	0.00	0.01	0.00	0.00	0.10	0.28	0.02	0.08
14	0.056	1.414	-0.5	0.03	0.03	0.02	0.01	0.04	0.01	0.13	0.63	0.03	0.17
18	0.039	1.000	0.0	0.14	0.12	0.09	0.10	0.35	0.02	0.41	1.79	0.12	0.37
25	0.028	0.707	0.5	0.94	0.53	0.66	1.36	2.81	0.16	1.28	4.44	0.24	0.67
35	0.020	0.500	1.0	5.20	2.75	4.80	11.82	11.34	1.44	3.03	7.64	0.44	0.74
45	0.014	0.354	1.5	26.11	19.05	29.76	37.59	23.96	7.53	5.23	7.14	0.35	0.45
60	0.010	0.250	2.0	42.67	43.68	43.71	33.00	31.14	21.62	9.12	5.53	0.54	0.44
80	0.007	0.177	2.5	15.52	21.05	15.05	10.67	18.92	28.79	15.74	7.56	2.76	1.84
120	0.005	0.125	3.0	6.55	10.60	4.50	3.92	9.54	28.06	48.38	44.73	49.20	53.97
170	0.003	0.088	3.5	2.66	1.48	0.47	0.36	0.90	11.43	14.53	17.57	40.43	35.37
200	0.003	0.074	3.75	0.05	0.12	0.06	0.01	0.03	0.13	0.87	1.39	2.81	3.64
230	0.002	0.063	4.0	0.02	0.04	0.02	0.00	0.01	0.03	0.15	0.31	0.56	0.72
Total				99.92	99.50	99.14	98.85	99.04	99.22	99.08	99.32	97.50	98.47

Sieve	Size (in)	Size (mm)	Size (ϕ)	Percent By Weight Coarser Than									
				V-86									
				Dune (11')	Dune (9')	Berm (7')	Berm (5')	HWL (1')	HWL (0')	LWL (-3')	-8'	-13'	-18
5/16"	0.315	8.000	-3.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.5	0.223	5.657	-2.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.187	4.757	-2.3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
5	0.157	4.000	-2.0	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.05	0.00	0.00
7	0.111	2.828	-1.5	0.02	0.01	0.00	0.00	0.00	0.00	0.11	0.31	0.00	0.01
10	0.079	2.000	-1.0	0.03	0.05	0.00	0.01	0.00	0.00	0.21	0.59	0.02	0.09
14	0.056	1.414	-0.5	0.06	0.08	0.02	0.02	0.04	0.01	0.34	1.22	0.05	0.26
18	0.039	1.000	0.0	0.20	0.20	0.11	0.12	0.39	0.03	0.75	3.01	0.17	0.63
25	0.028	0.707	0.5	1.14	0.73	0.77	1.48	3.20	0.19	2.03	7.45	0.41	1.30
35	0.020	0.500	1.0	6.34	3.48	5.57	13.30	14.54	1.63	5.06	15.09	0.85	2.04
45	0.014	0.354	1.5	32.45	22.53	35.33	50.89	38.50	9.16	10.29	22.23	1.20	2.49
60	0.010	0.250	2.0	75.12	66.21	79.04	83.89	69.64	30.78	19.41	27.76	1.74	2.93
80	0.007	0.177	2.5	90.64	87.26	94.09	94.56	88.56	59.57	35.15	35.32	4.50	4.77
120	0.005	0.125	3.0	97.19	97.86	98.59	98.48	98.10	87.63	83.53	80.05	53.70	58.74
170	0.003	0.088	3.5	99.85	99.34	99.06	98.84	99.00	99.06	98.06	97.62	94.13	94.11
200	0.003	0.074	3.8	99.90	99.46	99.12	98.85	99.03	99.19	98.93	99.01	96.94	97.75
230	0.002	0.063	4.0	99.92	99.50	99.14	98.85	99.04	99.22	99.08	99.32	97.50	98.47

	Dune (11')	Dune (9')	Berm (7')	Berm (5')	HWL (1')	HWL (0')	LWL (-3')	-8'	-13'	-18
USCS Classification	SP	SP	SP	SP	SP	SP	SP	SW	SP	SP
Median (d50,mm)	0.31	0.29	0.31	0.36	0.31	0.20	0.16	0.16	0.13	0.13
Mean (μ,mm)	0.30	0.28	0.31	0.35	0.31	0.20	0.18	0.21	0.13	0.13
Standard Deviation (σ,ϕ)	0.56	0.54	0.48	0.52	0.64	0.60	0.71	1.01	0.41	0.52
Skewness (α,ϕ)	0.30	0.04	0.22	0.31	-0.08	-0.31	-1.63	-1.28	-2.60	-3.37
Kurtosis (β,ϕ)	4.10	4.20	3.87	3.50	2.80	2.72	6.77	4.03	19.10	21.27
% Fines (passing #230)	0.08	0.50	0.86	1.15	0.96	0.78	0.92	0.68	2.50	1.53
% Gravel (retained on #4)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00
% Carbonate	10.58	10.83	16.05	18.19	19.38	11.66	10.10	15.89	7.31	6.24
Munsell Color (moist)	10YR 8.0 / 10	10YR 8.0 / 10	10YR 8.0 / 10	10YR 8.0 / 10	10YR 7.5 / 10	10YR 7.5 / 10	10YR 7.5 / 10	10YR 7.0 / 10	10YR 7.0 / 10	10YR 7.0 / 10

Sample elevations are in feet NAVD88

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APPENDIX D

Kennedy Space Center Shoreline Restoration
Created Inland Dune Monitoring Report
Fall 2011-February 2013

Introduction

During the summer of 2010, an inland dune was constructed behind the primary dune between Launch Complexes 39A and 39B, east of Phillips Parkway on Kennedy Space Center (KSC) (Figure 1). The dune was 221 m (725 ft) long, 24 m (80 ft) wide, and 4.6 m (15 ft) tall. The purpose of the dune was to improve sea turtle nesting habitat by creating a natural visual screen between the beach and LC 39 complexes, and to improve southeastern beach mouse (*Peromyscus polionotus niveiventris*) habitat that was highly disturbed. The stretch of primary dune in that area has been severely compromised in the past by activities associated with railroad operations, and during the last several years by wash-overs and inundation from storm surges. Free sand to construct the dune was obtained from Cape Canaveral Air Force Station, and half of the sand was transported at no cost. The other half of the transport was done by contractors, as was the shaping of the dune. The U.S. Fish and Wildlife Service (FWS) at Merritt Island National Wildlife Refuge provided funding for vegetation and planting, which occurred in April 2011. Ecological monitoring was requested by the FWS Endangered Species Office in Jacksonville in order to determine if and when southeastern beach mice would populate the new dune habitat. Monitoring funds were provided from 21st Century Launch Complex resources.

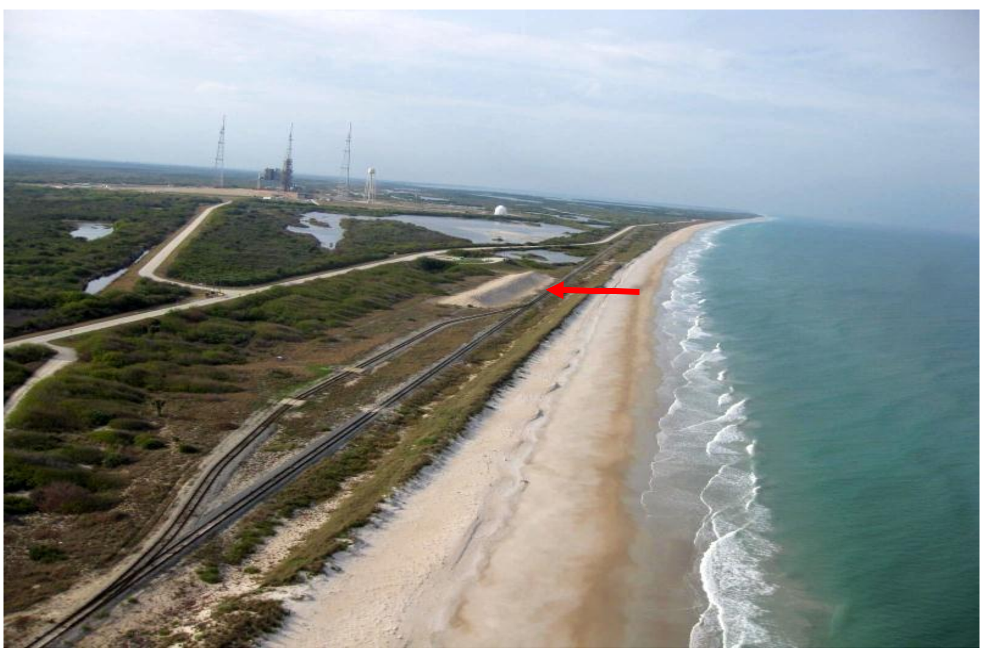

Figure 1. Location of created inland dune southeast of LC 39B on Kennedy Space Center, Florida.

Methods

A monitoring plan was developed that focused on vegetation cover, and occupancy by gopher tortoises (*Gopherus polyphemus*) and southeastern beach mice. A list of other wildlife species observed on the dune was also kept. Eleven transects were evenly spaced transversely across the dune from east to west (Figure 2). For vegetation monitoring, there were five sample points on each transect: Sample point 1 was within the first 5 meters (16.4 ft) from the base of the dune on the east face, point 2 was within the second 5 meters, point 3 was near the top of the dune, point 4 was within the first 5 meters from the top on the west side, and point five was within the last 5 meters on the west side, for a total of 55 points. Exact sample point locations were based on randomly chosen coordinates within 5 meters north or south of each transect. These random points, once chosen, were kept the same for all survey events. A one-square meter (10.8 ft^2) plot frame was used to survey the vegetation at each point. Survey methods followed Daubenmire 1968; bare ground, detritus, and each species of plant within the frame were assigned a number based on a range of cover percentages. Values were compared with subsequent sampling event data to determine changes over time in the vegetation coverage and composition.

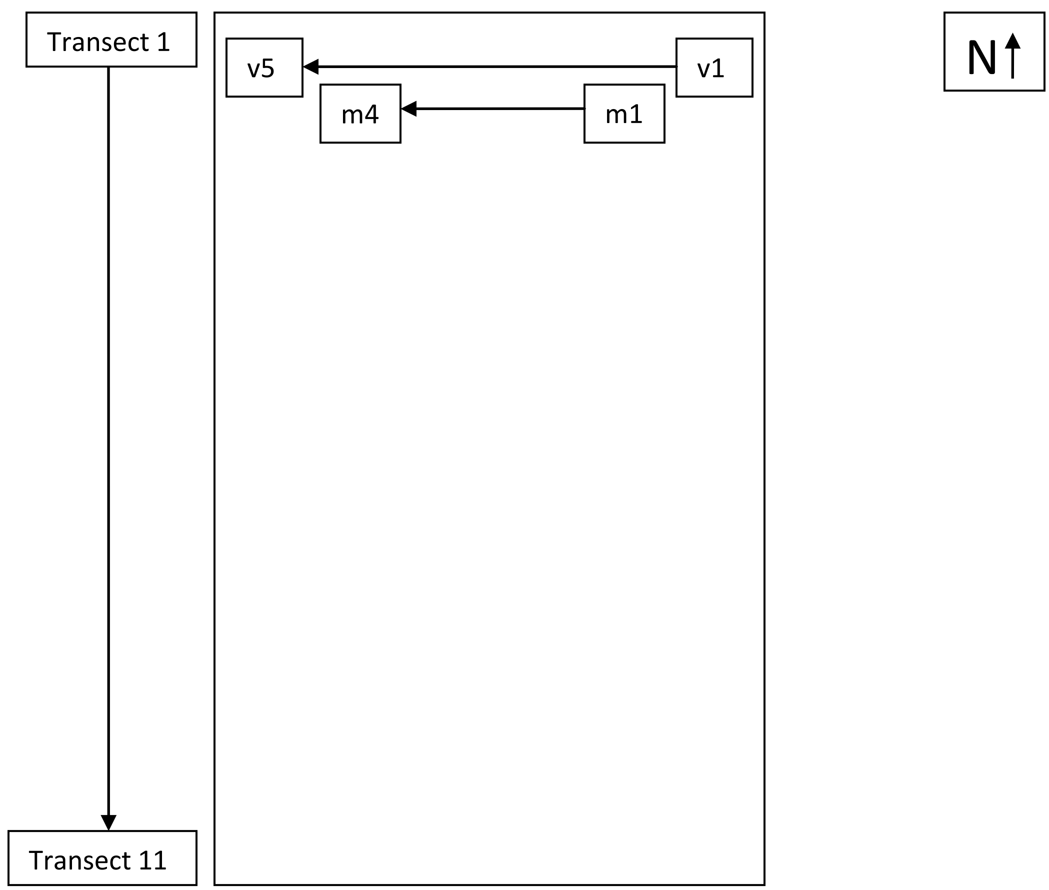

Figure 2. Layout of transects (1 -11) from north to south, vegetation sample points (v1 – v5) from east to west, and small mammal trap stations (m1 – m4) from east to west on the created inland dune on Kennedy Space Center, Florida. See text for details.

A 100% coverage gopher tortoise burrow survey was done once during each survey event by walking five parallel lines from north to south along the dune. Burrows found were examined with an infrared burrow camera to determine occupancy.

Southeastern beach mice were surveyed by trapping. On each transect, Sherman live traps were placed one-third and two-thirds of the way up the dune face on the east and west sides, for a total of four traps per transect, equaling 44 traps on the dune (Figure 2). Ten traps were placed on the primary dune directly east of the inland dune to serve as a control site. Traps were baited with sunflower seeds and a piece of cotton was placed inside for use as bedding. Trapping occurred for three consecutive nights during each survey period. Captured mice and rats were weighed, the sex and age classifications were determined, and the reproductive condition was assessed. Southeastern beach mice were ear tagged for future identification. All animals were released at their capture locations.

Results

Vegetation - Table 1 shows the percent cover for the parameters sampled during the vegetation monitoring. Based on the 55 samples taken during each of the five sampling events, the amount of the site that was not vegetated (bare sand and detritus) varied between 58% and 70%; vegetated area was between 30% and 40%. The vegetation that was planted accounted for about 23% of the vegetation coverage. There was some establishment of native species that were not planted; these combined with the planted species accounted for 31% of the total vegetation. Coverage by these plants increased over time (Figure 3). Nuisance plants made up 17.5% of the total coverage during the first monitoring event, but decreased substantially over time (Figure 3). Table 2 is a list of all plants documented on the dune.

Table 1. Vegetation survey results (% cover) from five quarters of sampling on the created inland dune, Kennedy Space Center, Florida.

Parameter	Nov. 11	Feb. 12	May 12	Aug. 12	Nov. 12
% vegetated	41.4	29.6	33.6	39.6	40.4
% bare (sand, detritus)	58.6	70.4	66.4	60.4	59.6
Planted vegetation	21.2	21.7	24.8	23.0	24.6
Planted & volunteer	23.9	25.1	29.7	30.9	31.9
Nuisance species	17.5	4.5	3.9	8.7	8.5

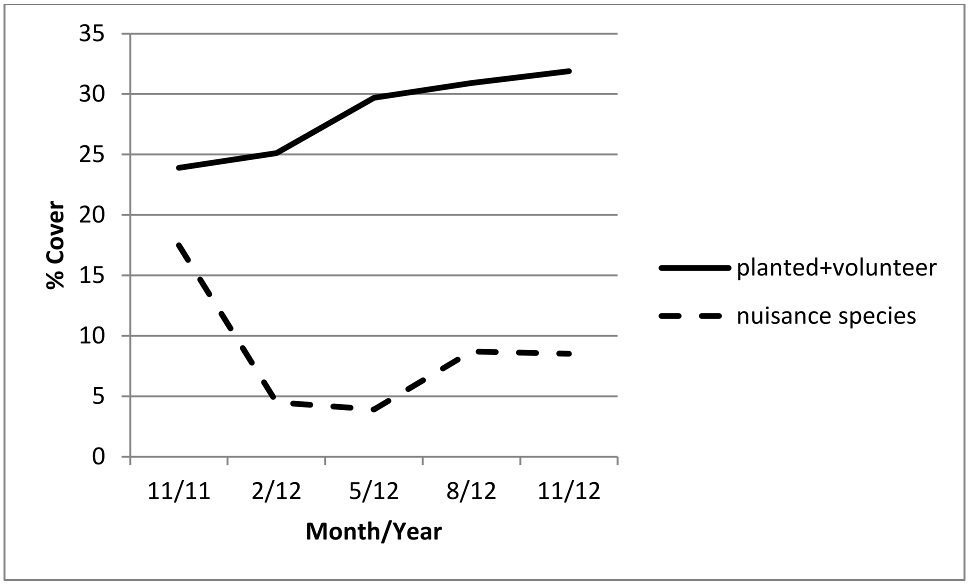

Figure 3. Percent cover of desirable plant species (those planted and native volunteers) and nuisance species on the created inland dune, Kennedy Space Center, Florida.

Table 2. List of plants documented from the created inland dune, Kennedy Space Center, Florida.

	Scientific Name	Common Name
Desirable (planted)	*Coccoloba uvifera*	Seagrape
	Gaillardia pulchella	Blanket flower
	Helianthus debilis	Cucumberleaf sunflower
	Iva imbricata	Seacoast marsh elder
	Panicum amarum	Bitter panicgrass
	Serenoa repens	Saw palmetto
	Spartina patens	Salt meadow cordgrass
	Uniola paniculata	Seaoats
Desirable (volunteer)	*Canavalia rosea*	Baybean
	Cenchrus sp.	Sandspur
	Chamaesyce sp.	Milk purslane
	Chapmannia floridana	Florida alicia
	Cyperus sp.	Flatsedge
	Ernodea littoralis	Beach creeper
	Heterotheca subaxillaris	Camphorweed
	Ipomea sp.	Morning glory
	Panicum sp.	Unid. grass species
	Paspalum sp.	Unid. grass species
	Phyla nodiflora	Turkey tangle
	Physalis viscosa	Groundcherry
	Poaceae	Unid. grasses
	Rynchosia sp.	Snoutbean
	Trifolium sp.	Clover
	Vicia sp.	Vetch
	Vigna luteola	Cowpea
Nuisance	Ambrosia artemisiifolia	Common ragweed
	Cynodon dactylon	Bermudagrass
	Dactyloctenium aegyptium	Crowfoot grass
	Digitaria sp.	Crabgrass
	Indigofera spicata	Hairy indigo
	Melinis repens	Natal grass

Gopher Tortoises - During the first monitoring event in November 2011, three gopher tortoise burrows were found, and all three were occupied. These same three burrows were present and occupied in February 2012. In May 2012, the three burrows were present and two more were found; all five were occupied. By August 2012, the number of burrows had increased to 13, but only five had tortoises. In November 2012, there were 17 burrows: one burrow that was originally found in August 2012 was abandoned; eight burrows were occupied and the rest were empty; five of the eight empty burrows showed signs of recent activity. In Aug. 2012, a tortoise was hand-captured outside of a burrow on the east side of the dune. It was an adult male, 25.7 cm (10.1 in) carapace length. The shell was permanently marked using standard techniques and he was released into the burrow.

Table 3. Results from gopher tortoise burrow surveys on the created inland dune, Kennedy Space Center, Florida.

Date	# Burrows	Occupied	Empty	Empty/Active	Abandoned
Nov. 2011	3	3			
Feb. 2012	3	3			
May 2012	5	5			
Aug. 2012	13	5	8		
Nov. 2012	17	8	8	5	1

Southeastern Beach Mice - Of the 810 potential trapnights during the five quarterly sampling events, traps were taken out of commission 90 times because they were raided (bait taken, but no animal caught), snapped without capturing anything, were disturbed and made inoperable, or caught non-target species [seven spotted skunks (*Spilogale putorius*), three ghost crabs (*Ocypode quadrata*), and one unidentified grasshopper]. This left a total of 720 effective trapnights which captured 140 small mammals. Catch-per-unit-effort was 0.19, which is within the range of what would be expected based on previous work done at KSC (Provancha et al. 2005).

Small mammals captured, besides southeastern beach mice, were eight cotton rats (*Sigmodon hispidis*), five cotton mice (*Peromyscus gossypinus*) and one least shrew (*Cryptotis parva*). There were 126 captures of 53 individual beach mice (Table 4; one mouse captured is not included in Table 4 or Table 5 because it escaped before any data were taken). There were reproductively active mice in all seasons, and subadult mice were captured in every survey except Aug. 2012. Only one juvenile was captured.

Table 4. Capture data for southeastern beach mice trapped on the created inland dune and control dune on Kennedy Space Center, Florida.

Date	Total	Males (reproductive)	Females (reproductive)	Adults	Subadults	Juveniles
Nov. 2011	23	12 (4)	11 (2)	21	1	1
Feb. 2012	35	16 (2)	19 (6)	33	2	0
May 2012	27	14 (8)	13 (4)	24	3	0
Aug. 2012	13	7 (6)	6 (1)	13	0	0
Nov. 2012	27	16 (4)	11 (4)	26	1	0

Table 5 shows the recapture data for all surveys. Thirty-two mice were captured during two consecutive surveys (three months apart), 15 were captured six months apart, and one animal originally tagged in Nov. 2011 was recaptured in Nov. 2012.

Table 5. Recapture data for southeastern beach mice trapped on the created inland dune and control dune on Kennedy Space Center, Florida.

Date	New Captures	Recaptures (same survey)	Recaptures (3 months)	Recaptures (6 months)	Recaptures (9 months)	Recaptures (1 year)
Nov. 2011	17	6				
Feb. 2012	13	6	16			
May 2012	13	7	4	3		
Aug. 2012	4	0	5	4	0	
Nov. 2012	6	5	7	8	0	1

Fifteen small mammals (five cotton rats and ten southeastern beach mice) and one spotted skunk were captured on the control dune east of the created inland dune. There was some movement by beach mice between the control dune and the created dune. One mouse was captured in May 2012 on the created inland dune and was subsequently captured twice on the control dune, once in Aug. 2012 and once in Nov. 2012. On the two next nights in Nov., it was captured from the west side of the created dune approximately 55 m (180 ft) away. Another beach mouse was tagged on the control dune in May 2012 and recaptured on the control dune the next night. On the third night, it was captured on the west side of the created dune, approximately 50 m (164 ft) away. In Aug. 2012, it was recaptured twice from the control dune. Both of these animals were females.

Miscellaneous Observations and Captures - In addition to the target species (gopher tortoises and small mammals), a number of other species of interest were observed on the created dune during the surveys and other visits to the site (Table 6).

Table 6. Wildlife species opportunistically observed or captured at the created inland dune on Kennedy Space Center.

Date	Species	#	Notes
Nov. 2011	Common ground dove *(Columbina passerina)*	5	Loafing in dune grass; seen during all subsequent surveys
Nov. 2011	Eastern spadefoot toad (*Scaphiopus holbrookii*)	1	Very small juvenile
Nov. 2011	Black racer (*Coluber constrictor*)	1	Startled by observer and crawled off of dune on the west side; another (or same) seen Aug. 2012
Nov. 2011	Mourning dove (*Zenaida macroura*)	1	Flew off of dune; seen during all subsequent surveys
Nov. 2011	Eastern indigo snake (*Drymarchon couperi*)	1	Captured at base of east side of dune; processed and released on 11/22; female, 128 cm (50 in) total length, 106 cm (42 in) snout-vent length; PIT tagged
Nov. 2011	Green anole (*Anolis carolinensis*)	1	On west side of dune; another (or same) seen Feb. 2012
Nov. 2011	Coachwhip (*Masticophis flagellum*)	1	Startled by observers on west side of dune; consuming something (rodent?) that was squeaking loudly; approximately 1.8 m (6 ft) long adult; escaped into vegetation west of dune
Feb. 2012	Marsh rabbit (*Sylvilagus palustris*)	X	Feces; seen during all subsequent surveys
Feb. 2012	Bobcat (*Lynx rufus*)	X	Feces

Discussion

The monitoring surveys went very smoothly and efficiently. Approximately 20 hours were spent setting up the survey site, and field time to complete each survey was approximately 36 hours, split between three or four people.

The results from the vegetation surveys were encouraging. Although the amount of vegetated area has fluctuated slightly, the percent of desirable species (planted and volunteer) has increased over time. Nuisance species comprised over 17% of the coverage during the first survey (Nov. 2011, seven months post-planting), but that quickly decreased and has remained low. A recommendation for future projects such as this is to clear more of the nuisance vegetation out of the general area before planting in order to provide less seed source.

On KSC, in any given area of natural habitat, the number of gopher tortoise burrows that is occupied is often lower (25 – 30%) than the total number of burrows (Smith et al. 1997). However, in many man-made habitats, such as dikes and berms, the occupancy rate is much higher, as was seen on the inland dune during the first three surveys (Nov. 2011 – May 2012; 100% occupancy of burrows). This could be an indication of a new opportunity being exploited; the tortoises may not have had time to establish home ranges and dig multiple burrows as is typical in natural habitats. Subsequent monitoring indicates that the tortoises are beginning to use the created inland dune in a more “natural” fashion. Whenever tortoises on or near the dune can be caught, they will be marked for identification, which will start giving us an idea of site fidelity. Radiotracking would be an even better method to determine site fidelity, habitat use, and carrying capacity for the dune. These data would be invaluable if shoreline restoration efforts on KSC in the future involve the natural dune or a large-scale created inland dune.

It is apparent from the small mammal trapping that these animals are quite capable of quickly taking advantage of new habitat that becomes available. A catch-per-unit-effort of 19% is excellent and indicates a robust population. Beach mice in all three age categories (adult, subadult, and juvenile) were captured. The percent of beach mice that appeared to be reproductively active ranged between 19% (May 2012) and 54% (Nov. 2012). Successful reproduction is an important indicator of ecosystem function. An area or habitat can be crowded with adults, but if there is no reproduction, the population eventually will decline and disappear.

It is interesting that so few animals were caught on the natural primary dune that was intended to be a control site. That section of the dune has been completely inundated at least four times during severe storm events since 1999, and there have been three attempts to restore the primary dune by piling sand on top of it (2005, 2008, and 2011). Apparently there has not been time for the vegetation, small mammal, or gopher tortoise populations to recover. Two incidences of beach mice moving between the control dune and the created dune are evidence of the possibility of immigration from the natural habitat onto the created habitat, but it is not likely that the large number of animals captured on the created dune came from the control dune. They may have moved in from intact primary dune to the south, as there is an impounded wetland adjacent to the north. As with the gopher tortoises, mark-recapture of the beach mice will give some indication of site fidelity, but radiotracking would provide a much clearer picture of how the mice reach the created dune and how they make use of it.

Incidental observations and opportunistic captures of frogs, lizards, birds, and snakes from the inland dune are signs that predator/prey relationships have been established. The coachwhip, eastern indigo snake, and bobcat are considered to be top level predators that eat a wide variety of prey, including small mammals (Maehr and Brady 1986; Stevenson and Dyer 2002; Stevenson et al 2010). The presence of animals at various trophic levels is another indicator of a functioning ecosystem.

Placement of the inland dune landward of the section of degraded primary dune may reduce light pollution on the beach generated from the LC 39 area. Disorientation data from hatchling and nesting marine turtles should eventually indicate whether or not the inland dune is effective.

Before April 2011 when the dune was planted with vegetation, it was a barren pile of sand. In 19 months, it has become a functioning ecosystem, supporting robust floral and faunal communities, including two federally listed wildlife species (eastern indigo snake, southeastern beach mouse) and one candidate species (gopher tortoise). If our coastline experiences violent storm surges in the future, as is predicted, it will be interesting to see if the created inland dune affords some protection to the habitat west of it. Continued monitoring of the system will provide important information that can be used as KSC contends with the realities of climate change and sea level rise that threaten valuable man-made assets and natural resources.

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Inland dune construction, Aug. 2010

Partially completed dune, Sep. 2010

Planting, Apr. 2011

Vegetation survey, Nov. 2012

Gopher tortoise burrow

Southeastern beach mouse

Cotton rat

Eastern indigo snake

APPENDIX E

Essential Fish Habitat Assessment

Shoreline Protection Project

Kennedy Space Center

Brevard County, Florida

June 2012

(Revised July 2015)

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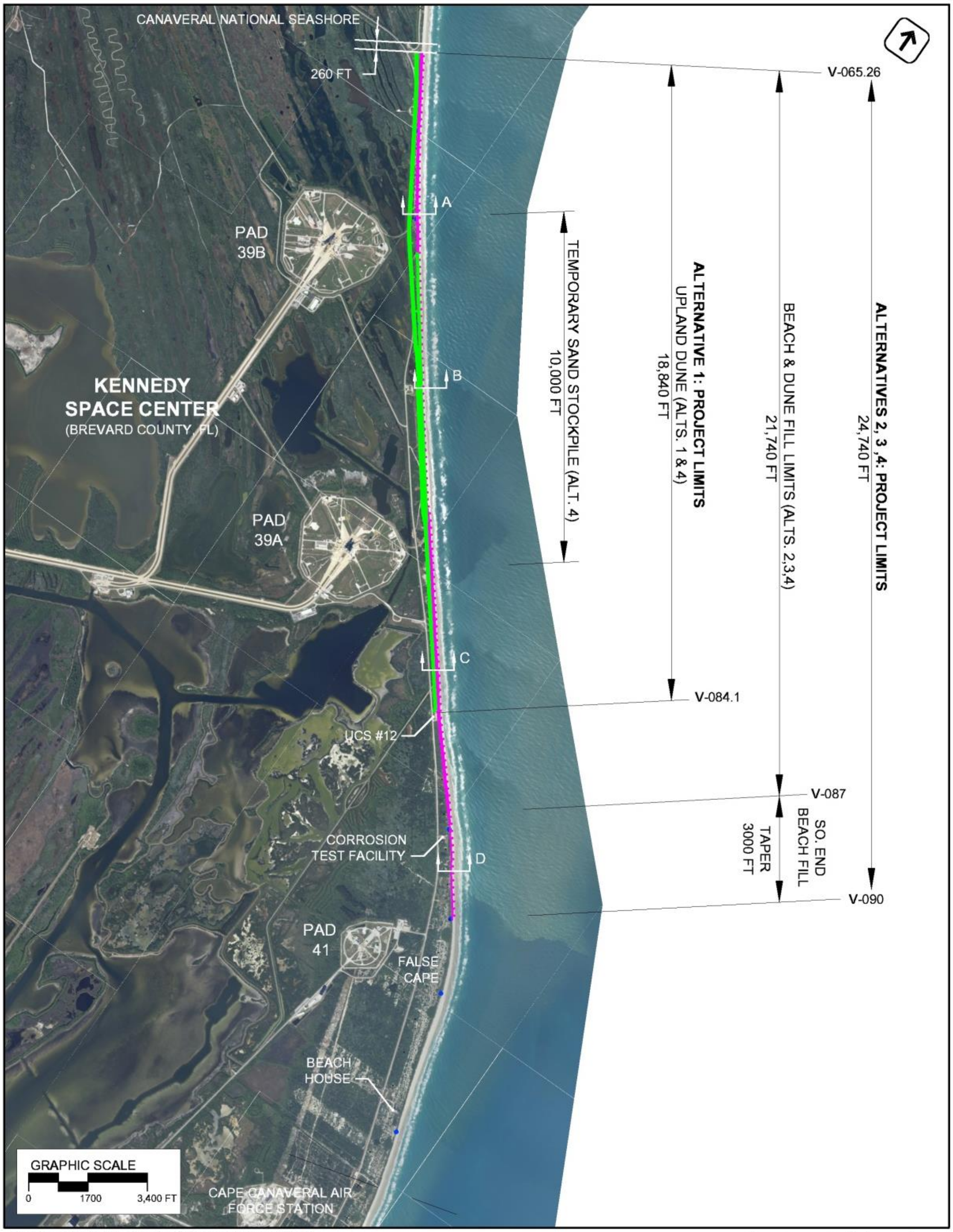
PROJECT BACKGROUND

Kennedy Space Center (KSC), owned and managed by the National Aeronautics and Space Administration (NASA), serves as the world's premiere launch complex for sending humans and payloads into space. In addition to its long and storied history supporting US Government space operations, KSC also plays a central and expanding role in fostering commercial space technology development and launch initiatives. At over 140,000 acres, KSC represents 67% of NASA's total landholdings nationwide and manages 20% of its 30 billion dollars in facilities infrastructure. Many of KSCs most valuable assets, most notably Launch Complexes (LC) 39A and 39B, are located within a few hundred meters of the Atlantic Ocean. The beaches and dunes along the KSC shoreline have historically protected this critical launch infrastructure from the impact of waves and storm surge inundation. They also provide high value habitat for several rare or federally protected species and serve as a physical buffer between launch facilities and important sea turtle nesting areas, thereby reducing photo-pollution and resulting turtle disorientation.

Over the past several years, there have been significant hurricane and non-hurricane storm events which have resulted in overwash and severe erosion of the dunes and beach at KSC (Jaeger et al., 2011). In 1999, Hurricane Floyd impacted the much of the Florida east coast, causing over 15 m of shoreline retreat at KSC. This shoreline loss has not been recovered. Further erosion during Hurricanes Francis, Charley, and Jeanne in 2004, and Tropical Storm Fay in 2008 coupled with other non-hurricane storm events, have further degraded the beach and dune and have required emergency, yet temporary, repairs to areas experiencing severe overwash. These processes have resulted in the loss of valuable wildlife habitat and increased rates of turtle disorientation in areas where dunes have been breached.

In support of NASA's overall mission and requirements of 10 U.S.C. 2273 (policy regarding assured access to space), KSC has identified the need for shoreline protection actions to safeguard critical launch infrastructure. The explicit purpose of the proposed beach renourishment actions outlined herein is to reduce shoreline erosion, safeguard critical launch infrastructure (e.g., launch pads, roads, utility corridors), and protect valuable threatened and endangered species habitat along the KSC coastline from future storm wave and sea-level rise damage. This project will focus on the northern 7.6 km of KSC's 10 km ocean shoreline between the KSC north boundary/Eagle 4 and the False Cape (Fig. 1). This reach, and in particular the 3.9 km of shoreline between LC 39A and 39B, features low upland elevations, very narrow and low dunes, and chronically high shoreline erosion rates.

Figure 1. Overview map of the proposed shoreline renourishment project area at KSC



Date of Photograph: 18 November 2008

olsen associates, inc.

Figure 2. Map depicting the spatial extent of each of the four alternative renourishment scenarios currently under consideration

PROJECT ACTION ALTERNATIVES

Four project action alternatives (each described in detail below) are currently being evaluated for the purposes of reducing flooding and long-term loss of land along the KSC Atlantic shoreline due to impacts of beach erosion. Several other alternatives were also considered but deemed impossible to implement, environmentally adverse, or did not meet project objectives. Each of these four alternatives address all or part of the northern 7.6 km of the KSC's 10 km ocean shoreline between Florida Department of Environmental Protection (FDEP) virtual monument locations V-065.3 (Eagle 4 Watch Tower) and V-090 (False Cape) (Fig. 2). This reach, particularly the 3.9 km of shoreline between LC 39A and LC 39B (V-070 to V-082), features low upland elevations, very narrow and low dunes, and chronically high shoreline erosion rates of between 0.9 and 2 meters per year. The dune along this area has been frequently overwashed by high tides and waves and is prone to breaching (Jaeger et al. 2011). Breaching and/or loss of the dune results in extensive flooding of the uplands between the shore and the launch pads. While seasonal operational schedules are outlined below for each alternative, funding has not yet been secured to perform any of the remaining alternatives under consideration so the exact timeline of this renourishment project remains undetermined.

Alternative One: Inland Dune

Project Alternative One entails the construction of large secondary dunes behind the existing primary dune in areas most vulnerable to erosion and flooding. These areas are located along the northern 5.8 km of the KSC shoreline between monuments V-065.3 and V-084 (Fig. 2). This alternative involves placing beach-compatible sand along or behind the landward side of the existing dune to create a substantial and continuous inland sand dune (Fig. 3). Salt-tolerant vegetation would be planted along the dune crest and slopes to further stabilize the constructed dune. Minimal sand fill would be placed on the beach. In areas where the existing primary dunes are most extensively degraded (e.g., between monuments V-071 and V-079), sand fill and vegetation would be used to both augment the existing primary dune and construct the secondary inland dune. Where there is little or no existing primary dune, frequent overwash, and narrow dune strand (e.g., between monuments V-073.8 and V-078.5), the primary and secondary dunes would be constructed as a single unit atop and behind the existing dune line.

Alternative One represents a managed retreat strategy by establishing shore protection landward of the existing dune and beach berm. It seeks to minimize impacts to the existing beach and dune and to reduce requirements for periodic beach/dune renourishment (maintenance) of the project area. Unavoidable project impacts will occur from initial dune construction in back-beach habitats. Alternative One actions are located principally within the

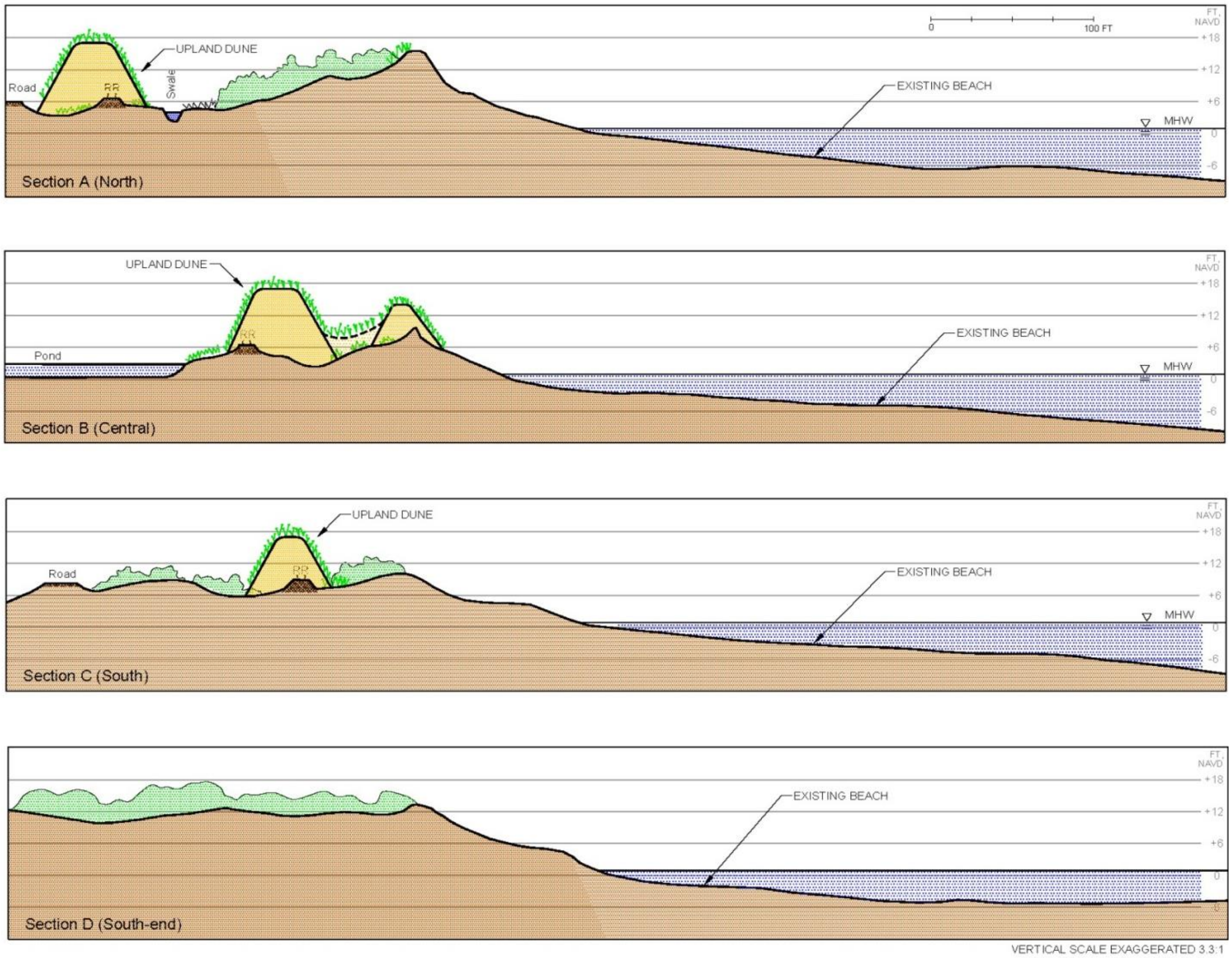


Figure 3. Alternative One: Inland Dune

uplands but will impact some natural freshwater swale wetlands and potentially remove up to 1500 m of a permanently flooded manmade ditch that parallels the roadway. Up to approximately 367,000 m^3 of sand would be required to construct this alternative which would also need subsequent native plant installation. This equates to about 19 m^3 of sand per ft on average. The fill sand would be trucked to the site from one or more upland sand sources that contain sediment compatible with existing beach and dune sediments. The specific sources of sand fill would be determined prior to construction and may include commercial upland quarries or other sites of excavation that are available. The sand would be placed and graded by mechanical excavators, payloaders, and bulldozers. Project construction would likely require on the order of 14 months, presuming that removal of unnecessary infrastructure (e.g., NASA railway), sand placement, and vegetation planting were conducted with overlapping schedules. Because construction will be landward of the primary dune, no calendar restrictions on the construction schedule are proposed. Long-term maintenance (sand replacement) may be required in areas where the existing primary dune was augmented. Otherwise, the constructed secondary dune, to be placed well landward of the primary dune, is intended to be beyond the extent of typical storm impacts and annual erosion for at least one or two decades (barring very severe hurricane overwash) and therefore, should not require frequent maintenance.

Alternative Two: Restore Beach and Dunes

Project Alternative Two involves sand placement for beach nourishment to restore the dune and beach to a condition that existed approximately 10 to 15 years ago. The twin goals of this alternative are to restore beach width lost to erosion and to reinforce the height and width of the primary dune, principally along its crest and seaward face (Fig. 4). This approach will better ensure protection from storm waves and flooding while also serving to shade nesting and hatching sea turtles from artificial lighting from launch facilities. The affected project area includes the northern 7.6 km of the KSC shoreline between monuments V-065.3 and V-090 (Fig. 2). Of this total area, dune and beach nourishment would occur along the northern 6.6 km from V-065.3 (north KSC boundary) to V-087. The remaining 1.0 km from V-087 to V-090 along False Cape would be constructed as a long tapered transition into the existing dune using beach renourishment with minor augmentation of the existing dune toe.

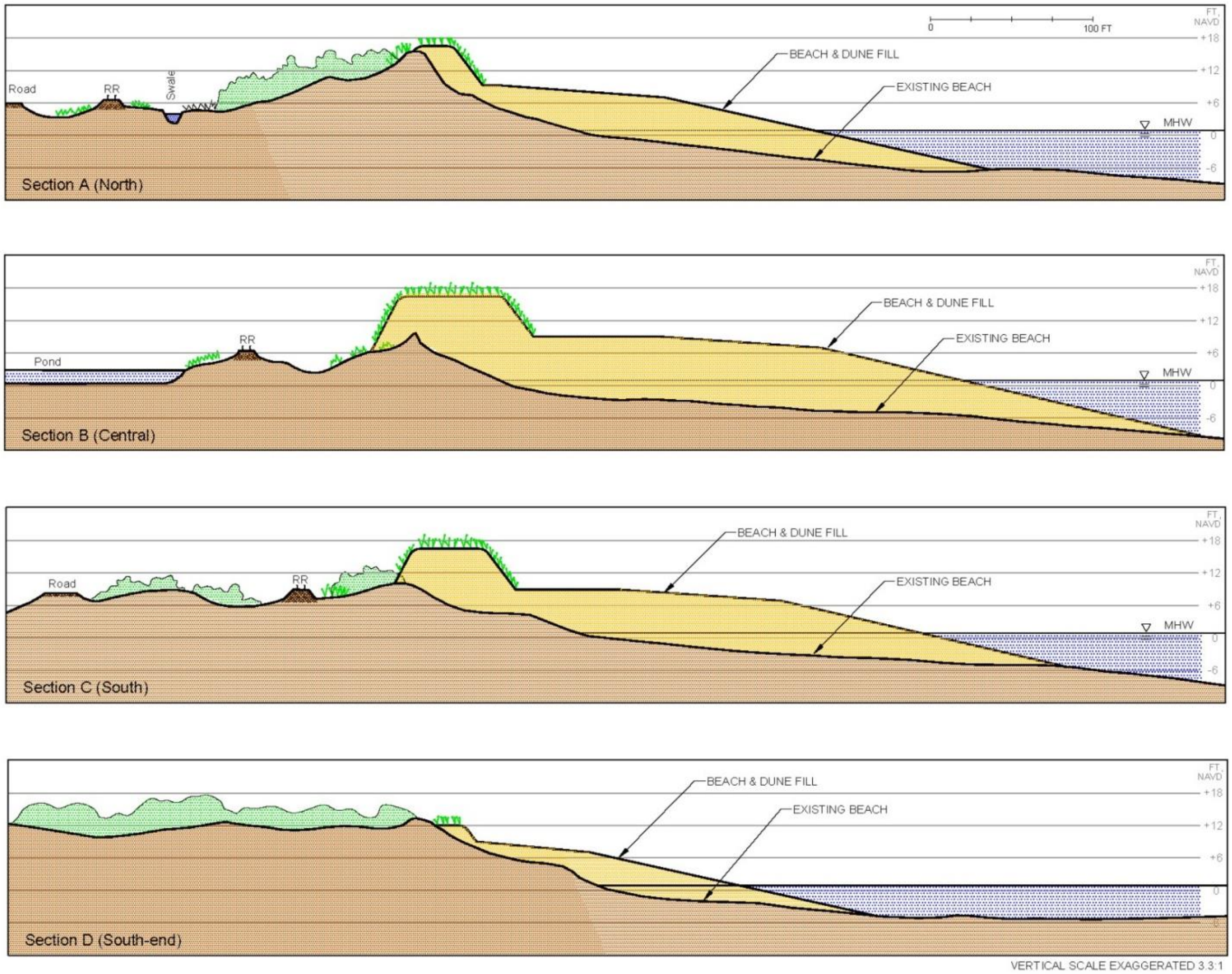


Figure 4. Alternative Two: Restore Beach and Dune

Alternative Two is an aggressive beach restoration strategy that seeks to reinforce and restore the beach/dune system on its ocean side; i.e., mostly seaward of the existing dune and vegetation line. This approach minimizes impact to existing dune and upland habitats, but because the installed fill is fully exposed to the sea, it is subject to higher erosion rates and requires dedicated future renourishment to ensure shoreline longevity. Sand fill would be placed along the existing beach, dune crest, and seaward face north of V-087 to provide a consistent dune height of about +5.0 m north of V-087 and a dune width and location that is approximately equivalent to that which existed circa 1995. The beach berm would be widened and elevated to similarly restore historical conditions, along with additional sand fill placement to allow for initial fill equilibration and six to ten years of advance renourishment. The constructed dune improvements would be planted with native salt-tolerant dune vegetation immediately after construction.

Up to 2,140,000 m^3 of beach fill sand would be required to initially construct Alternative Two. This equates to about 287 m^3/m on average along the entire project length. The source of the beach-compatible sand fill would be the existing Canaveral Shoals II (CS-II) offshore borrow area in federal waters, or alternately, the Canaveral Shoals I (CS-I) offshore borrow area in State of Florida waters (Fig. 5). The sand would be excavated by hydraulic hopper dredge, pumped to the project area via temporary pipeline, and then spread and graded by payloaders and bulldozers. Up to 2,370,000 m^3 of excavation at the borrow area may be required to construct the 2,140,000 m^3 beach fill. One or more hopper dredges would carry the excavated sand in 1500 to 3000 m^3 loads, moor to one of several submerged pipelines temporarily placed between the nearshore and the beach, and pump the sand load to the beach through the pipelines via a seawater slurry. After spreading and grading, the beach would be tilled above the wave zone to reduce compaction and to facilitate marine turtle nesting activity.

The schedule for Alternative 2 would be driven by constraints of the sea turtle nesting season (May – October). Initial project construction would require 30 days for mobilization, a minimum of 165 days for sand placement, plus 30 to 75 days for dune vegetation installation. Sand fill placement would be limited to the period November 1 to April 30. Construction of a project of this size in one season (i.e., 2.1 million m^3 in less than 180 days) is challenging and dependent upon favorable seas. If equipment mobilization can occur in October, the schedule will require net sand placement of over 11,850 m^3 per day, every day, including weather and mechanical downtime. This will require one large hopper dredge 3060+ m^3 or two medium dredges, 1530+ m^3 each, and probably some combination thereof.

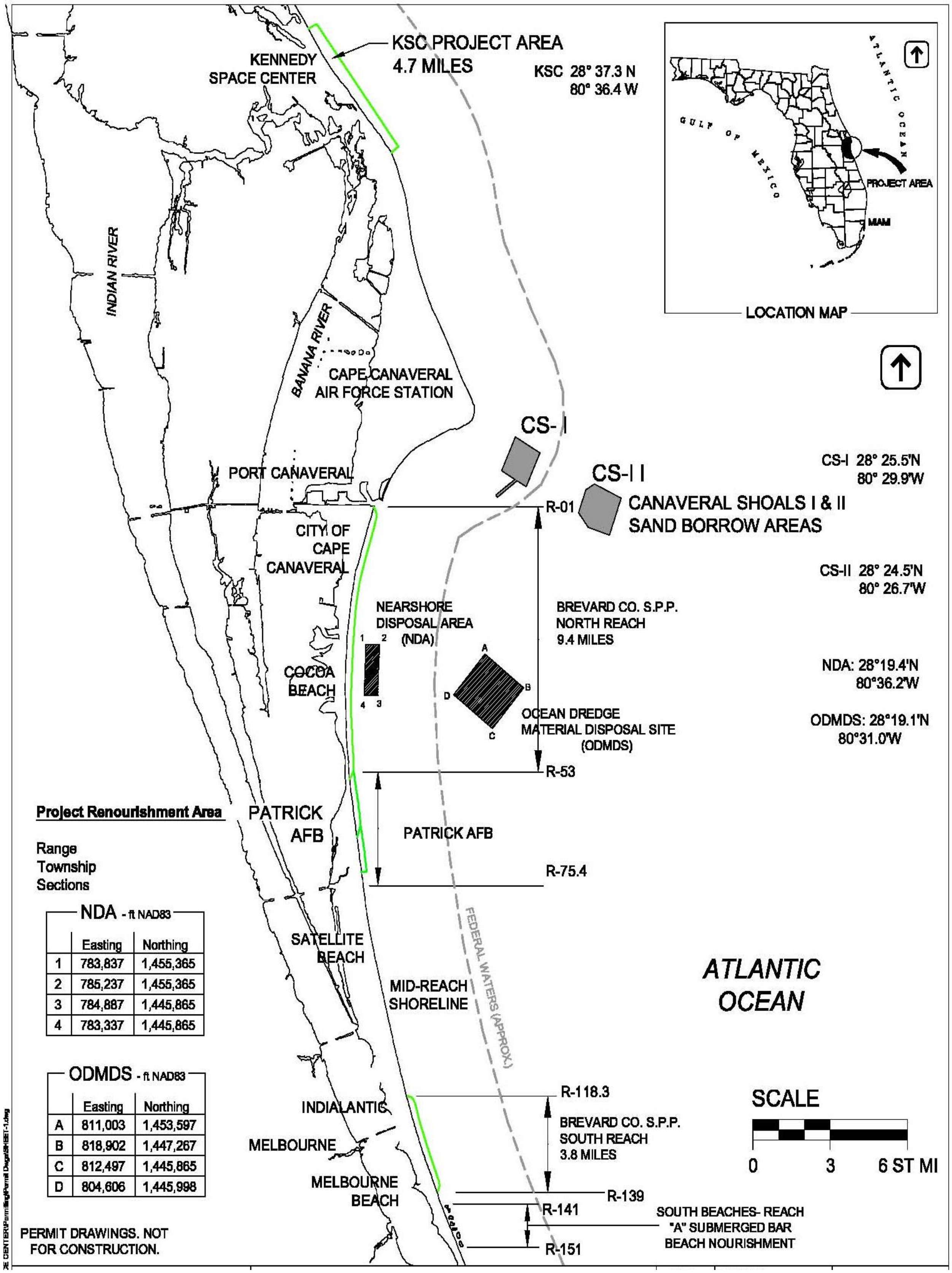


Figure 5. Map of the Canaveral Shoals I and Canaveral Shoals II offshore sand borrow sites

Maintenance renourishment of the project would be required at intervals of between 6 and 10 years, likely comprising between 596,000 m^3 and 994,000 m^3 per event, depending upon the renourishment frequency and the severity of storm erosion between events. Interim renourishment may be required after severe storm erosion. Periodic renourishment would seek to more or less restore the initial project construction template, adjusted to reflect the project performance observed through prior physical monitoring. Future project renourishment would be constructed by hopper dredge, using offshore sand sources, between November 1 and April 30, as outlined above.

Alternative Three: Reinforce Dune Plus Beach Fill

This alternative includes beach fill with a significant augmentation of the existing dune. The primary dune would be reconstructed or reinforced with sand and vegetation, and sand would be placed on the beach to provide a wide berm, restoring it to a less eroded condition and protecting the dune (Fig. 6). The dune would be reinforced at its existing location, avoiding advancement toward the sea by sand placement atop the existing dune. The affected project area includes the northern 7.6 km of the KSC shoreline between approximately monuments V-065.3 and V-090 (Fig. 2). Of this total area, full dune and beach nourishment would be implemented along the northern 6.6 km from V-065.3 to V-087. The remaining 1.0 km from V-087 to V-090 would be constructed as a long taper to help integrate the newly renovated areas into the natural system.

Alternative Three represents a “hold-the-line” restoration strategy that seeks to reinforce and restore the beach/dune system at its current, eroded location. This differs from Alternative Two which seeks to restore the dune and beach to a seaward, historical location by placing the sand fill seaward of the existing duneline. In order to establish a stable dune along the existing dune line, Alternative Three places the sand fill atop the existing dune. This approach increases the chance of project success by defending against future erosion rather than attempting to reverse or combat it. Likewise, this approach decreases, but does not eliminate, the requirement for dedicated future renourishment.

Sand fill would be placed along the existing dune crest to provide a consistent dune height of about +5.0 to +5.2 m north of V-087. The dune width would be constructed to establish a fairly consistent sand volume across the entire primary dune as measured above the 25-year and 100-year still water storm surge elevations. Seaward of the improved dune, the beach berm would be widened and elevated by sand fill to protect the dune from typical high-frequency storms and wave uprush. This would include sand fill placement to allow for initial fill equilibration and six to ten years of advance renourishment. The constructed dune improvements would be planted with native salt-tolerant vegetation immediately after construction.

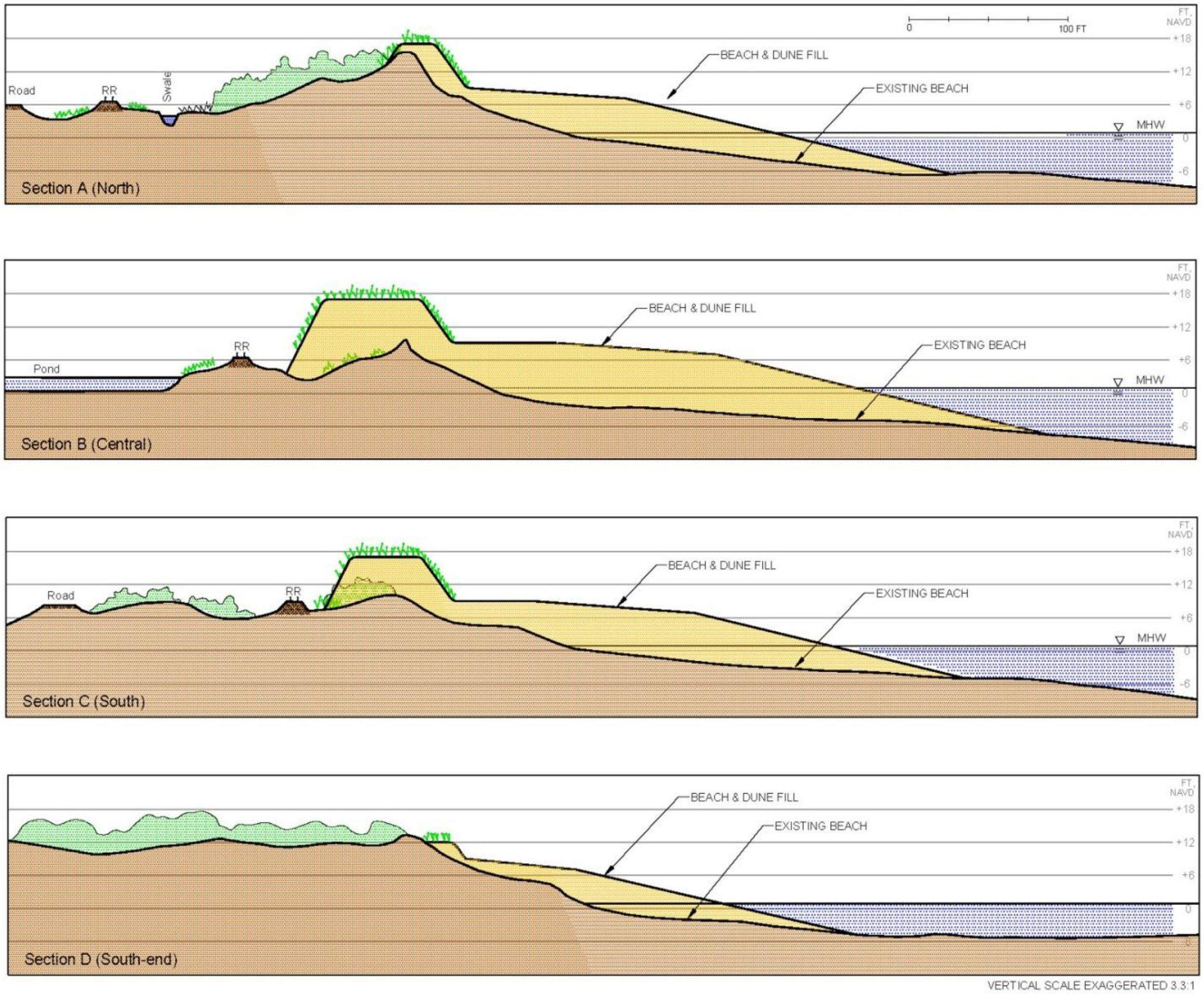


Figure 6. Alternative Three: Reinforce Dune plus Beach Fill

On the order of up to 1,760,000 m^3 of beach fill sand would be required to initially construct Alternative Three. This equates to about 237 m^3/m on average along the entire project length. These values represent a minimum typical recommended fill density for initial construction of beach restoration projects on Florida's east coast. Similarly to Alternative 2, the source of the beach-compatible sand fill would be the existing Canaveral Shoals II (CS-II) offshore borrow area in federal waters, or alternately, the Canaveral Shoals I (CS-I) offshore borrow area in State of Florida waters. The sand would be excavated by hydraulic hopper dredge, pumped to the project area via temporary pipeline, and then spread and graded by payloaders and bulldozers. Up to 1,950,000 m^3 of excavation at the borrow area may be required to supply the 1,758,000 m^3 beach fill. One or more hopper dredges would carry the excavated sand in 1500 to 3000 m^3 loads, moor to one of several submerged pipelines temporarily placed between the nearshore and the beach with the aid of temporary anchors or tender vessels, and pump the sand load to the beach through the pipelines via a seawater slurry. After spreading and grading, the beach would be tilled above the wave zone to reduce compaction and to facilitate marine turtle nesting activity.

Initial project construction would require approximately 30 days for mobilization, 150 days for sand placement, and 30 and 75 days for dune vegetation installation. Sand fill placement would be limited to the period November 1 to April 30, outside the sea turtle nesting season, and vegetation installation would occur in April through July. Construction of a 1.8 million m^3 project in one season (180 days) is practical as long as winter seas are typical. Assuming initial mobilization commences October 15, net sand placement of over 9557 m^3/day, including downtime, will be required. At this site, this is a reasonable expectation for one large hopper dredge (3058+ m^3), or two medium dredges (1529 m^3) each.

The post-project loss rate of sand from the project area is preliminarily anticipated to be on the order of 91,750 m^3 per year. Periodic renourishment of the project would be required at intervals of between 6 and 10 years, likely comprising between 550,480 m^3 and 917,500 m^3 per event, depending upon the renourishment frequency and the severity of storm erosion between events. Interim renourishment may be required after severe storm erosion. Periodic renourishment would seek to more or less restore the initial project construction template, adjusted to reflect the project performance as determined through prior physical monitoring.

Alternative Four: Hybrid Approach – Inland Dune Plus Beach Fill

Alternative Four is a hybrid of proposed Alternatives 1, 2, and 3. This action includes placement of sand to restore beach lost to erosion, reinforcement of the existing primary dune (principally along the seaward edge and face, similar to Alternative 2), and construction of a secondary dune inland of the primary dune, identical to Alternative 1 (Fig. 7). The inland dune would be constructed from either upland sand sources or offshore dredged sources. In the latter case, sand would be temporarily stockpiled on the beach and then mechanically rehandled to construct the inland dune. Swale wetlands and critical habitat would be avoided as much as possible during construction of the secondary dune. Salt-tolerant native vegetation would be planted along the crest and face of both the primary dune and inland dune as needed for stabilization.

The affected project area includes the northern 7.6 km of the KSC shoreline, between monuments V-065.3 and V-090 (Fig. 2). Of this total area, the inland dune would be constructed along the northern 5.8 km from V-065.3 to V-084.1; nourishment of the beach and primary dune would be accomplished along the northern 6.6 km, V-065.3 to V-087. The remaining 1.0 km, V-087 to V-090, would be constructed as a long taper consisting of beach renourishment with minor augmentation of the existing dune toe. Temporary stockpiling of sand on the beach for construction of the inland dune would occur along the central 3.1 km of shoreline, between monuments V-070 and V-080.

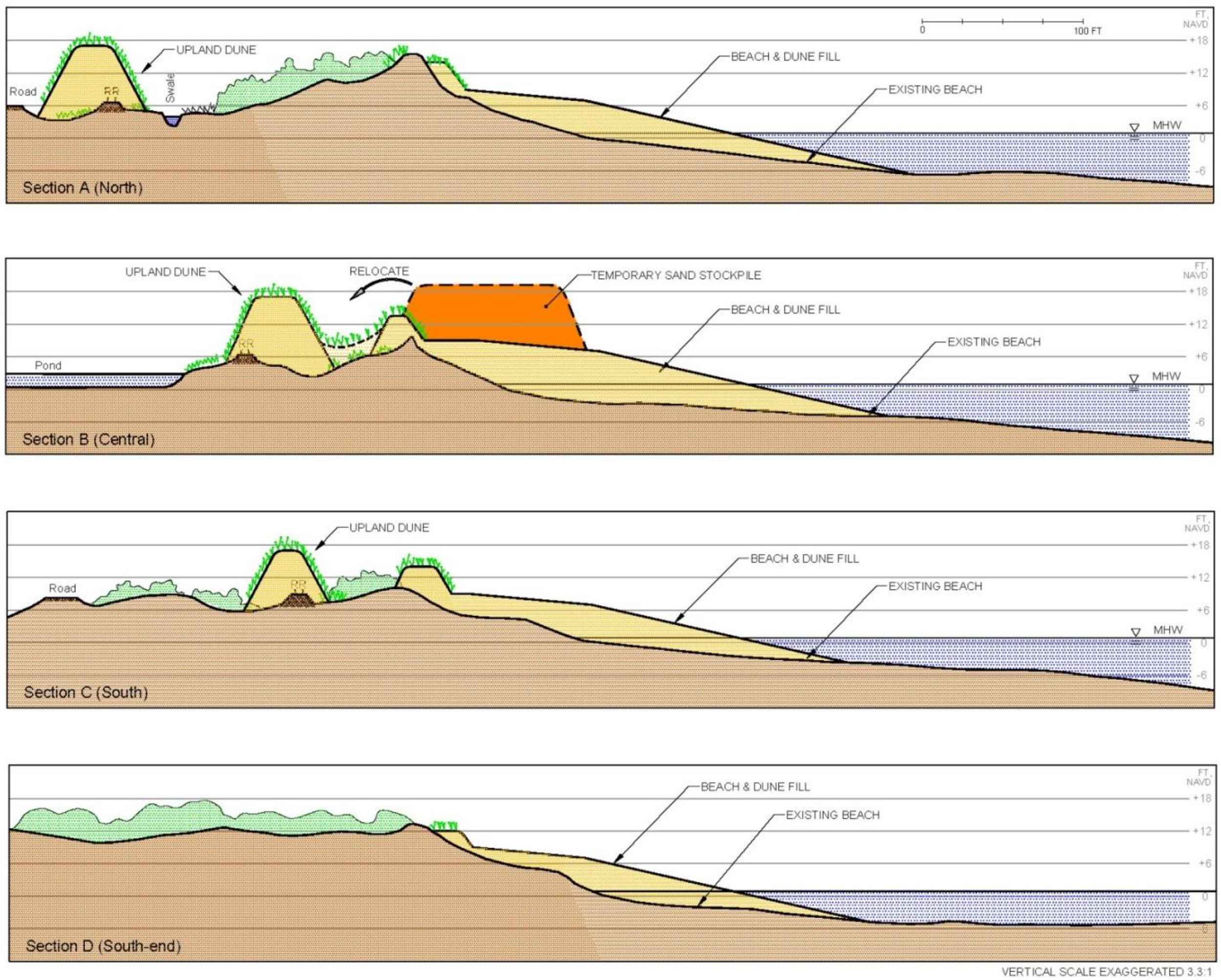


Figure 7. Alternative Four: Hybrid Approach – Inland Dune plus Beach Fill

Alternative Four represents a hybrid strategy that combines managed retreat with beach renourishment. That is, it combines construction of the inland dune (identical to Alternative 1) with a modest-scale beach/dune nourishment project (similar to Alternatives 2 and 3). But, in contrast to the latter two alternatives, Alternative Four limits the width and placement of beach fill sand to the seaward face of the primary dune in order to minimize the encroachment of the dune upon the beach and to minimize impacts to the existing dune vegetation/habitat. Alternative Four allows the inland dune to be constructed from sand dredged from an offshore borrow area in lieu of, or in addition to, upland truck-haul sand sources. The ability to construct the inland dune from offshore sands potentially improves the sediment and habitat quality of the dune, given the consistent, beach-compatible characteristics of sediment from the available offshore borrow areas. Further, it avoids impacts associated with upland truck-haul delivery of sand to the site. The nourishment of the beach and primary dune, constructed in addition to the secondary inland dune, will partly restore and stabilize the eroded beach/dune system; and as such, it will serve to protect the inland dune and therefore augment its longevity. The sand placed on the beach and primary dune will ultimately erode and require renourishment; however, future renourishment is not inherently critical to the long-term integrity of this project alternative because the inland dune provides a longer term, inland measure of shore and flood protection.

The overall dimensions and layout of the inland dune would be similar to that described for Alternative One. The beach and dune restoration north of monument V-087 would consist of augmentation of the primary dune to a crest elevation of at least +4.3 m. The beach nourishment berm would be constructed at a width of 23 to 30 m sloping from about +2.7 m at the dune to +2.1 m at the seaward edge. Along the southern 0.9 km of the project area (V-087 to V-090), the beach/dune nourishment would consist of augmentation of the existing dune toe, seaward of the vegetation line, and a berm width of about 21 m likewise sloping from elevation +2.7 to +2.1 m. For construction of the inland dune, a temporary sand stockpile would be constructed on the beach nourishment berm between monuments V-070 and V-080, above the typical limit of wave runup, to an elevation of +5.8 m. The nominal storage volume would approach 275,240 m^3. This stockpile would be created during hydraulic placement of the beach nourishment fill, and then offloaded by trucks to create the inland dune.

Up to 1,530,000 m^3 of beach fill sand would be required to initially construct Alternative Four. This equates to about 207 m^3/m on average along the entire project length. Up to 1,682,000 m^3 of excavation at the borrow area might be required to construct a 1,529,000 m^3 beach fill. The source of the beach-compatible sand fill would be the existing Canaveral Shoals II (CS-II) offshore borrow area in federal waters, or alternately, the Canaveral Shoals I (CS-I) offshore borrow area in State of Florida waters. The sand would be excavated by hydraulic hopper dredge, pumped to the project area via temporary pipeline, and then spread and graded by payloaders and bulldozers. One or more hopper dredges would carry the excavated sand in 1500 to 3000 m^3 loads, moor to one of several submerged pipelines temporarily placed between the nearshore and the beach with the aid of temporary anchors or tender vessels, and pump the sand load to the beach through the pipelines via a seawater slurry. The temporary sand stockpile would be constructed during the hydraulic beach fill operation using the same bulldozers and payloaders to lift and shape the stockpile. During and/or immediately after placement of the sand stockpile, excavators, payloaders and trucks would transfer the stockpiled sand to the inland dune locations. After final spreading and grading, the beach fill area would be tilled above the wave zone to reduce compaction and facilitate marine turtle nesting activity.

If properly sequenced, initial project construction would require on the order of 30 days for mobilization, 165 days for sand placement (beach fill and inland dune), plus between 30 and 75 days for dune vegetation installation after sand placement. Sand fill placement would be limited to the period November 1 to April 30. Dredging and beach placement of up to 1.5 million m^3 of sand would require about 160 days. Allowing initial mobilization of equipment upon the beach to commence October 15, and assuming a dredge start date of not later than November 15, it will require net sand placement of about 9,557 m^3 per day. At this site, this is a reasonable expectation of one large hopper dredge (3000+ m^3) or two medium dredges (1500+ m^3) each.

The post-project loss rate of sand from the project area is anticipated to be on the order of 91,750 m^3 per year. If elected, periodic maintenance renourishment of the beach element of the project would be required at intervals of 6 to 10 years, likely comprising between 550,480 m^3 and 917,470 m^3 per event, depending upon the renourishment frequency and storm severity. Interim renourishment may be required after severe storm erosion. Unlike Alternatives 2 and 3, however, periodic renourishment is optional (i.e., it can be delayed or forgone) because long-term defense against flooding and coastal inundation would be provided by the inland dune in the event that the primary dune and beach are eroded or breached by storms. Maintenance beach renourishment, when elected, would seek to more or less restore the initial project construction template, adjusted to reflect the project performance observed through monitoring.

ESSENTIAL FISH HABITAT BACKGROUND AND JUSTIFICATION

The 1996 amendment to the 1976 Magnuson-Stevens Fishery Conservation and Management Act (also known as the Sustainable Fisheries Act) set forth a mandate to describe, identify, and protect high value habitats for federally managed marine and anadromous fishes. The overarching purpose of this legislation is to ensure the long term quality and quantity of our nation's fishery resources. The Magnuson-Stevens Act requires Essential Fish Habitat (EFH) be designated for all species covered under a federal fishery management plan (FMP). EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (16 U.S.C. § 1801[10]). Waters include aquatic areas and their associated physical, chemical, and biological properties. Substrate includes sediment underlying the waters. Necessary means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem. "Fish" includes finfish, mollusks, crustaceans, and all other forms of marine animal and plant life other than marine mammals and birds. Spawning, breeding, feeding, or growth to maturity covers all habitat types utilized by a species throughout its entire life cycle.

EHF designations are often geographically expansive, a result of the fact that Fishery Management Plans often encompass multiple species with similar, but rarely identical, habitat requirements. Further, a majority of marine fish and invertebrate species have varied life history strategies and are dependent on both benthic and pelagic habitats as they mature. The Magnuson-Stevens Act also allows for a subset of EFH to be classified as Habitat Areas of Particular Concern (HAPC) in order to focus conservation efforts on areas that play a particularly important role in the life history of federally managed fishery species, are especially vulnerable to human-induced degradation, are under stress, or are naturally rare.

Fishery management plans are typically developed and enforced by one or more of our nation's eight fishery management councils. In East Florida, most FMPs are implemented by the South Atlantic Fishery Management Council (SAFMC) which has jurisdiction of federal waters from North Carolina to South Florida. A small number of species are jointly managed with the Gulf of Mexico Fishery Management Council (GMFMC) if stock boundaries so warrant. In addition, highly migratory fish species (HMS) such as tuna, billfish, swordfish, and sharks, are directly managed by the HMS Division of the NMFS.

NASA, like any federal agency which permits, funds, or undertakes an action with the potential to adversely affect EFH (i.e., reduce its quantity or quality) in either federal or state waters must first consult with NMFS. Adverse affects may include direct (e.g., contamination, physical disruption), indirect (e.g., loss of prey), site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions. NMFS and/or the relevant Councils review details of the project and provide advisory recommendations designed to avoid, mitigate, or offset damage to EFH during the project. While HAPC is not afforded additional regulatory protections, federal actions with the potential to cause adverse impacts to HAPC will be more carefully scrutinized during the consultation process and will be provided with more stringent conservation recommendations. The federal agency must then respond in writing to NMFS concerns and recommended conservation measures within 30 days with a plan to reduce EFH impacts or provide reasons why recommendations cannot be implemented as proposed.

Regional EFH Designations

Several federal Fishery Management Plans have been instituted to protect economically valuable fish and invertebrate resources off the east Florida coast. These include: Spiny Lobster, Shrimp, Golden Crab, Highly Migratory Species, Coastal Migratory Pelagics, Dolphin-Wahoo, and the Snapper-Grouper Complex. In addition, fishery management plans are also in place for Coral, Coral Reefs, Live/Hardbottom, and Sargassum (which does not have designated EFH) due to the large number of managed fish and invertebrate species intimately dependent on these habitats. Red drum also have a FMP, although management of the species has been largely transferred to the Atlantic States Marine Fisheries Commission because virtually all harvest now takes place in state (not federal) waters.

FISH HABITATS AND COMMUNITIES IN THE PROJECT AREA

Soft Bottom Substrates

Beach renourishment and sand mining actions described in Project Alternatives 2-4 are expected to primarily affect sub-tidal soft bottom and surf zone habitats with little if any anticipated impact to hard bottom substrates of the region. Soft bottom sand-mud substrates compose 77-90% of the inner continental shelf of the South Atlantic Bight (SAB) in terms of total areal coverage (Rowe and Sedberry, 2006). The fish fauna associated with this habitat has received some attention with early descriptions (e.g., Anderson and Gehringer, 1965; Struhsaker, 1969; Knowlton, 1972) typically the result of bycatch assessments in the penaeid shrimp fishery. The most compressive survey is the ongoing Southeast Area Monitoring and Assessment Program - South Atlantic (SEAMAP-SA), a joint effort of the South Carolina Department of Natural Resources and National Marine Fisheries Service. SEAMAP-SA began conducting annual standardized fishery-independent trawl surveys to monitor the abundance, habitat requirements, and life history attributes of coastal fishes and macroinvertebrates from Cape Hatteras to Cape Canaveral in 1973. The southern boundary of this survey lies just north of the proposed project area. In a 10-year (1990-1999) SEAMAP summary, 195 finfish taxa, 30 elasmobranchs, and 90 decapod crustaceans were collected (ASMFC, 2000). Fish captures were numerically dominated by two species, spot (*Leiostomus xanthurus*) and Atlantic croaker (*Micropogonias undulatus*), which together totaled 36% of all fish and invertebrates taken. Other abundant taxa included Atlantic bumper (*Chloroscombrus chrysurus*), porgies (*Stenotomus* spp.), and striped anchovy (*Anchoa hepsetus*). The most common macrocrustaceans included white shrimp (*Litopenaeus setiferus*), coarsehand lady crab (*Ovalipes stephensoni*), brown shrimp (*Farfantepenaeus aztecus*), iridescent swimming crab (*Portunus gibbesi*), and the lesser blue crab (*Callinectes similis*). Elasmobranchs, particularly carcharhinid sharks and pelagic and demersal rays, were collected less frequently but constituted a large percentage of overall biomass due to their large average sizes. Generally speaking, most fish species of direct economic value to the region occur at low densities in soft bottom habitats.

Soft bottom fish communities within or directly adjacent to the proposed project site at Cape Canaveral have never themselves been the subject of rigorous sampling. A brief Minerals Management Service survey (September 2000 and June 2001) of nine sand shoal sites offshore Brevard, Indian River, St. Lucie, and Martin Counties (including the Canaveral Shoals II borrow site) produced 63 fish taxa with dusky anchovy (*Anchoa lyolepis*) and silver seatrout (*Cynoscion nothus*) comprising 69% of all fish caught (Hammer et al., 2005). Macroinvertebrate catches included 32 taxa of stomatopods, decapod crustaceans, echinoderms, and squid.

Surf Zone

Surf zone habitats at Cape Canaveral (north of the Port Canaveral Jetty) differ from those further south in that they do not encompass hard-bottom resulting from exposed Anastasia limestone or the reef-building polychete *Phragmatopoma lapidosa*. Consequently, the resident fish fauna is likely qualitatively similar to sand-shell-mud communities in adjacent deeper water but may be somewhat depauperate, supporting elevated densities of those taxa [e.g., whiting (*Menticirrhus* spp.), Florida pompano (*Trachinotus carolinus*)] better adapted to surf conditions (Gilmore, 1977) while largely excluding species poorly adapted to high energy wave action. Only one published field survey (Peters and Nelson, 1987) near Melbourne and Sebastian Inlet (~75 km south of False Cape) has described the surf zone ichthyofauna of the central or north Florida Atlantic coast in any detail. This effort using beach seines documented 61 fish species with the scaled herring (*Harengula jaguana*), shortfinger anchovy (*Anchoa lyolepis*), and Florida pompano (*Trachinotus carolinus*) composing 70% of total catch.

The surf zone fish fauna at Cape Canaveral also contrasts to areas both north and south with respect to management. Due to national security and safety concerns at KSC and the adjacent Cape Canaveral Air Force Station (CCAFS), Canaveral beaches offer limited public access resulting in one of the least accessible shorelines of the Florida east coast. Shore-based fishing is allowed only by KSC and CCAFS personnel within 200 yards of three CCAFS dune crossovers (1200 yards total). Boat-based fishing is permitted on non-launch days but appears limited, especially north of the tip of the Cape (E. Reyier pers. obs.), likely due to the long distance anglers must travel from Port Canaveral as well as the shallow Southeast Shoal which hinder navigation of larger vessels. Data on surf zone fish abundance are unavailable but density of several economically valuable fish species (e.g., red drum, black drum, pompano, sheepshead, whiting) appears quite high (E. Reyier, pers. obs.). Most notably, the open surf zone and longshore troughs serve as a high value nursery for juvenile lemon sharks, which are present year round but gather in aggregations up to several hundred individuals each winter from November through March (Reyier et al., 2008). KSC and collaborating fisheries research groups are currently funding acoustic telemetry studies to assess site fidelity, habitat preferences, and migrations of several nearshore fish species including lemon sharks, red drum, black drum, pompano, and whiting.

Consolidated Substrates

Hardbottom substrates offer attachment sites for algae, sponges, corals, ascidians, and other sessile invertebrates, and serve as critical habitat for a multitude of fish taxa, many of which maintain near-obligate reliance on hardbottom for spawning, recruitment, and foraging. SAB hardbottom substrates consistently demonstrate higher levels of fish diversity and biomass than open sand-shell substrates and also support demersal species of greatest fishery valuable to the region (e.g., grouper and snapper; Sedberry and Van Dolah, 1984; Rowe and Sedberry, 2006). Consequently, hard-bottom is protected in the Coral, Coral Reef, and Live/Hard Bottom Fishery Management Plan and is considered EFH for many managed species including the snapper-grouper complex and spiny lobster.

Along the east-central and northeast Florida continental shelf, natural hard bottom substrate largely consists of low to moderate relief limestone pavement, ledges, and escarpments which are apparently relic Pleistocene dune formations. A comprehensive survey of limestone reefs and their associated fauna in the vicinity of the project area has not been undertaken although Perkins et al. (1997) compiled all available locational data of hardbottom substrates along the entire Florida Atlantic coast. This study demonstrated that hard bottom is widely distributed in waters off Cape Canaveral but did not identify any within either the proposed Canaveral Shoals I or II borrow sites or beach renourishment footprint potentially affected under Project Alternatives 2-4. The only consolidated substrate confirmed in the project area consist of low-relief (~0.25 m) humate sand outcroppings in the mid and lower-intertidal and shallow sub-tidal zones directly east of Launch Complex 39A (N 28.6070/W 80.5924; Figs. 8-9; Jaeger et al., 2011) Opportunistic field observations over the last several years suggest that these formations formations are spatially discrete, experience significant wave action, and are repeatedly exposed and reburied. The humate sands themselves have a spongy consistency supporting only poorly developed communities of algae, sessile invertebrates (e.g., sea urchins, snails, bivalves), and fish when compared to more typical nearshore reefs found in central and southern Brevard County

(Reyier, pers. obs.). Further, aerial imagery suggests that sub-tidal outcroppings only encompass an estimated 2000-3000 m^2 (0.5-0.75 acres), mostly near LC39A (Fig. 9). These features have never been formally surveyed but are expected to be similarly composed of consolidated humate sands.

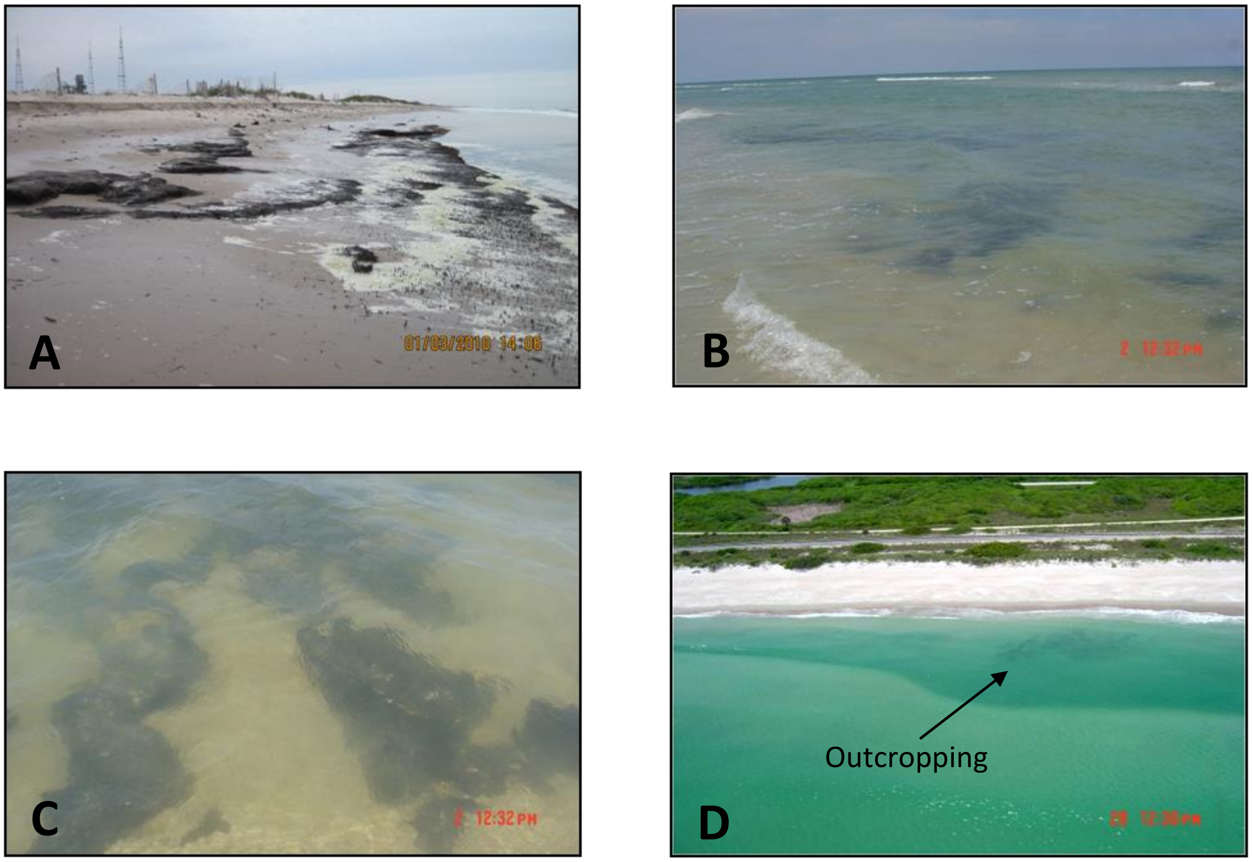


Figure 8. Consolidated low-relief humate sand outcropping. Outcrops occurs in both intertidal (A) and sub-tidal (B, C) but have a soft consistency seemingly unsuitable for extensive colonization by algae or invertebrates. Aerial observations suggest these outcrops are small, spatially discrete, and often buried (D).

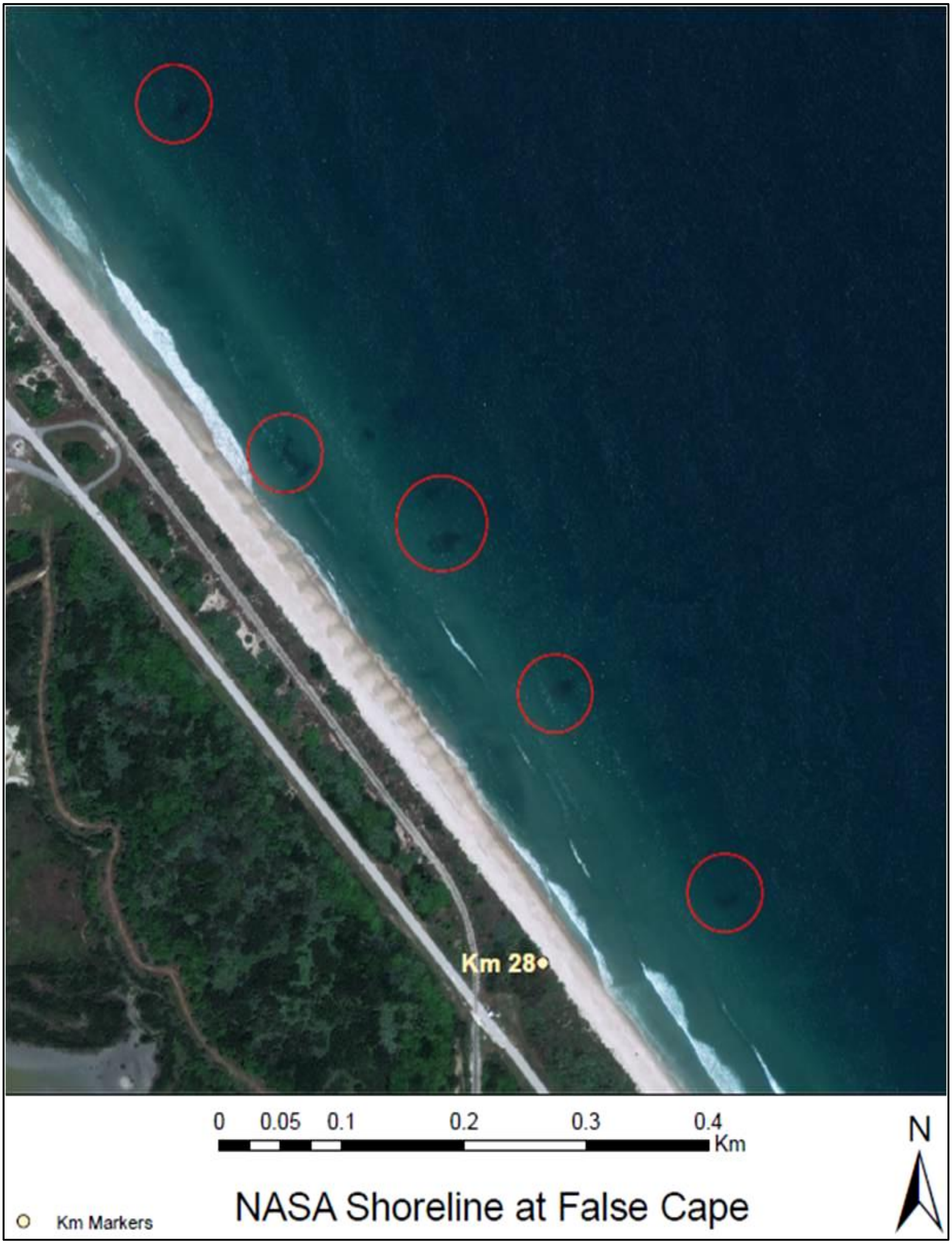


Figure 9. Aerial view of humate sand outcropping due east of Launch Complex 39A during a period of atypically good water clarity

Coastal Wetlands

The construction of an inland dune (as proposed in Alternatives 1 and 4) has the potential to temporarily impact small natural swales (via the construction of temporary access corridors, elevated turbidity, etc.) and may result in the permanent infilling of a manmade ditch near LC39B (Fig. 10). The exact project impacts are contingent on the final engineering design and construction mitigation measures. The natural swales are unquestionably landlocked and therefore unavailable for use as EFH. The connectivity of the manmade ditch is unclear. This ditch, approximately 1500 m long and 1-2 m wide (estimated surface area of 0.2 hectares), is at least 780 m from tidally-connected waters of the Banana River Lagoon and 2900 meters from Mosquito Lagoon, and water exchange with these water bodies is unquestionably hindered by numerous paved roads and impoundment dikes. Nonetheless, the ditch is connected with a culvert to a larger pond on the north side of LC39B. Even limited connectivity of this feature to the open estuary may allow it to serve as EFH for certain species such as penaeid shrimp, red drum, and sheephead. A field survey on 19 June 2012 noted a salinity of 26.3 psu but only marsh resident fishes (eastern mosquitofish, sailfish molly, and gulf killifish) were observed. Further, no sightings of large-bodied estuarine fishes (black drum, seatrout) were noted during a low altitude aerial overflight of the adjacent marsh ponds on 18 June 2012.

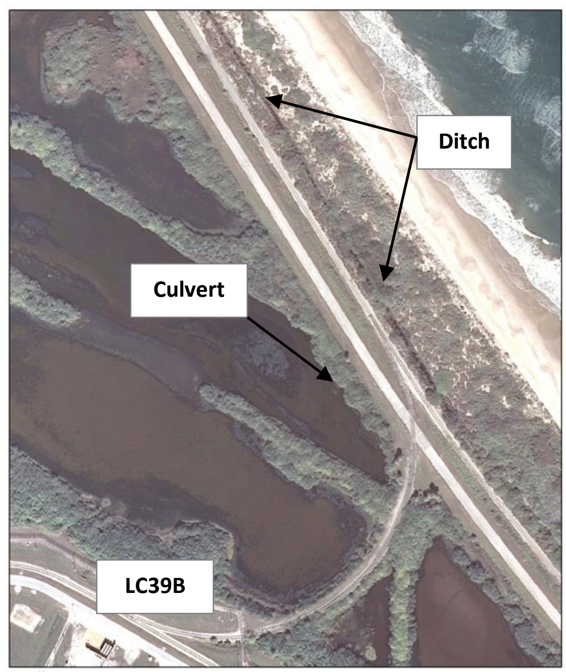


Figure 10. Aerial image of wetlands near LC39B in 1943 (left) and 1999 (right).

MANAGED SPECIES IN THE PROJECT REGION

Spiny Lobster

Spiny Lobster Life History

The spiny lobster (*Panulirus argus*) has a geographic range extending from North Carolina to Brazil including waters of the Gulf of Mexico, Caribbean Sea, and Bermuda, with scattered records from West Africa (Tavares, 2002a). Lobsters have a pelagic phase in which larvae are potentially dispersed long distances by ocean currents before they settle on rocky shorelines, coral reefs, and in seagrass beds. Lobsters tend to aggregate in ledges and crevices in reefs and rock rubble. Spiny lobsters prefer shallow water but move deeper with age can be found as deep as 90 m. Their diet consists mainly of small gastropod mollusks, isopods, amphipods, and ostracods.

The spiny lobster is the most valuable lobster species in the western central Atlantic and supports a sizeable recreational and commercial harvest out of nearby Port Canaveral. Spiny lobster should be expected to occur on any nearshore hardbottom and artificial reefs of east-central Florida and have been documented to exist in small numbers along the rock revetments inside Port Canaveral (Reyier et al., 2010) but are rare or absent in surveys of the nearby Indian River Lagoon system (Tremain and Adams, 1995; Paperno et al., 2001)

Lobster EFH and HAPC

EFH for juvenile and adult spiny lobster includes seagrass, unconsolidated soft bottom, coral and other hard bottom substrates, sponges, algal communities, and mangroves. The Gulf Stream is also considered EFH for its role in dispersing pelagic lobster larvae (SAFMC, 1998). All estuarine and nearshore waters in the Cape Canaveral region are designated as EFH (NOAA EFH Mapper, Table 1). Most spiny lobster EFH-HAPC is located in Florida Bay, Biscayne Bay, Card Sound, and coral/hard bottom habitat from Jupiter Inlet, Florida through the Dry Tortugas. A small area of EFH-HAPC (the northernmost HAPC established for the species) has been identified directly adjacent to the Canaveral Shoals II sand borrow site.

Project Impacts to Lobster EFH and HAPC

Impact to lobster EFH during any renourishment of KSC beaches is expected to be minimal because the project footprint is primarily comprised of open sand-shell bottoms where lobster density is expected to be low. The only consolidated substrates known in the renourishment zone are 0.5-0.75 acres of ephemerally-exposed humate sand outcrops (Fig. 8,9). These formations are located in very shallow water and experience significant wave action as well as repeated exposure and reburial. Further, the humate sands have a spongy consistency which appears less suitable for colonization by algae and sessile invertebrates. Given these factors, these outcrops are likely less than ideal substrates for settlement-size spiny lobster. Further, while EFH-HAPC is found directly adjacent to the Canaveral Shoals II borrow area, no hardbottom is known from the borrow site itself (Perkins et al, 1997).

Shrimp

Shrimp Life Histories

Five shrimp species are managed under the federal shrimp fishery management plan including the pink shrimp (*Farfantepenaeus duorarum*), brown shrimp (*Farfantepenaeus aztecus*), white shrimp (*Litopenaeus setiferus*), rock shrimp (*Sicyonia brevirostris*), and royal red shrimp (*Pleoticus robustus*). Cape Canaveral is a center of commercial shrimping on the Florida east coast. Trawlers work shallow nearshore waters for penaeid shrimp while rock shrimp (whose fishery originated in the Canaveral region) are harvested in deeper water. White and pink shrimp have been collected during limited scientific trawling surveys at the Canaveral Shoals II borrow site and within nearby Port Canaveral (Hammer et al. 2005; Reyier et al., 2010).

Pink Shrimp

The pink shrimp occurs in coastal waters from Chesapeake Bay to the Yucatán Peninsula with highest abundance off southwestern Florida and Gulf of Campeche. While occurring at depths greater than 300 m, they are generally found in water <70 m with maximum abundance in depths of 11 to 36 m (Tavares, 2002b). Adult pink shrimp prefer mud, sand, and calcareous shell bottom along the continental shelf. Spawning peaks offshore in warmer months (Bielsa et al., 1983). Females release 500,000 - 1 million eggs with post-larvae recruiting to estuaries as early as April and May. Juvenile pink shrimp typically overwinter in coastal seagrass beds and salt marshes before migrating to nearshore waters (Howe and Wallace, 2000). The pink shrimp life span is often less than one year and they can attain a maximum size of 300 mm but typically less than 200 mm. Pink shrimp are omnivorous, consuming polychetes, amphipods, nematodes, mysids, copepods, various other invertebrates, as well as organic debris. In turn, pink shrimp are a valuable prey item for a wide variety of finfish species.

Brown Shrimp

The brown shrimp ranges from Massachusetts to south Florida and throughout the Gulf of Mexico to the Yucatán Peninsula. Adult brown shrimp are most abundant over mud or sand/mud substrates in water less than 110 m (Tavares, 2002b). The spawning season is not well defined but females typically produce 500,000 - 1 million eggs. Many postlarval shrimp enter estuaries during February through late March to grow out and then migrate to deeper saltier water at night. Highest densities of post-larval and juvenile shrimp are found associated with seagrass and emergent marshes (Howe and Wallace, 2000). Both juveniles and adults are omnivorous bottom feeders on polychetes, amphipods, nematodes, caridean shrimps, mysids, copepods, and organic debris (Lassuy, 1983). The entire life span is about 1.5 years with a maximum size of 236 mm. Predators of post-larval shrimp are sheepshead minnows, insect larvae, water boatmen, grass shrimp, killifishes and blue crab. Juvenile and adult shrimp are targeted by many different finfish.

White Shrimp

The white shrimp occurs from New York to the St. Lucie Inlet in east Florida and from the Ochlocknee River on the Gulf Coast of Florida to Campeche, Mexico (Tavares, 2002b). White shrimp reach peak abundance over mud or clay bottoms in the lower reaches of estuaries and shallow continental shelf at depths less than 30 m. In the US South Atlantic, white shrimp spawn from March to November and produce about 500,000 to 1 million eggs. Post-larvae recruit to soft muddy bottoms of estuaries until growing out to the juvenile stage and migrating back to the ocean. Their lifespan is less than one year and they reach a maximum of 257 mm in length. White shrimp are omnivorous bottom feeders with a diet similar to brown shrimp (Muncy, 1984).

Rock Shrimp

Rock shrimp are typically found in deeper water than penaeid shrimp. Cobb et al. (1973) found the inshore distribution of rock shrimp to be associated with terrigenous and biogenic sand substrates and only sporadically on mud. Rock shrimp also utilize hard bottom and coral or more specifically, Oculina coral habitat areas (Kennedy et al., 1977). Commercial trawling for rock shrimp has caused considerable damage to coral on the Oculina Bank. Other than Kennedy et al. (1977), no characterization of habitat essential to rock shrimp has been conducted.

Royal Red Shrimp

Although no details are available regarding preferred habitats of royal red shrimp, they are often caught in association with deep water corals on the continental slope. Deep sea corals support high levels of marine biodiversity by providing habitat for numerous benthic species. As structure-forming animals, deep sea corals enhance habitat complexity by growing in the form of "reefs", fans, stalks, and "bushes". The *Enallopsamia* reefs off South Carolina, the *Oculina* habitat off Florida, and the *Lophelia* reefs from North Carolina to Florida may eventually prove important in the life history of royal red shrimp. Bottom impacting mobile gear such as trawls will likely impact these sensitive habitats.

Shrimp EFH and HAPC

For penaeid shrimp, EFH includes inshore nursery areas, nearshore Atlantic waters, and all interconnecting water bodies from North Carolina to the Florida Keys (SAFMC 1998). Inshore nurseries include tidal freshwater, estuarine, and marine emergent wetlands, mangroves, submerged aquatic vegetation, and subtidal and intertidal non-vegetated flats. Both the Canaveral Shoals I and II borrow site and renourishment areas listed in Project Alternatives 2-4 are classified as EFH (Table 1). HAPC for penaeid shrimp includes estuarine waters, tidal inlets, and state-designated overwintering areas. The project area is not classified as penaeid shrimp HAPC (NOAA EFH Mapper).

For rock shrimp, EFH consists of offshore terrigenous and biogenic sand bottom habitats from 18 to 182 meters in depth from North Carolina through the Florida Keys. The Gulf Stream is considered EFH for its role in dispersing rock shrimp larvae and deeper waters off Cape Canaveral are considered EFH because the shelf current systems here may help inshore recruitment of shrimp larvae. Nonetheless, the project will occur in water <18 deep so will not affect rock shrimp EFH. No HAPC has been identified for rock shrimp.

EFH for royal red shrimp include the upper regions of the continental slope from 180 meters to about 730 meters. The Gulf Stream is considered EFH for its role in dispersing royal red shrimp larvae. The project area is not considered royal red shrimp EFH and no HAPC has been identified for the species.

Project Impacts to Shrimp EFH and HAPC

Project alternatives 2-4 are expected to disturb penaeid shrimp EFH although these effects will be temporary and be of minimal population-level importance. While some direct mortality of shrimp should be expected at both the Canaveral Shoals borrow site and beach renourishment footprint, the primary impact may result from degradation of the epifaunal and infaunal communities that serve as a forage base for large juvenile and adult shrimp. These communities are expected to quantitatively recover in time although the species assemblage may take several years to return to a natural state. Until this occurs, the shrimp carrying capacity in the project footprint may be reduced and force existing shrimp to relocate to adjacent undisturbed habitat. The permanent in-filling of the manmade ditch near LC39B under Alternative 1 and 4 may also affect shrimp EFH if this feature has enough connectivity with the open estuary to allow shrimp recruitment. Nonetheless, the amount of area impacted (~0.2 ha) suggests that this impact will be spatially limited in scope.

Golden Crab

Golden Crab Life History

The golden crab (*Chaeceon fenneri*) is a large commercially marketable species that inhabits deep water (200-1000 m) of the continental shelf from Bermuda, the SE US, and eastern Gulf of Mexico (SAFMC, 2009). It supports a small deepwater fishery off east Florida.

Golden Crab EFH and HAPC

EFH for juvenile and adult golden crab includes benthic substrates of the continental slope from Chesapeake Bay south through the Florida Straits and into the Gulf of Mexico. The Gulf Stream is considered EFH for pelagic golden crab larvae (SAFMC, 1998). All designated EFH lies outside the project area and no HAPC has been identified (Table 1).

Projects Impacts to Golden Crab EFH and HAPC
None

Highly Migratory Species (Tuna, Billfish, Swordfish, Sharks)

Highly Migratory Species Life Histories
Tuna, billfish, swordfish, and sharks are directly managed by the Highly Migratory Species Office of the NMFS because most species in these groups are strongly migratory, a life history strategy which complicates stock management by a single Fishery Management Council. Five tuna species (albacore, bigeye, bluefin, yellowfin, skipjack), four billfish species (blue marlin, white marlin, sailfish, longbill spearfish), and the swordfish are included in the HMS Fishery Management Plan. All are pelagic, fast moving species that produce pelagic eggs and larvae (NMFS, 2009). Further, 39 of the 73 shark species known from waters of the US Atlantic (including the Gulf of Mexico, Puerto Rico, and the US Virgin Islands) are also covered under this plan. These sharks exhibit considerable variability in size, appearance, growth characteristics, reproductive strategies, and habitat preferences. Many (e.g., white sharks, tiger sharks) undertake extensive seasonal migrations although some (e.g., nurse shark) appear more sedentary. The movements and habitat preferences of many species remain largely unknown.

The Cape Canaveral region sustains a diverse shark fauna (Dodrill, 1977) and supports a modest commercial gill net and longline fishery (Trent et al., 1997; Burgess and Morgan, 2002). This fishery historically targeted blacktip and sandbar sharks but has shifted somewhat to other large coastal species (e.g., lemon and bull sharks) as the former species have become depleted. Local charter boats and recreational fishermen also directly target coastal sharks to some extent. Recent scientific studies have demonstrated that the Canaveral region serves as an especially important nursery for lemon sharks, nurse sharks (Reyier et al., 2008), spinner sharks (Aubrey, 2001) and scalloped hammerhead sharks (Adams and Paperno, 2007; Reyier et al., 2010). Young lemon sharks aggregate each winter within the surf zone and longshore troughs at Cape Canaveral in schools often containing several hundred animals. Scalloped hammerheads, nurse sharks, and spinner sharks are also found near the beach and along the shoals but in slightly deeper waters.

Highly Migratory Species EFH and HAPC

EHF has been delineated for most species under the HMS Fishery Management Plan. The project area is classified as EFH for twenty HMS species including sailfish, yellowfin and bigeye tuna, as well as sharpnose, blacknose, blacktip, bonnethead, bull, dusky, finetooth, great hammerhead, lemon, nurse, sand tiger, sandbar, scalloped hammerhead, silky, spinner, tiger, and white sharks (NMFS, 2009; Table 1). HAPC for HMS species has only been identified for bluefin tuna and sandbar shark and does not include waters off Cape Canaveral.

Projects Impacts to Highly Migratory Species EFH and HAPC

All HMS species are highly mobile as juveniles and adults and should suffer negligible direct mortality from sand mining and beach renourishment. Ephemeral increases in turbidity will also be of limited concern because Canaveral waters are not EFH for pelagic eggs/larvae of sailfish or tuna, and sharks produce precocious young capable of avoiding high turbidity conditions. Possibly the greatest concern would be changes in the behavior of juvenile lemon sharks. This species is exceedingly abundant at Cape Canaveral in winter and regularly inhabits the open surf and longshore troughs in water less than 0.5 m. While ongoing acoustic telemetry studies demonstrate that individual sharks are fairly mobile along the Canaveral shoreline, some locations appear to continuously hold sharks though the entire winter and even across years. Reworking or temporary infilling of longshore troughs resulting from renourishment may reduce foraging efficiency or cause sharks to displace to less optimal habitat.

Coastal Migratory Pelagics

Coastal Migratory Pelagics Life Histories

The coastal migratory pelagic fishery management plan includes the king mackerel (*Scomberomorus cavalla*), Spanish mackerel (*S. maculatus*), cero mackerel (*S. regalis*), cobia (*Rachycentron canadum*), and little tunny (*Euthynnus alletteratus*). Dolphinfish (*Coryphaena hippurus*), historically included under this FMP, are now managed under a more recent dolphin-wahoo FMP (SAFMC, 2003). All species are highly migratory along the southeast US coast with stocks jointly managed (when necessary) by the SAFMC and GMFMC. All species grow fairly rapidly, mature early, produce pelagic larvae, and have relatively high fecundity. Each species is important to some extent in regional recreational and commercial fisheries.

King mackerel

King mackerel are widely distributed over the continental shelf of the Southeast US coast and are found in both open water and associated with natural and artificial hard bottom. Juveniles generally occur closer to shore than adults but rarely enter estuaries. Both sexes mature at 3 to 4 years of age and spawning takes place from April to September in water deeper than 120 feet (Finucane et al., 1986; Collins and Stender, 1987). Diet consists of small schooling fishes including anchovies, menhaden, and threadfin herring (Naughton and Saloman, 1981). Two migratory groups mix in winter off the southeast Florida coast with the Atlantic stock migrating north in spring and the Gulf of Mexico stock migrating west. The king mackerel is the most economically valuable of all mackerel species. Off east Florida, it is pursued by recreational anglers, is the target of numerous fishing tournaments, and supports commercial harvest out of Port Canaveral.

Spanish mackerel

Spanish mackerel are found throughout the US southeast coast and northern Gulf of Mexico. The species forms fast-moving schools that are highly migratory. On the US east coast, the Spanish mackerel overwinters off Florida but moves north to the Carolinas in spring and to New York by early summer. While adults are most abundant in open water of the continental shelf, juveniles also regularly enter high salinity bays, and are known to occur sporadically within Port Canaveral and the Indian River Lagoon system (Reyier et al., 2008). Females mature by year two and spawn from May through September, generally in water less than 120 feet (Collins and Stender, 1987). As with the congeneric king mackerel, juvenile Spanish mackerel feed on small schooling fishes including anchovies, menhaden, and threadfin herring (Naughton and Saloman, 1981). The species supports a sizeable recreational fishery. Off Canaveral, a gill net fishery also occurs in Federal waters.

Cero mackerel

The range of the cero mackerel is limited to the western Atlantic Ocean from Massachusetts to Brazil, the Bahamas, and Caribbean Sea. Cero are more solitary than other mackerel species but can be found in small groups over reefs and ledges. It is usually seen in mid-water and near the water's surface. Cero feeds primarily on pelagic schooling fishes such as herrings as well as squid and shrimp. Spawning occurs year round off the coast of Florida with females producing up to 2.2 million eggs each year. Predators of cero mackerel include wahoo, sharks, dolphins, and diving sea birds. The cero mackerel is of only minor commercial importance but is a valued sportfish in some areas. Locally, the Cero mackerel has been documented associated with jetties inside Port Canaveral (Reyier et al., 2010).

Cobia

Adult cobia inhabit continental shelf waters and occasionally enter high salinity estuaries. They are common in open water, over hard bottom including reefs and wrecks, and associate with large marine organisms (rays, sea turtles, sharks), as well as drifting or stationary objects (buoys, pier pilings, etc.). Juveniles utilize inshore habitats such as estuaries, river mouths, bays, sounds, and inlets, as well as coastal and barrier island or beachfront waters. Both sexes mature by 2 to 3 years of age and spawning occurs May through August, most likely in the mouths of bays and sounds. Some spawning also occurs in open ocean waters. Like other coastal pelagics, cobia generally migrate south and offshore in fall and north and inshore in spring. Cobia are opportunistic bottom feeders, consuming portunid crabs, shrimp, and fish, including elasmobranchs. The species has commercial and recreational value throughout its range. Offshore Cape Canaveral, recreational and charter fishing, while seasonal, can be intense.

Little Tunny

The little tunny has a worldwide distribution in tropical and warm temperate seas. In the western Atlantic Ocean it ranges from Bermuda, Massachusetts to Brazil, the Gulf of Mexico, and Caribbean Sea. Little tunny school according to size and are found over the inner continental shelf. Little tunny typically occur closer to land than other tuna species and commonly gather around inlets, points, jetties, and sandbars. Spawning occurs in April through November with females producing as many as 1,750,000 eggs per year. Little tunny have a broad diet, feeding on crustaceans, clupeid fishes, squids, and tunicates. It often feeds on herring and sardines at the surface of the water. In turn it is preyed on by other tuna, dolphinfish, wahoo, billfish, and sharks. The little tunny is commercially important in some areas of the western Atlantic and has some interest in recreational fisheries as well. The flesh of the little tunny is darker and stronger tasting than that of the other large tunas. It is often used as bait for larger sportfish.

Coastal Migratory Pelagics EFH and HAPC

EFH for coastal migratory pelagics in the South Atlantic Bight includes shoals, capes, and offshore bars, the surf zone, high relief hard bottom, coastal inlets, and floating sargassum from the shoreline to the Gulf Stream (SAFMC, 1998; NOAA EFH Mapper). In addition, the Gulf Stream itself is EFH because it provides a mechanism to disperse pelagic larvae. In Florida, HAPC includes the Point off Jupiter Inlet, *Phragmatopoma* (worm) reefs, nearshore hard bottom south of Cape Canaveral, The Hump off Islamorada, the Marathon Hump off Marathon, the Wall off of the Florida Keys, and pelagic sargassum wherever it occurs. In the project area, EFH occurs in the surf zone at the northern boundary of the proposed renourishment footprint (Table 1). No HAPC is designated locally except that associated with pelagic sargassum.

Projects Impacts to Coastal Migratory Pelagics EFH and HAPC

The impact to coastal migratory fish EFH is expected to be minimal. While beach renourishment actions may have temporary direct or indirect impacts to some surf zone fishes, mackerel, little tunny, and cobia are highly mobile and can rapidly displace from ephemeral disturbances caused by this action (e.g., turbidity, noise). Further, these species largely forage on pelagic fishes, not benthic invertebrate communities most likely to be altered by sand mining and fill placement.

Dolphin-Wahoo

Dolphin and Wahoo Life Histories

Dolphinfish

Dolphinfish (*Coryphaena hippurus*), commonly known as mahi mahi, are one of the most popular pelagic recreational fishery species and also support a modest commercial fishery in Florida. Dolphinfish are circumtropical with populations migrating over long distances. In the western Atlantic, dolphinfish spawn in the Florida Current from November through July with peak reproductive effort in March. Juveniles and adults migrate northward in spring, reaching northeast Florida in late spring and early summer. An extremely fast growing species, dolphinfish feed on fish (e.g., flying fish, halfbeaks, man-o-war fish, *Sargassum* fish, rough triggerfish), cephalopods, and crustaceans, and are themselves consumed by larger tunas, billfish, jacks, and dolphin. They are often associated with floating mats of sargassum, especially around the edges of the Gulf Stream. They normally stay in clear oceanic water and move over the continental shelf with meanders and eddies of ocean currents. The best available scientific information indicates there is one stock of common dolphin throughout the western Atlantic.

Wahoo

The wahoo (*Acanthocybium solandri*) is a fast growing oceanic pelagic fish found worldwide in tropical and subtropical waters. In the western Atlantic, wahoo are found from New York through Columbia including Bermuda, the Bahamas, the Gulf of Mexico, and the Caribbean. Wahoo are present off east Florida year round where they sustain commercial and recreational fishermen (SAFMC, 2003). Spawning season extends from June through August with peak spawning in June and July. Wahoo are strongly piscivorous. Based on work in North Carolina, fish (e.g., mackerels, butterfishes, porcupine fishes, round herrings, scads, jacks, pompanos, and flying fishes) accounted for 97.4% of all food organisms (Hogarth, 1976).

Dolphin-Wahoo EFH and HAPC

EFH for dolphin and wahoo includes the Gulf Stream, Charleston Gyre, Florida Current, and pelagic Sargassum (SAFMC, 2003). In Florida, HAPC for dolphin and wahoo includes the Point off Jupiter Inlet, The Hump off Islamorada, the Marathon Hump off Marathon, the Wall off of the Florida Keys, and pelagic sargassum wherever it occurs. The proposed project area does not include EFH or HAPC except when sargassum is present (Table 1).

Projects Impacts to Dolphin-Wahoo EFH

As with coastal migratory pelagics, the impact to coastal migratory fish EFH is expected to be minimal. Both species are highly mobile and can rapidly displace from habitat disturbance in the project area, and their preferred food sources (pelagic prey) will not be significantly impacted by sand mining or beach renourishment.

Snapper-Grouper

Snapper-Grouper Life Histories

Seventy-three species from ten fish families (Balistidae, Carangidae, Ephippidae, Malacanthidae, Haemulidae, Polyprionidae, Labridae, Lutjanidae, Serranidae, Sparidae) are managed under the snapper-grouper fishery management plan. This group contains among the most economically valuable finfish species in the US South Atlantic. Groupers (family Serranidae) and snapper (Lutjanidae), in particular, are of tremendous commercial and recreational value to the region. These species are managed collectively because they all exhibit some association with coral reef or other hard bottom habitats throughout their life history. Some are intimately dependent on hard bottom throughout ontogeny (spawning, foraging, shelter) while other have facultative associations or are also dependent on other regional habitat types (e.g., mangroves, seagrass), especially as juveniles. Some species are sequential or simultaneous hermaphrodites, most spawn pelagic eggs, all produce pelagic larvae, and many form distinct spawning aggregations at the same sites each year. These sites are often well known to fishermen, making overharvest more likely. Many species are highly migratory and can swim several hundred kilometers. These migrations are not well known for many taxa.

The majority of species in the snapper-grouper complex should be expected within nearshore waters of Cape Canaveral (26 species from this group were recently documented from hard-bottom habitats within nearby Port Canaveral, Reyier et al., 2010). Scamp, gag, and red grouper, gray and red snapper, and amberjack are of particular importance to recreational and commercial fishermen locally. Goliath grouper (now prohibited from harvest) are a common presence on shallow reefs, while sheepshead, gray snapper, and jack crevalle are of considerable interest to the recreational fishery in the nearby Indian River Lagoon.

Snapper-Grouper EFH and HAPC

EFH for species listed in the snapper-grouper management plan includes coral reefs, other live/hard bottom, artificial reefs, unconsolidated soft bottom, and submerged aquatic vegetation (seagrass and macroalgae), from the shore to at least 183 meters deep where annual water temperature is adequate to sustain adult populations (SAFMC, 2009). EFH also includes the water column overlying adult demersal habitats as well as pelagic sargassum because these habitats are utilized for spawning and/or pre-settlement larvae. The Gulf Stream is also EFH because it provides a mechanism to disperse snapper-grouper larvae.

Areas which meet the criteria for snapper-grouper HAPC include nearshore and offshore hard bottom where spawning normally occurs, sites of known or suspected spawning aggregations, mangrove, submerged aquatic vegetation, oyster reefs, coastal inlets, sargassum as well as specific locations including The Point, The Ten Fathom Ledge, and Big Rock (North Carolina); The

Charleston Bump (South Carolina), Hoyt Hills for wreckfish, the Oculina Bank Habitat Area of Particular Concern, all hermatypic coral habitats and reefs, manganese outcroppings on the Blake Plateau, and Council-designated Artificial Reef Special Management Zones (SAFMC, 2009). Locally, all areas within and adjacent to both the offshore sand borrow site and nearshore deposition site are classified as snapper-grouper EFH (Table 1). Snapper-grouper HAPC is limited to a small area adjacent to the northwest corner of the Canaveral Shoals II sand borrow site (NOAA EFH Mapper).

Projects Impacts to Snapper-Grouper EFH and HAPC

Impacts to snapper-grouper EFH and HAPC are expected to be modest and temporary in nature. No substantial limestone reef, hermatypic coral, or artificial reefs are known from either the Canaveral Shoals sand borrow sites or the proposed renourishment footprint (Perkins et al., 1997; NOAA EFH Mapper; E. Reyier, pers. obs.). The only consolidated substrates are small humate sand outcroppings due east of Launch Complex 39A. The location and characteristics of these outcrops suggest they do not serve as high quality reef habitat and likely supports reduced fish densities and diversity relative to true hard bottom habitats in the region. Some species in the snapper-grouper complex do not consistently associate with reefs. Sheepshead, jack crevalle, and horse-eye jack are commonly observed in the open surf at Cape Canaveral; spadefish and black sea bass are often observed associated with even small pieces of structure (debris, large shells). While these species may be most directly impacted by mining and renourishment activities, they are also highly mobile and able to relocate to nearby undisturbed settings.

Corals, Coral Reefs, and Live/Hard Bottom

While the majority of the Florida east coast continental shelf is characterized by expansive sand and mud-covered plains with rather low biological productivity, hard bottom habitats are scattered at varying densities and depths throughout the region (Struhsaker 1969; Sedberry and Van Dolah, 1984; SAFMC, 1995). These features serve as attachment substrates for a diverse assortment of marine life including algae, coral colonies, tunicates, bryozoans, and provide shelter and provide foraging opportunities for a wide variety of invertebrates and fishes including many of considerable economic value to the region. Hard bottom in nearshore waters off east Florida consists of many different materials. Substantial hermatypic coral reefs are found in shallow water (typically in water less than 40 m) from the Florida Keys to roughly Martin County. In addition to sustaining high productivity and biodiversity, these reefs protect shorelines and shelter other marine habitats (e.g., seagrass, mangroves) from otherwise high energy conditions.

Non-coral nearshore hardbottom habitats are the primary natural reef structures in east-central and north Florida. These habitats are derived from large accretionary ridges of coquina mollusks, sand, and shell marl which lithified parallel to ancient shorelines during Pleistocene interglacial periods. Nearshore hardbottom habitats on the inner shelf are patchily distributed among large expanses of barren, coarse sediments and show reduced coral diversities. Nelson (1990) recorded 325 species of invertebrates and plants from nearshore hardbottom habitats at Sebastian Inlet. In some areas, the hardbottom reaches heights of 2 m above the bottom and is highly convoluted. Hard corals are rare due to high turbidities and wave energy. However, hard corals that are encountered are *Siderastrea radians*, *Oculina diffusa* and *Oculina varicosa*.

A keystone contributor to the biological diversity of nearshore hardbottom habitats along the east Florida coast is the polychete *Phragmatopoma lapidosa.* Worms of this species (Family Sabellariidae) bind sand particles together to make sand tubes, forming vast reefs in intertidal and shallow (<5 m) subtidal hard bottom from just south of Cape Canaveral to Key Biscayne as well as elsewhere in the Caribbean. In Florida, the structure provided by these worm reefs support a higher diversity and abundance of marine species than that of neighboring sand or hardbottom habitats. In particular, worm reefs are considered important sources of food and shelter for juvenile green turtles (*Chelonia mydas*).

Coral EFH and HAPC

EFH for corals (stony corals, octocorals, and black corals) incorporates habitat for over 200 species. Specific EFH for stony corals includes rough, hard, exposed, stable substrate from Palm Beach County south through the Florida reef tract in subtidal water to 30 m depth, subtropical (15°-35° C), oligotrophic waters with high salinity, and turbidity levels sufficiently low enough to provide algal symbionts adequate sunlight penetration for photosynthesis. EFH for ahermatypic stony corals (which are not light-restricted) includes defined hard substrate in subtidal to outer shelf depths throughout the management area. EFH for Antipatharia (black corals) includes rough, hard, exposed, stable substrate, offshore in high salinity waters in depths exceeding 18 meters, not restricted by light penetration on the outer shelf throughout the management area. EFH for octocorals excepting the order Pennatulacea (sea pens and sea pansies) includes rough, hard, exposed, stable substrate in subtidal to outer shelf depths within a wide range of salinity and light penetration throughout the management area. EFH for Pennatulacea (sea pens and sea pansies) includes muddy and silty bottoms in subtidal to outer shelf depths within a wide range of salinity and light penetration.

In east Florida, HAPC for corals, coral reefs, and live/hard bottom include *Phragmatopoma* (worm) reefs, the Oculina Banks from Ft. Pierce to Cape Canaveral, nearshore (0-4 m) hard bottom from Cape Canaveral to Broward County; offshore (5-30 m) hard bottom off from Palm Beach County to Fowey Rocks, Biscayne Bay, Biscayne National Park, and the Florida Keys National Marine Sanctuary. Within the project area, coral EFH and HAPC is designated in the immediate vicinity of both the Canaveral Shoals I and II borrow sites as well as immediately offshore the KSC shoreline (Table 1).

Projects Impacts to Corals, Coral Reef, Live/Hard Bottom EFH and HAPC

Sand mining and beach renourishment actions have the potential to damage coral and hard bottom communities through a number of mechanisms including direct physical damage from dredge heads, pipes, and anchors, as well as elevated turbidity, and burial. However, no significant coral or hard bottom habitats have been identified within the Canaveral Shoals borrow sites or the nearshore beach renourishment footprint. Therefore, the risk to these habitats appears limited.

POTENTIAL ADVERSE EFFECTS OF PROJECT ON EFH AND MANAGED SPECIES

Coastal dredging and renourishment operations affect marine organisms in several ways. Short-term impacts can include ephemeral changes in habitat quality, water chemistry, or organism behavior derived from the mechanical disturbance of the seafloor during the act of dredging. These impacts, while harmful, are usually localized and dissipate rapidly once dredging activity ceases. Long-term impacts can consist of more permanent changes to benthic substrates and hydrodynamics, or disruptions of vulnerable life history stages of marine species. The following section summarizes the potential threats specific to fish and commercially important macroinvertebrate communities that may arise from dredging and renourishment operations along the east-central Florida continental shelf including: (1) entrainment, (2) behavioral alterations, (3) turbidity and sedimentation, (4) changes to soft-bottom bathymetry, and (5) risks to hardbottom habitats. Much of this information is derived from other regions where dredging has been more thoroughly studied, however, even where dredging impacts to biota have received considerable scrutiny, long term consequences to habitat suitability and population-level dynamics of marine organisms often remain poorly understood (National Research Council, 1995).

Entrainment

Entrainment refers to the physical uptake of organisms during dredge operation. Dredge entrainment of fish and invertebrates has long been a concern because associated mortality rates are likely quite high. Entrainment rates are a function of dredge type, water depth, speed and volume of dredge operations, as well as species-specific characteristics. Benthic macroinvertebrates tend to be especially prone to entrainment. Female blue crabs (*Callinectes sapidus*) are considered vulnerable since egg-bearing individuals overwinter within sediments and may be too lethargic to avoid uptake. Sand shrimp (*Crangon* spp.) and commercially valuable penaeid shrimp are also thought to be susceptible as are sessile bivalves such as oysters, mussels, clams, and scallops (Reine and Clarke, 1998).

Fishes are also regularly entrained in dredges although generally in low numbers. Larval and juvenile fishes are often of greatest risk of entrainment due to their limited mobility and swimming strength. In one of the more complete studies, McGraw and Armstrong (1990) recorded entrainment of 28 fish species in Grays Harbor, WA, at species-specific rates ranging from <0.001 to 0.594 individuals per cubic yard with highest entrainment suffered by burrowing or otherwise demersal fishes. To date, however, the greatest concern is directed towards anadromous sturgeon, salmon, shad, and striped bass spawning and recruitment success that may be dependent on their ability to successfully bypass estuarine and riverine dredging operations and associated turbidity plumes. Entrainment-related mortality of fishes has not been adequately assessed in open coastal waters.

On the east Florida continental shelf, the distribution of individual fish and macroinvertebrate species is largely determined by water depth, temperature, and salinity with most species ranging widely throughout the study area (ASMFC, 2000; Rowe and Sedberry, 2006). Therefore, entrainment during offshore sand dredging operations, even if associated mortality is high, is likely to have minimal population-level impacts for most taxa. Fish entrainment should be a localized, short-term concern for only a few families such as burrowing eels and gobies as well as slow moving demersal taxa including sea robins, flatfish, and batfish. Further, given the scarcity of economically valuable reef fishes in open sand habitats that serve as common borrow sites, entrainment mortality is expected to have negligible negative economic impact on coastal fisheries. Entrainment of penaeid shrimp may be more of a concern. Some entrainment should be anticipated year round but rates may be elevated during periods of high juvenile fish recruitment, likely during the spring and summer.

Behavioral Alterations

Fish use underwater sound pressure waves to locate food and detect the presence of predators. In addition, many coastal fishes are soniferous, using sound to communicate, especially during courtship and spawning. Certain macroinvertebrates such as alpheid snapping shrimp and barnacles also produce sound. It has been demonstrated that biological sounds are often considerable at certain times and places and are known to attract settlement stage fish larvae to reefs (Leis et al., 2003). While behavioral alterations of nekton resulting from anthropogenic sound pollution including dredging is poorly studied, it is possible that foraging, spawning, and recruitment success of fishes and macroinvertebrates will be impacted in the immediate vicinity of dredging operations, causing some organisms to relocate. It is also possible however that the physical presence of dredging infrastructure and light produced during nighttime operations may actually attract other species to the vicinity.

Turbidity and Sedimentation

Increased turbidity is often generated directly at the site of sediment excavation or as slurry overflow and dewatering from dredge barges. Wind, waves, and strong directional currents can also resuspend fine particles that accumulate in dredge areas for many years after excavation has ceased. Turbidity may alter the trophic dynamics of an area by reducing the feeding efficiency of planktivorous fish (Hecht and Van der Lingen, 1992; Benfield and Minello, 1996) and may clog feeding structures of infaunal taxa, leading to a reduction in benthic prey resources. In rivers and estuaries, turbidity plumes may hinder spawning migration of anadromous fishes (although some estuarine turbid zones are recognized as high value habitat for larval fishes due to high rates of survival and growth; North and Houde, 2001). Turbidity can also directly influence fishes by irritating or clogging gill membranes and sediment deposition can coat eggs of deposit spawners, hindering egg respiration and increasing mortality.

The direct impact of turbidity on mortality, growth, and spawning behavior for continental shelf fishes and macroinvertebrates is largely unstudied but is likely a minimal concern in the project footprint since most fish are mobile enough to escape or avoid areas of highest turbidity. Further many shelf fishes are likely adapted to relatively high ambient turbidity levels. Sedimentation also likely poses minimal threat to fish spawning success because most shelf taxa, including virtually all valuable fishery species, produce pelagic eggs.

Changes to Soft-Bottom Bathymetry

Sand shoals may support an ichthyofauna somewhat dissimilar to the surrounding seafloor. Many shoals that possess differing sediment types and associated infaunal communities, may also serve as shallow-depth refugia from predators, physical landmarks on which fish assemble or spawn, and may also be areas of high turbidity that enhance survival of small-bodied prey taxa. In U.S. Atlantic waters, the fisheries value of sand shoals has received some scrutiny as a result of MMS interest in mining offshore sand deposits (e.g., Byrnes et al., 1999; 2003; Hammer et al., 2005; Slacum et al., 2006) and shoals have previously been identified as valuable habitat for fishes including cod (Fahay et al., 1999) and juvenile sharks (Rountree and Able, 1996; Reyier et al., 2008).

The physical reworking during dredging and renourishment may lead to an immediate reduction in the biomass, density, and diversity of infauna and epifauna. These organisms serve as essential prey for many small-bodied benthic fishes. Loss of this forage base during dredging will have an immediate negative consequence on the survival and growth rates of benthic fishes in the immediate vicinity of dredge operations, with the most severe impacts apportioned to those species with limited mobility. Further, borrow sites are often recolonized by differing benthic communities, a factor that may eliminate some selective benthic feeders, resulting in lower local diversity of demersal fish and macrocrustaceans.

Damage or burial of hard bottom

Dredging impacts to hardbottom substrates have been a concern for many decades. Damage to reefs is caused by the dredges themselves, barge anchors and mooring chains, and sand discharge pipelines. These dredging impacts typically destroy the coral and associated invertebrate communities and reduce reef rugosity. Such changes often reduce reef carrying capacity, alter fish spawning behavior, and shift the communities toward algal dominated systems. In Florida, much dredging-related reef damage is related to sand deposition on nearshore reef structures. Lindeman and Snyder (1999) documented a dramatic decline in both fish species and individuals after the burial of a nearshore reef structure in southeast Florida.

Although substantial hardbottom is not known in the project footprint, it is widespread in the general vicinity (Perkins et al., 1997). These substrates should be expected to harbor a diverse assemblage of reef fishes and macrocrustaceans, many of which are the target of recreational and commercial fishermen throughout the region.

Cumulative Impacts

Cumulative impacts to EFH and the local fish fauna are also expected to be minimal. Dredging and renourishment operations will most adversely affect soft-bottom demersal fishes through entrainment or removal of their invertebrate forage base. However, given the planktonic dispersal strategies of most local fishes and the relatively high adult mobility of even small fish taxa, recolonization will occur after each dredge cut. This recolonization should proceed rapidly because the species assemblage adjacent to project impact areas are likely similar offering a proximate source of both adults and young recruits. Cumulative impacts to reef fish taxa, which is a legitimate issue in many areas due to mechanical damage or siltation of exposed hardbottom, is of minor concern locally since no hardbottom is within the proposed sand borrow areas. Impacts to pelagic fish species are also negligible given their high mobility and limited reliance on substrate type and benthic invertebrate prey.

NASA'S CONCLUSION REGARDING PROJECT EFFECTS TO EFH

Project Alternative One: Inland Dune

Alternative One represents a managed retreat strategy by establishing shore protection on 5.8 linear km of shoreline landward of the existing dune with minimal fill placed on the beach. Habitat impacts would occur primarily in uplands with sand fill obtained from upland sand sources. While some low salinity swales may also be impacted, these features have no existing connection to the adjacent Banana River Lagoon estuary and are therefore of no habitat value to federally managed fish and invertebrate species (e.g., shrimp) which commonly utilize coastal wetlands. A small (0.2 ha) manmade ditch may also be permanently removed as the result of dune construction. The connectivity of this ditch with the open estuary is unknown but appears limited or non-existent so its EFH value is negligible. **NASA therefore concludes that Alternative One, if implemented, will have no effect on EFH or managed fish species.**

Project Alternative Two: Restore Beach and Dunes

Alternative Two entails an aggressive beach renourishment effort intended to restore 7.6 km of the dune and beach to the dimensions that existed approximately 10 - 15 years ago. This effort will rebuild beach width lost to erosion and reinforce the height and width of the primary dune. Up to 2.4 million m^3 of beach-compatible sand fill would be mined with hopper dredges from the existing Canaveral Shoals II (preferred) or Canaveral Shoals I offshore borrow area to complete this renourishment.

A fraction of the sand fill initially placed on the beach will migrate with time into the lower intertidal and shallow sub-tidal zones. This fill has the potential to partially or completely smother epifanual and infaunal invertebrate communities, temporarily reducing overall invertebrate biomass and diversity. While these organisms are of minimal direct management concern, they serve as valuable forage for many economically valuable fishes. As such, the shallow surf zone is classified EFH for several managed fish species. Sand migration may also cause changes in beach profiles, reducing the extent and size of longshore troughs which serve as aggregation sites juvenile lemon sharks from November through March and teleost sportfish (e.g., black drum, pompano) throughout the year. The shoreline should eventually rebuild a natural bar profile and invertebrate densities should approach pre-renourishment densities over the timescale of weeks to months (although may remain qualitatively different for much longer). Dredging of the sand fill from the Canaveral Shoals II and Canaveral Shoals I offshore borrow sites will similarly affect EFH by altering or removing benthic invertebrate communities and may cause temporary displacement of mobile nekton from noise and turbidity plumes. Neither dredging nor subsequent renourishment are anticipated to have impacts to limestone or coral hard bottom substrates.

NASA concludes that Alternative Two, if implemented, is unlikely to have direct lethal effects on managed fishes (most are mobile enough to avoid direct mortality) but may adversely affect EFH by degrading benthic invertebrate food resources and altering shore profiles and bathymetry. All of these effects are expected to be temporary with physical and biological characteristics eventually returning to a relatively natural state.

Project Alternative Three: Reinforce Dune Plus Beach Fill

Under Alternative Three, the primary dune would be reconstructed or reinforced in its existing location with sand and vegetation over a 7.6 km section of shoreline, and sand would also be placed atop the existing beach to provide a wide berm protecting the dune. This strategy represents a “hold-the-line” renourishment approach. This approach differs from Alternative Two in that it does not intend to restore the dune or beach seaward to an earlier (less eroded) state. Up to 1.8 million m^3 of sand would be required and would be obtained by dredging the existing Canaveral Shoals II (preferred) or Canaveral Shoals I offshore borrow area.

As with Alternative Two, this restoration approach is unlikely to cause significant direct mortality to managed species but may affect EFH by degrading the benthic invertebrate forage base, and possibly through changes in beach morphology which reduce habitat complexity. However, given that less sand is required from offshore borrow sites as opposed to Alternative Two (1.8 million m^3 vs. 2.4 million m^3) and that sand will be placed on the beach simply to protect the dune, not extend the shoreline, overall EFH impacts are likely to be less than in Alternative Two. **NASA concludes that Alternative Three, if implemented, may adversely affect EFH. These effects are expected to be temporary with physical and biological characteristics of habitats in the project area eventually returning towards a natural state.**

Project Alternative Four: Inland Dune Plus Beach Fill

Alternative Four is a hybrid of Alternatives 1, 2 and 3 that combines managed retreat with a modest-scale beach/dune nourishment effort. This action includes placement of sand on the beach to restore that lost to erosion, reinforcement of the existing primary dune, and construction of a secondary dune inland of the primary dune. Sand fill would not be used to extend the primary dune or beach seaward to a previous, less eroded stated. The affected project area includes the northern 7.6 km of the KSC shoreline. Up to about 1.5 million m^3 of beach fill sand would be required to initially construct Alternative Four. Most material would be dredged from Canaveral Shoals II (preferred) or Canaveral Shoals I although the secondary dune could be constructed from fill derived from upland sources.

The potential impact to EFH and managed species in Alternative Four is identical to those provided in Alternatives 2 and 3. Managed fishes should suffer negligible direct mortality but may displace from the beach and offshore borrow sites due to reduction in prey densities, as well as ephemeral turbidity and noise. Given that a maximum of 1.5 million m^3 of fill is required (with some placed on the secondary inland dune), the spatial extent of EFH impacts are expected to be less than in Alternatives 2 and 3. **NASA concludes that EFH may be adversely affected under**

Alternative 4 through changes in invertebrate communities and habitat complexity but that conditions will eventually return to a near-natural state.

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Table 1. EFH and HAPC for managed species present on the east-central Florida coast. Determinations drawn from NOAA EFH Mapper, NMFS (2009), and SAFMC (1998, 2003, 2009)

Common Name	Scientific Name	Agency	Essential Fish Habitat				Habitat Areas of Particular Concern			
			Egg Larvae Neonate	Juvenile	Adult	All Life Stages	Egg Larvae Neonate	Juvenile	Adult	All Life Stages
Spiny Lobster FMP										
Spiny Lobster	*Panulirus argus*	SAFMC, GMFMC				X				X[b]
Shrimp FMP										
Pink shrimp	*Farfantepenaeus duorarum*	SAFMC				X				
White shrimp	*Litopenaeus setiferus*	SAFMC				X				
Brown shrimp	*Farfantepenaeus aztecus*	SAFMC				X				
Rock shrimp	*Sicyonia brevirostris*	SAFMC								
Royal red shrimp	*Pleoticus robustus*	SAFMC								
Golden Crab FMP										
Golden Crab	*Chaceon fenneri*	SAFMC								
Highly Migratory Species FMP										
Atlantic Sharpnose Shark	*Rhizoprionodon terraenovae*	NMFS	X	X	X					
Bigeye Tuna	*Thunnus obesus*	NMFS		X[b]						
Blacknose Shark	*Carcharhinus acronotus*	NMFS		X	X					
Blacktip Shark	*Carcharhinus limbatus*	NMFS		X	X					
Bonnethead Shark	*Sphyrna tiburo*	NMFS	X	X	X					
Bull Shark	*Carcharhinus leucas*	NMFS	X	X	X					
Dusky Shark[a]	*Carcharhinus obscurus*	NMFS		X	X					
Finetooth Shark	*Carcharhinus isodon*	NMFS		X	X					
Great Hammerhead[a]	*Sphyrna mokorran*	NMFS				X				
Lemon Shark[a]	*Negaprion brevirostris*	NMFS		X						
Nurse Shark	*Ginglymostoma cirratum*	NMFS		X	X					
Sailfish	*Istiophorus platypterus*	NMFS		X	X					
Sand Tiger Shark[a]	*Carcharius taurus*	NMFS	X	X	X					
Sandbar Shark	*Charhinus plumbeus*	NMFS		X[c]	X					
Scalloped Hammerhead[a]	*Sphyrna lewini*	NMFS	X	X	X					

Common Name	Scientific Name	Agency	Essential Fish Habitat				Habitat Areas of Particular Concern			
			Egg Larvae Neonate	Juvenile	Adult	All Life Stages	Egg Larvae Neonate	Juvenile	Adult	All Life Stages
Silky Shark[a]	*Carcharhinus falciformis*	NMFS				X				
Spinner Shark	*Carcharhinus brevipinna*	NMFS	X	X	X					
Tiger Shark[a]	*Galeocerdo cuvier*	NMFS		X	X					
White Shark[a]	*Carcharodon carcharias*	NMFS				X				
Yellowfin Tuna	*Thunnus albacares*	NMFS		X						
Coastal Migratory Pelagics FMP										
Cero	*Scomberomorus regalis*	SAFMC, GMFMC				X[c]				
Cobia	*Rachycentron canadum*	SAFMC, GMFMC				X[c]				
King mackerel	*Scomberomorus cavalla*	SAFMC, GMFMC				X[c]				
Little tunny	*Euthynnus alletteratus*	SAFMC, GMFMC				X[c]				
Spanish mackerel	*Scomberomorus maculatus*	SAFMC, GMFMC				X[c]				
Dolphin-Wahoo FMP										
Dolphinfish	*Coryphaena hippurus*	SAFMC	Sargassu	Sargassu	Sargassu	Sargassu				
Wahoo	*Acanthocybium solanderi*	SAFMC	Sargassu	Sargassu	Sargassu	Sargassu				
Snapper-Grouper FMP										
Almaco jack	*Seriola rivoliana*	SAFMC				X				X[b]
Banded rudderfish	*Seriola zonata*	SAFMC				X				X[b]
Bank sea bass	*Centropristis ocyurus*	SAFMC				X				X[b]
Bar jack	*Carangoides ruber*	SAFMC				X				X[b]
Black grouper	*Mycteroperca bonaci*	SAFMC				X				X[b]
Black margate	*Anisotremus surinamensis*	SAFMC				X				X[b]
Black sea bass	*Centropristis striata*	SAFMC				X				X[b]
Black snapper	*Apsilus dentatus*	SAFMC				X				X[b]
Blackfin snapper	*Lutjanus buccanella*	SAFMC				X				X[b]
Blue runner	*Caranx crysos*	SAFMC				X				X[b]
Blue stripe grunt	*Haemulon sciurus*	SAFMC				X				X[b]

Common Name	Scientific Name	Agency	Essential Fish Habitat				Habitat Areas of Particular Concern			
			Egg Larvae Neonate	Juvenile	Adult	All Life Stages	Egg Larvae Neonate	Juvenile	Adult	All Life Stages
Blueline tilefish	*Caulolatilus microps*	SAFMC				X				X[b]
Coney	*Epinephelus fulvus*	SAFMC				X				X[b]
Cottonwick	*Haemulon melanurum*	SAFMC				X				X[b]
Crevalle jack	*Caranx hippos*	SAFMC				X				X[b]
Cubera snapper	*Lutjanus cyanopterus*	SAFMC				X				X[b]
Dog snapper	*Lutjanus jocu*	SAFMC				X				X[b]
French grunt	*Haemulon flavolineatum*	SAFMC				X				X[b]
Gag	*Mycteroperca microlepis*	SAFMC				X				X[b]
Golden tilefish	*Lopholatilus chamaeleonticeps*	SAFMC				X				X[b]
Grass porgy	*Calamus arctifrons*	SAFMC				X				X[b]
Gray snapper	*Lutjanus griseus*	SAFMC				X				X[b]
Gray triggerfish	*Balistes capriscus*	SAFMC				X				X[b]
Graysby	*Epinephelus cruentatus*	SAFMC				X				X[b]
Greater amberjack	*Seriola dumerili*	SAFMC				X				X[b]
Hogfish	*Lachnolaimus maximus*	SAFMC				X				X[b]
Goliath Grouper[a]	*Epinephelus itajara*	SAFMC				X				X[b]
Jolthead porgy	*Calamus bajonado*	SAFMC				X				X[b]
Knobbed porgy	*Calamus nodosus*	SAFMC				X				X[b]
Lane snapper	*Lutjanus synagris*	SAFMC				X				X[b]
Lesser amberjack	*Seriola fasciata*	SAFMC				X				X[b]
Longspine porgy	*Stenotomus caprinus*	SAFMC				X				X[b]
Mahogany snapper	*Lutjanus mahogoni*	SAFMC				X				X[b]
Margate	*Haemulon album*	SAFMC				X				X[b]
Misty grouper	*Epinephelus mystacinus*	SAFMC				X				X[b]
Mutton snapper	*Lutjanus analis*	SAFMC				X				X[b]
Nassau grouper[a]	*Epinephelus striatus*	SAFMC				X				X[b]
Ocean triggerfish	*Canthidermis sufflamen*	SAFMC				X				X[b]

Common Name	Scientific Name	Agency	Essential Fish Habitat				Habitat Areas of Particular Concern			
			Egg Larvae Neonate	Juvenile	Adult	All Life Stages	Egg Larvae Neonate	Juvenile	Adult	All Life Stages
Porkfish	*Anisotremus virginicus*	SAFMC				X				X[b]
Puddingwife	*Halichoeres radiatus*	SAFMC				X				X[b]
Queen snapper	*Etelis oculatus*	SAFMC				X				X[b]
Queen triggerfish	*Balistes vetula*	SAFMC				X				X[b]
Red grouper	*Epinephelus morio*	SAFMC				X				X[b]
Red hind	*Epinephelus guttatus*	SAFMC				X				X[b]
Red porgy	*Pagrus pagrus*	SAFMC				X				X[b]
Red snapper	*Lutjanus campechanus*	SAFMC				X				X[b]
Rock hind	*Epinephelus adscensionis*	SAFMC				X				X[b]
Rock sea bass	*Centropristis philadelphica*	SAFMC				X				X[b]
Sailors choice	*Haemulon parrai*	SAFMC				X				X[b]
Sand tilefish	*Malacanthus plumieri*	SAFMC				X				X[b]
Saucereye porgy	*Calamus*	SAFMC				X				X[b]
Scamp	*Mycteroperca phenax*	SAFMC				X				X[b]
Schoolmaster	*Lutjanus apodus*	SAFMC				X				X[b]
Scup	*Stenotomus chrysops*	SAFMC				X				X[b]
Sheepshead	*Archosargus probatocephalus*	SAFMC				X				X[b]
Silk snapper	*Lutjanus vivanus*	SAFMC				X				X[b]
Smallmouth grunt	*Haemulon chrysargyreum*	SAFMC				X				X[b]
Snowy grouper	*Epinephelus niveatus*	SAFMC				X				X[b]
Spadefish	*Chaetodipterus faber*	SAFMC				X				X[b]
Spanish grunt	*Haemulon macrostomum*	SAFMC				X				X[b]
Speckled hind	*Epinephelus drummondhayi*	SAFMC				X				X[b]
Tiger grouper	*Mycteroperca tigris*	SAFMC				X				X[b]
Tomtate	*Haemulon aurolineatum*	SAFMC				X				X[b]
Vermilion snapper	*Rhomboplites aurorubens*	SAFMC				X				X[b]
Warsaw grouper	*Epinephelus nigritus*	SAFMC				X				X[b]

Common Name	Scientific Name	Agency	Essential Fish Habitat				Habitat Areas of Particular Concern			
			Egg Larvae Neonate	Juvenile	Adult	All Life Stages	Egg Larvae Neonate	Juvenile	Adult	All Life Stages
White grunt	*Haemulon plumieri*	SAFMC				X				X[b]
Whitebone porgy	*Calamus leucosteus*	SAFMC				X				X[b]
Wreckfish	*Polyprion americanus*	SAFMC				X				X[b]
Yellow jack	*Caranx bartholomaei*	SAFMC				X				X[b]
Yellowedge grouper	*Epinephelus flavolimbatus*	SAFMC				X				X[b]
Yellowfin grouper	*Mycteroperca venenosa*	SAFMC				X				X[b]
Yellowmouth grouper	*Mycteroperca interstitialis*	SAFMC				X				X[b]
Yellowtail snapper	*Ocyurus chrysurus*	SAFMC				X				X[b]
Red Drum FMP										
Red Drum	*Sciaenops ocellatus*	ASMFC				X				
Coral, Hard Bottom FMP										
Corals[a]	>200 Species	SAFMC				X				X

[a] Prohibited species in Florida waters

[b] Canaveral Shoals borrow site only

[c] Beach renourisment site only

APPENDIX F

Air Emissions Worksheets

- Hooper EM
- NEI Criteria Pollutants
- EF EPA
- EF GOADS 2000

Estimated emissions for KSC Shoreline Project Alternative Two

Emissions Estimates for Brevard County Beach Restoration, Trailing Suction Hopper

Maximum Volume Dredged from Borrow Area	3,100,000	yd3
Volume Placed on Beach	2,800,000	yd3
Mean Load	2,900	yd3
Cut/Fill Dredge Efficiency	1.11	
No. of Hopper Loads	1072	
Loads/Day	4.0	
Total Days	268	
Total Dredging Time (less lost hrs)	6430	
Total Effective Time (dredging hrs)	1072	
Percent Effective Time	16.7%	
Percent Lost Time	0.0%	

Offshore Activities

Dredging Activity

Equipment	**Horsepower**		
	mean	min	max
Propulsion	3,500	1700	9000
Dredge Pumps	2,000	1000	3000
Pumpout Pumps	2,000	1000	3000
Aux. & Misc.	1,165	185	2000
Total	8,665		

Rating or Loading Factors

Activity	**Propulsion Factor**	**Pumps Factor**	**Aux. & Misc. Factor**		**Duration of cycle**		**Hp-hr per cycle**
					hr	min	
Dredging	0.5	0.8	0.25		1.00	60	3,641
Haul & Return	0.8		0.25		2.60	156	8,037
Pumpout	0.25	0.8	0.25		0.70	42	1,936
Idle/Connect/Disconnect	0.1		0.25		1.70	102	1,090
				Total	6.00	360	14,705
				Daily Hrs	24.0	1440	

	Dredge Emissions per cycle, lb-hr					
Activity	NOX	VOC	SO2	CO	PM10	PM2.5
Dredging	87.5	2.3	1.5	20.1	1.5	1.4
Haul & Return	193.1	5.1	3.3	44.3	3.2	3.2
Pumpout	46.5	1.2	0.8	10.7	0.8	0.8
Idle/Connect/Disconnect	26.2	0.7	0.4	6.0	0.4	0.4
Total	353.4	9.4	5.9	81.0	5.9	5.8

	Total Dredge Project Emissions, tons					
Activity	NOX	VOC	SO2	CO	PM10	PM2.5
Dredging	46.9	1.2	0.8	10.8	0.8	0.8
Haul & Return	103.5	2.8	1.7	23.7	1.7	1.7
Pumpout	24.9	0.7	0.4	5.7	0.4	0.4
Idle/Connect/Disconnect	14.0	0.4	0.2	3.2	0.2	0.2
Total Dredge Emissions	**189.4**	**5.0**	**3.2**	**43.4**	**3.2**	**3.1**

Total hp-hr, dredge	15,759,703
Fuel Rate, gal/hp-hr	0.056
Total Fuel, gal	882,543

Supporting Activity

				Emissions, tons					
Relocate Mooring Buoy (5 relocations)	**Horsepower**	**Rating Factor**	**No. Hrs**	NOx	VOC	SO2	CO	PM10	PM2.5
2 Tender Tugs	1000	0.8	60	1.15	0.03	0.02	0.26	0.02	0.02
Derrick Barge	0	0.5	60	0.00	0.00	0.00	0.00	0.00	0.00
2 Work Barges	0	0.5	60	0.00	0.00	0.00	0.00	0.00	0.00
Generator/Light Crane	0	1	60	0.00	0.00	0.00	0.00	0.00	0.00
Transport Crew									
Supply/Crew Vessel	440	0.8	1072	4.53	0.12	0.08	1.04	0.08	0.15
Total Supporting Activity Emissions, tons				**5.7**	**0.2**	**0.1**	**1.3**	**0.1**	**0.2**

Emission Factors for Tugs and Barges, g/hp-hr
Source: U.S. EPA AP-42, 2002, Table 3.4-1

NOx	10.9
VOC	0.29
SO2	0.184
CO	2.50
PM10	0.182
PM2.5	0.178

Beach Fill

Placement Activity

	Emission Factors - Ref. AP-42, Table 3.3-1, Diesel Engines < 600 hp						
Equipment	NOx	VOC	SO2	CO	PM10	PM2.5	
3 Bulldozers / 1 Pipeline Mover - 215 hp (80% run-time)	4.155	0.269	0.754	1.791	0.327	0.327	g/hp-hr
2 Light/HD Truck (80% run-time)	1.22	1.61	0.74	15.7	0.01	0.01	g/mi

			Emissions, tons						
Equipment	**Horsepower**	**No. of hours**	NOx	VOC	SO2	CO	PM10	PM2.5	
3 Bulldozers / 1 Pipeline Mover - 215 hp (80% run-time)	215	20577	20.3	1.3	3.7	8.7	1.6	1.6	Assume 4 dozers operating 24 hours/day 80% of time
2 Light/HD Truck (80% run-time)	-	10289	0.07	0.09	0.04	0.89	0.00	0.00	Assume 2 light trucks operating 24/hrs day 80% of time at 5 mi/hr
Total Beach Fill Emissions, tons			**20.3**	**1.4**	**3.7**	**9.6**	**1.6**	**1.6**	

TOTAL PROJECT EMISSIONS, tons

	NOx	VOC	SO2	CO	PM10	PM2.5	
OCS Waters	126.5	3.4	2.1	29.0	2.1	2.1	Assume 75% of travel in OCS waters
State Waters	68.5	1.8	1.2	15.7	1.1	1.2	Assume 25% of travel in State waters
Beach	20.3	1.4	3.7	9.6	1.6	1.6	
Total State Emissions	**88.8**	**3.2**	**4.9**	**25.3**	**2.7**	**2.8**	
Total Emissions	**215.4**	**6.6**	**7.0**	**54.4**	**4.9**	**4.9**	
check	215.4	6.6	7.0	54.4	4.9	4.9	

NOX Emission factors for Diesel Engines > or = 600 hp
Source: U.S. EPA AP-42, 2002, Table 3.4-1

	NOX	VOC	SO2	CO	PM10	PM2.5		
EF	3.2	0.08	0.0505	0.85	0.057	0.056	lb/mmBtu	AP-42, Table 3.4-1 and Table 3.4-2 (for PM10)
EF	10.9	0.29	0.1835	2.5	0.182	0.178	g/hp-hr	AP-42, Table 3.4-1, for PM10 assume 1 hp-hr = 7000 Btu (ERG, 2007)
Diesel Fuel Heating Value	19300						Btu/lb	
Fuel Density	7.1						lb/gal	
EF by fuel use	438	11.0	6.9	116.5	7.8	7.7	lb/1000gal	S= Fuel oil sulfur content (0.05)

NOX Emission factors for Diesel Engines < 600 hp
Source: U.S. EPA AP-42, 2002, Table 3.4-1

	NOX	VOC	SO2	CO	PM10	PM2.5		
EF	4.41	0.33	0.0505	0.95	0.31	9.31	lb/mmBtu	AP-42, Table 3.4-1 and Table 3.4-2 (for PM10)
EF	14.1	1.04	0.1835	3.03	1	1	g/hp-hr	AP-42, Table 3.4-1, for PM10 assume 1 hp-hr = 7000 Btu (ERG, 2007)
Diesel Fuel Heating Value	19300						Btu/lb	
Fuel Density	7.1						lb/gal	
EF by fuel use	604	45.2	6.9	130.2	42.5	1275.7	lb/1000gal	

http://www.epa.gov/air/data/

	Point Source Emissions	Nonpoint+Mobile Source Emissions	Total
Nox	9,219	10,077	19,296
CO	12,021	73,578	85,599
Sox	17,042	2,271	19,313
VOC	998	13,006	14,004
PM10	1,964	3,893	5,857
PM2.5	1,762	1,426	3,188

NOX Emission factors for Diesel Engines > 600 hp
Source: U.S. EPA AP-42, 2002, Table 3.4-1

	NOX	VOC	SO2	CO	PM10	PM2.5		
EF	3.2	0.09	0.055	0.85	0.0573	0.0556	lb/mmBtu	AP-42, Table 3.4-1 and Table 3.4-2 (for PM10)
EF	0.024	0.000642	0.000405	0.0055	0.000401	0.00039	lb/hp-hr	AP-42, Table 3.4-1, for PM10 assume 1 hp-hr = 7000 Btu (ERG, 2007)
EF	10.89	0.29	0.18	2.49	0.182	0.178	gm/hp-hr	
Diesel Fuel Heating Value	19300						Btu/lb	
Fuel Density	7.1						lb/gal	
EF by fuel use	438	12.3	7.5	116.5	7.9	7.6	lb/1000gal	

Nox emission Factors based on GOADS 2000 report

E (g/kW-hr) = A * (Load Factor) ^-x + B

x	1.5	0.000401
B	10.4496	0.182099
A	0.1255	

Activity	**Propulsion Rating Fact.**	**Pumps Factor**	**Aux. & Misc. Factor**		**Duration of cycle**	
					min	hr
Dredging	0.45	0.5	0.3		81	1.4
Haul & Return	0.8		0.25		132	2.2
Pumpout		0.8	0.25		79	1.3
Idle			0.25		32	0.5
				Total	324	5.4
				Trips/day		4.4

Activity	**Propulsion NOX EF**	**Pumps NOX EF**	**Aux. & Misc. NOX EF**		**Duration of cycle**		Nox Emissions, lb
	EF, g/kWhr	E, g/kW-hr	E, g/kW-hr		min	hr	
Dredging	10.87	10.80	11.21		81	1.4	0.0
Haul & Return	10.62		11.45		132	2.2	0.0
Pumpout		10.62	11.45		79	1.3	0.0
Idle			11.45		32	0.5	0.0
				Total	324	5.4	0.0

Estimated emissions for KSC Shoreline Project Alternative Two (tons per year).

Activity	Emissions (tons)					
	NOx	**SO2**	**CO**	**VOC**	**$PM_{2.5}$**	**PM_{10}**
Dredge Plant (Hopper)						
Dredging/Operation	46.9	0.8	10.8	6.1	0.8	0.8
Turning/Sail	103.5	1.7	23.7	2.8	1.7	1.7
Pump-out	24.9	0.4	5.7	0.7	0.4	0.4
Idle / Connect-Disconnect	14.0	0.2	3.2	0.4	0.2	0.2
Supporting Offshore Activities	5.7	0.1	1.3	0.2	0.2	0.1
Beach Fill	20.3	3.7	9.6	1.4	1.6	1.6
Total Emissions	215.4	7.0	54.4	6.6	4.9	4.9
Total Emissions within State	88.8	4.9	25.3	3.2	2.8	2.7
Total Emissions at CS II	126.5	2.1	29.0	3.4	2.1	2.1
2002 Brevard County Emissions Nonpoint + Mobile (Point and Nonpoint + Mobile)	34,251 (46,403)	10,318 (25,865)	216,995 (218,319)	44,902 (45,561)	5,548 (6,712)	11,989 (13,350)
Brevard County 2002 emissions from EPA National Emission Inventory http://www.epa.gov/ttnchie1/net/2002inventory.html						

APPENDIX G

BIOLOGICAL ASSESSMENT FOR THE
KSC SHORELINE PROTECTION PROJECT
KENNEDY SPACE CENTER, FLORIDA

Prepared for:

National Aeronautics and Space Administration
Kennedy Space Center, Florida

2 November 2012

Prepared by:
Medical and Environmental Support Contract (MESC)
InoMedic Health Applications, Inc.
Environmental Services Branch
IHA-022
Kennedy Space Center, Florida 32899

BIOLOGICAL ASSESSMENT FOR THE KSC SHORELINE PROTECTION PROJECT KENNEDY SPACE CENTER, FLORIDA

November 2012

Prepared for:

Environmental Management Branch
TA-A4C
National Aeronautics and Space Administration
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EXECUTIVE SUMMARY

Federal agencies are required by Section 7 of the Endangered Species Act (16 U.S.C. § 1536(a)(2)) to consult with the U.S. Fish and Wildlife Service if the federal agency is proposing an action that may affect listed wildlife or plant species, or their designated critical habitats. A Biological Assessment (BA) is a document prepared by the action constituents under the Section 7 process that provides information needed to determine whether the proposed action is likely to adversely affect listed species, candidate species, or critical habitats.

The National Aeronautics and Space Administration at Kennedy Space Center (KSC) is proposing an action to restore beach and coastal dune habitat that has been severely eroded over the past several years. Changes in the coastline have brought about increased frequency and severity of inundation events that threaten KSC infrastructure and assets, including natural habitats that support federally protected wildlife species. Predictions are that this trend will continue into the future. In order to maintain and preserve launch infrastructure and coastal habitats, KSC is proposing to implement measures to protect the shoreline from continuing damage.

There are four alternatives being evaluated to accomplish shoreline protection. Seven federally protected wildlife species and one candidate for federal listing could be expected to occur within the project area; there have been no federally protected plant species documented. None of the area is designated critical habitat for any species. The purpose of this BA is to document presence, or potential presence, of the eight wildlife species and to determine if any of the four alternatives would be likely to adversely affect any of those species.

Anticipated impacts from the Shoreline Protection Project are separated into 1) impacts from construction and 2) long-term impacts. Construction impacts, depending on the species being considered and the alternative selected, range between minimal and moderate. Long-term effects from any of the four alternatives are expected to be beneficial for all species.

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ACRONYMS and ABBREVIATIONS

ac	acre
BA	Biological Assessment
BO	Biological Opinion
CCAFS	Cape Canaveral Air Force Station
CNS	Canaveral National Seashore
CTF	Corrosion Test Facility
FEMA	Federal Emergency Management Agency
ft	feet
ft^3	cubic feet
ha	hectares
km	kilometers
KSC	Kennedy Space Center
LC	Launch Complex
m	meters
m^3	cubic meters
mi	miles
MINWR	Merritt Island National Wildlife Refuge
NASA	National Aeronautics and Space Administration
pers. comm.	personal communication
pers. obs.	personal observation
STL	still water level
USFWS	United States Fish and Wildlife Service

Section 1 Purpose and Need

1.1 Purpose

The purpose of the proposed action is to reduce shoreline erosion that is caused by storms and sea level rise. Critical launch infrastructure and valuable threatened and endangered species habitat along the Kennedy Space Center (KSC) coastline are at risk.

There are seven federally protected wildlife species and one candidate for federal listing that could be expected to occur along the KSC shoreline and adjacent habitats. There have been no federally protected plant species documented within the area (Schmalzer et al. 2002). None of the area is designated critical habitat for any species. The purpose of this Biological Assessment (BA) is to document presence, or potential presence, of these eight species and to determine if any of the four alternatives proposed by National Aeronautics and Space Administration (NASA) to accomplish shoreline protection would be likely to adversely affect any species. A No Action alternative is also being evaluated.

1.2 Need

The proposed action is needed to ensure the continued ability of NASA to accomplish its mission at KSC. Prior studies have suggested that the volume of sediment contained in a dune or bluff above the 100-year storm tide still water level (SWL) is a descriptor of the dune's resistance to storm-induced erosion (Hallermeier and Rhodes, 1988). The Zone V designation is given to areas along coasts subject to inundation by the 1-percent-annual-chance flood event with additional hazards associated with storm-induced waves. For purposes of V-zone mapping and protection of habitable development within the coastal zone, the Federal Emergency Management Agency (FEMA) has recommended that a minimum frontal dune reservoir of between 51 and 104 m^3/m [540 and 1,100 ft^3/ft] alongshore, above the 100-year SWL, is required to prevent dune removal during a 100-year storm event (FEMA 2000). A value of at least 29 m^3/m (310 ft^3/ft) is associated with a 25-year storm event. These are empirical guidelines that reflect very wide variation in field data and refer to only the front half of the dune. The existing beach profile at KSC exhibits less than 26 m^3/m (280 ft^3/ft) which is far less than the minimum FEMA recommendation for the 100-year flood protection.

Section 2 Project Description

2.1 Proposed Action

Four alternative scenarios have been developed and are being evaluated for accomplishing the shoreline protection:

- Alternative 1 involves construction of a large secondary dune behind the existing primary dunes in areas where the primary dunes are highly eroded or non-existent. The created dunes would be planted with salt-tolerant vegetation along the dune crest and dune face to provide further stabilization. In areas where primary dunes are non-existent or minimal, the constructed inland dune would replace the primary dune and be fronted by a marginal beach.

- Alternative 2 involves renourishing the beach with sand to restore beach width lost to erosion over time, bringing it back to a condition that existed 10 -15 years ago. Dunes would be constructed seaward of the existing eroded primary dune as needed to provide elevation necessary to ensure protection from storm waves and flooding.

- Alternative 3 incorporates renourishing the beach as in Alternative 2, but in this alternative the existing primary dune would be reconstructed or reinforced at its current location. Appropriate vegetation would be planted along the dune crest and dune face.

- Alternative 4 is a hybrid of proposed Alternatives 1, 2 and 3. It includes placement of sand to restore beach lost to erosion, reinforcement of existing dune, and construction of secondary dunes in areas where the primary dune is subject to the most erosion or has a lower than desired elevation. Appropriate vegetation would be planted along the crest and face of both the primary dune and inland dune as needed for stabilization.

- Under the No Action Alternative, the KSC beach would be left in its current state. Nature would be allowed to take its course and storms would continue to erode the beach and further threaten or destroy KSC infrastructure and critical coastal habitat. The historical progression of dune and beach erosion along the northern 7.4 km (4.6 mi) of the KSC shoreline (north of False Cape) documented over the past decades, combined with the continuation or possible acceleration of sea level rise, strongly indicate that the beach and dune will continue to degrade in the absence of intervening actions. In the No Action Alternative, overtopping and breach of the primary dune, particularly between Launch Complex (LC) 39A and LC 39B, are likely to occur in the near future, which could result in large-scale inundation, habitat alteration, and land loss along the coastal strand.

Section 3 Action Area

3.1 Geographic Area

KSC is 56,500 ha (139,490 ac) located along the east coast of central Florida in Brevard and Volusia counties (Figure 1). The majority of the land areas comprising KSC are on the northern part of Merritt Island, which forms a barrier island complex with adjacent Cape Canaveral. NASA acquired the KSC lands in 1962 for the purpose of implementing the U.S. space program. NASA controls and manages 1,806 ha (4,463 ac) that are dedicated to NASA operations, which is approximately 5% of the total KSC area. Undeveloped areas, including uplands, wetlands, mosquito control impoundments, beach, coastal dune, and open water, comprise the remaining 95% of the total area. Nearly 40% of KSC is open water estuary, and includes portions of the Indian River, Banana River, Mosquito Lagoon, and all of Banana Creek. The areas of KSC not regularly used for NASA operations are managed by the U.S. Fish and Wildlife Service (USFWS) as Merritt Island National Wildlife Refuge (MIWNWR); these lands remain subject to operational controls from NASA as they may be needed to assure safety and security, may be used for future expansions, and/or provide a required buffer to other land uses (NASA 2010).

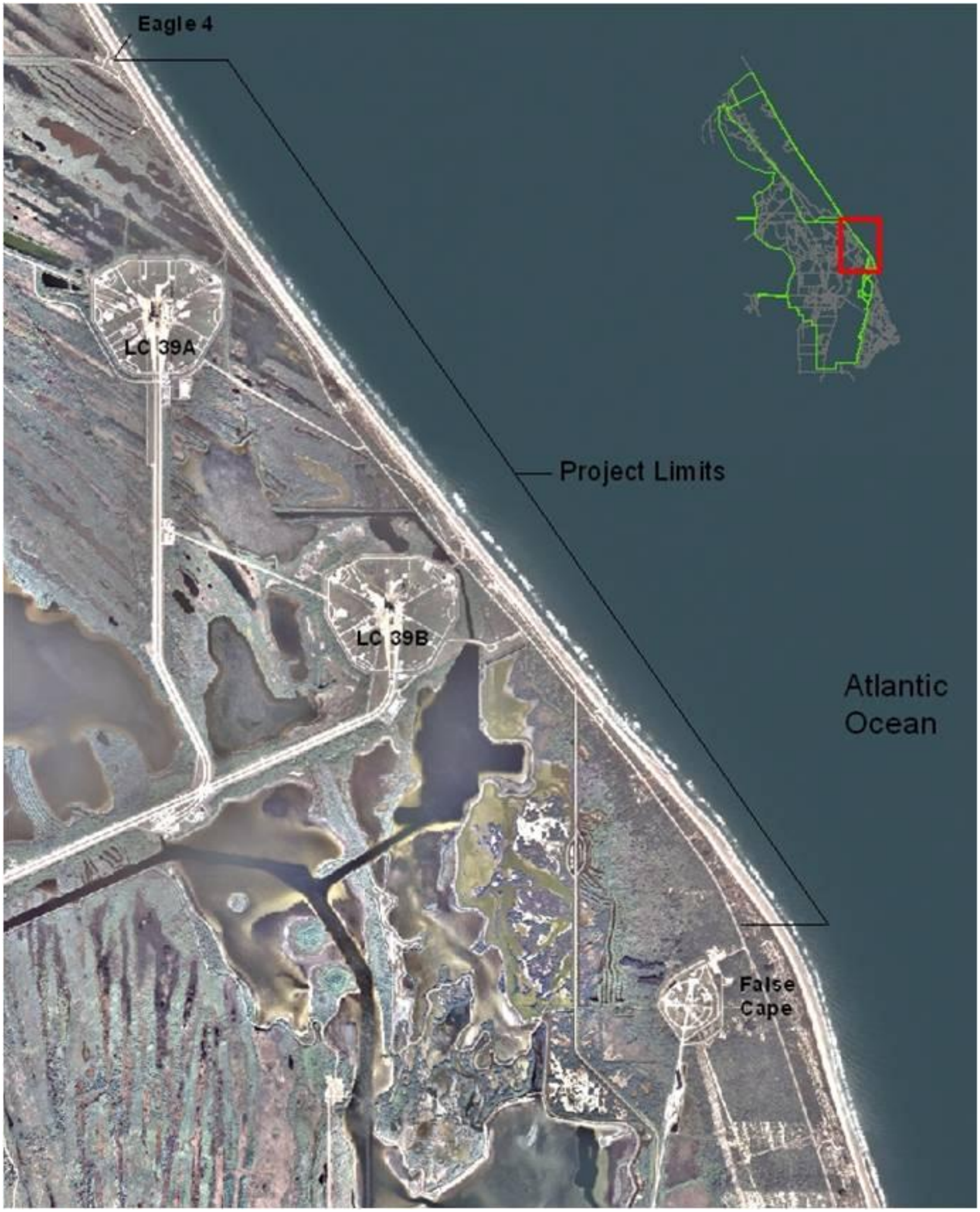

Figure 1. Shoreline Protection Project general location and boundaries, Kennedy Space Center, Florida.

3.2 Affected Area

The boundary of the affected area extends from the KSC/Canaveral National Seashore (CNS) border south 7.6 km (4.7 mi) to the False Cape on Cape Canaveral Air Force Station (CCAFS), and west from the high tide line to Phillips Parkway (Figure 1). This area encompasses approximately 150 ha (371 ac) of landcover.

Within the footprint of the four alternatives, there are six major land cover types (Table 1) that were derived from the Florida Land Use, Cover, and Forms Classification System, 3rd Edition (Florida Department of Transportation 1999). These are described in the following paragraphs; plant classification follows Wunderlin and Hansen, 2011, and species listings follow Schmalzer, Foster, and Duncan, 2002. Depending on the specific alternative chosen, different quantities of these land cover types may be impacted. Acreages potentially impacted for each alternative are given in Table 1.

Table 1. Acreages [ha (ac)] of the six major land cover types found within each Shoreline Protection Project alternative.

Land cover type	**Alt. 1**	**Alt. 2**	**Alt. 3**	**Alt. 4**
beach and primary dune	0.1 (0.4)	9.8 (24.2)	2.3 (5.6)	0.1 (0.4)
coastal strand	5.4 (13.4)	5.3 (13.1)	10.9 (26.8)	5.4 (13.4)
ditch	0.2 (0.4)		0.1 (0.2)	0.2 (0.4)
marsh - saltwater	0.1 (0.2)			0.1 (0.2)
ruderal - herbaceous	7.8 (19.3)	0.1 (0.3)	2.2 (5.3)	7.8 (19.3)
water - interior - fresh	<0.1 (0.1)		0.1 (0.2)	

Beach and Primary Dune
Primary dunes are poorly stabilized deposits subjected to salt spray and wave action during storms. Depending on sediment supply, these dynamic habitats can be accreting (prograding beaches), or eroding (transgressional beaches), with seasonal variability depending on weather. Vegetation is primarily composed of colonizing species able to tolerate moving sands and the higher salinities found adjacent to the ocean. These include grasses such as sea oats (*Uniola paniculata*), bitter panic grass (*Panicum amarum*), and marsh hay cordgrass (*Spartina patens*). Additional species include railroad vine (*Ipomoea pes-caprae*), baybean (*Canavalia rosea*), seacoast marsh elder (*Iva imbricata*), and gulf croton (*Croton punctatus*). Two species of cacti, prickly-pear (*Opuntia humifusa*) and shell mound prickly-pear (*Opuntia stricta*), are common. In many areas, saw palmetto (*Serenoa repens*) is found extending to the dune crest.

There are no federally listed plant species present, but the following coastal-occurring plants are protected by the State of Florida: sand dune spurge (*Chamaesyce cumulicola*), beach-star (*Cyperus pedunculatus*), coastal vervain (*Glandularia maritima*), narrow-leaved hoary pea (*Tephrosia angustissima* var. *curtissii*), sea lavender (*Argusia gnaphalodes*), shell mound prickly-pear, and Scaevola (*Scaevola plumieri*).

Coastal Strand
Coastal strand is located adjacent to the beach zone. It is typically a densely vegetated shrub community subject to effects of salt spray and sand displacement resulting from storms (Schmalzer & Hinkle, 1985). Open patches of bare sand are common. The topography is comprised of higher dunes and inter-dune swales. In lower areas, these swales can contain wetland vegetation and standing water, providing habitat for wading birds and shore birds. Vegetation is primarily composed of shrubs including saw palmetto, sea grape (*Coccoloba uvifera*), wax myrtle (*Myrica cerifera*), nakedwood (*Myrcianthes fragrans*), and live oak (*Quercus virginiana*). These shrubs become more abundant and thick as distance from the primary dune increases. Two species of cacti, prickly-pear and shell mound prickly-pear, are also found in this habitat.

There are no federally listed plant species, but the following coastal-occurring plants are protected by the State of Florida: sand dune spurge, coastal vervain, east coast lantana (*Lantana depressa* var. *floridana*), narrow-leaved hoary pea, nakedwood, shell mound prickly-pear, and Scaevola.

Ditch
Ditches occur throughout KSC and were constructed to facilitate water movement away from facilities and roads. Ditches contain primarily fresh water, but when the nearby estuary water levels are high or there is overwash from the beach, brackish water can flow into the ditches. Increased salinity within ditches affects plant species composition by selecting for salt-tolerant species.

Typical plant species found within the ditches include the submersed widgeon grass (*Ruppia maritima*), and emergent species such as maidencane (*Panicum hemitomon*), pink red stem (*Ammannia latifolia*), herb-of-grace (*Bacopa monnieri*), sawgrass (*Cladium jamaicense*), spikerush (*Eleocharis* spp.), marsh penny wort, (*Hydrocotyle* spp.), southern cattail (*Typha domingensis*), and arrowhead (*Sagittaria lancifolia*). Ditch slopes and adjacent areas generally support ruderal – herbaceous species (see the description of ruderal - herbaceous habitat below).

There are no federally listed or state-listed plant species documented from the ditch habitat.

Saltwater Marsh
Salt marshes are found adjacent to the estuary. Most have altered hydrology and salinity due to impoundment for mosquito control that occurred in the 1960s (Schmalzer & Hinkle, 1985). Additionally, several decades of fire suppression and decreased fire frequency caused by landscape alterations have led to changes in plant species composition. Graminoid species are replaced by woody species where fire has been excluded from the landscape. Saltmarsh plant species usually occur in distinct zones due to factors such as environmental gradients or vegetative reproduction.

KSC is located within a broad biogeographic transition zone between the Carolinian and subtropical Caribbean biotic provinces (DeFreese 1995) and the vegetation present is a mixture of both zones. From KSC northward, salt marshes become increasingly dominated by graminoid vegetation, primarily smooth cordgrass (*Spartina alterniflora*) and needle rush (*Juncus* *roemerianus*). Mixed stands of saltgrass (*Distichlis spicata*), seashore paspalum (*Paspalum vaginatum*), both the annual and perennial glassworts (*Salicornia bigelovii* and *Sarcocornia perennis*, respectively), saltwort (*Batis maritima*), leather fern (*Acrostichum danaeifolium*), and sea oxeye daisy (*Borrichia frutescens*) are found throughout these marshes (Schmalzer & Hinkle, 1985; Montague & Wiegert, 1990). From KSC south, these plants are increasingly replaced by mangroves, which are essentially tropical plants. These include black mangrove (*Avicennia germinans*), red mangrove (*Rhizophora mangle*), white mangrove (*Laguncularia racemosa*), and buttonwood (*Conocarpus erecta*). All of these species are common at KSC and are found along lagoon shorelines and within impoundments (Schmalzer & Hinkle, 1985).

There are no federally listed plant species, but mangroves are protected by the State of Florida.

Ruderal – Herbaceous
Ruderal vegetation is found in areas disturbed by past or present land uses. This land cover is typically dominated by weedy native and introduced species. Typical plants include Brazilian pepper (*Schinus terebinthifolius*), wax myrtle, and grasses such as bluestem (*Andropogon* spp.), groundsel tree (*Baccharis halimifolia*), beggar ticks (*Bidens alba*), and common ragweed (*Ambrosia artemisiifolia*).

There are no federally or state-listed plant species documented from the ruderal-herbaceous land cover type.

Fresh Water – Interior
Interior freshwater marshes are found in various depressions, such as swales between relict dunes and littoral zones of old borrow ponds. Vegetation is primarily composed of obligate wetland species similar to those found in ditches (described above). However, the shoreline slopes tend to be less steep, allowing littoral zones of greater area that support more species diversity than present along ditches. Typical plant species include emergents such as maidencane, pink red stem, herb-of-grace, sawgrass, spikerush, softstem bulrush (*Schoenoplectus tabernaemontani*), marsh penny wort, southern cattail, and arrowhead. Various sedges are common in wet areas. Grasses include seashore paspalum, and the non-native torpedo grass (*Panicum repens*). Primrose willow (*Ludwigia* spp.) and Virginia saltmarsh mallow (*Kosteletzkya pentacarpos*) can be locally abundant.

There are no federally listed plant species in the type, but lace-lip ladies' tresses (*Spiranthes laciniata*), classified as a Threatened species in Florida, has been documented on CCAFS and might occur on KSC adjacent to freshwater wetlands (Schmalzer et al. 2002).

3.3 Existing/Proposed Projects within the Action Area

The following previous, on-going, and proposed projects within the action area could have affected or could potentially affect wildlife and/or habitats in the future:

Created Inland Dune
During the summer of 2010, an inland 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 the dune was to improve

sea turtle nesting habitat by creating a natural visual screen between the beach and LC 39 facilities, and to improve southeastern beach mouse (*Peromyscus polionotus niveiventris*) habitat that was unproductive because of past disturbances. The stretch of primary dune adjacent to this area has been severely compromised in the past by activities associated with railroad operations, and during the last several years by wash overs and inundation from storm surges. Vegetation planting on the newly constructed dune occurred in April 2011 and was funded by the USFWS at MINWR through a grant from the National Fish and Wildlife Foundation for sea turtle management. Ecological monitoring was requested by the USFWS Endangered Species Office in Jacksonville in order to determine if and when southeastern beach mice would populate the new dune habitat. Monitoring surveys occurred in November 2011 and February, May, and August 2012. Fifty-five permanent vegetation plots are being sampled; 40% of the dune is vegetated (31% native desirable vegetation plus 9% nuisance species). Thirteen gopher tortoise burrows have been established and five tortoises inside burrows have been documented. Four species of small mammals have been trapped, including 52 individual southeastern beach mice, 25 of which were captured in two consecutive monitoring events, and 6 that were captured in three consecutive monitoring events. Ten other vertebrate species were documented on the dune, including an eastern indigo snake, which is a federally listed Threatened species. (Bolt et al. 2012).

Primary Dune Repair

In June 2011, MINWR supplied funding for equipment, labor, and materials to repair a breach in the primary dune adjacent to LC 39B, just north of the newly created inland dune (described above). The repair site was approximately 160 m (525 ft) long, 10 m (33 ft) wide, and 3 m (10 ft) in height above the existing grade of the beach. A grant to the USFWS from National Fish and Wildlife Foundation paid to furnish and install native plants on the repaired dune breach (R. Lloyd, pers. comm.).

Proposed Corrosion Test Facility Expansion

The Corrosion Test Facility (CTF) is 0.5 ha (1.3 ac) 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 for exposure of a wide variety of structures and materials to the elements present along the Atlantic coast, and both government and commercial entities use the facility. The existing test beds are full and current customers have requested more room for test articles, and it is anticipated that new commercial companies will soon be requesting additional space as well. A proposal has been submitted to increase the footprint of the exposure test beds by 0.1 ha (0.2 ac). This expansion would run 91 m (300 ft) north/south and be located adjacent to the south end of the existing test beds. Habitats within the proposed expansion area are primarily well managed coastal dune and strand.

Section 4 Species Considered

Seven species of federally protected wildlife have been documented within the Shoreline Protection Project boundaries; one additional species historically occurred, but is no longer believed to be present. These eight species are listed in Table 2.

Table 2. Federally protected wildlife species documented to occur or occurred historically within the Shoreline Protection Project boundary.
Status: T - threatened; E - endangered; C - candidate for listing

Scientific Name	**Common Name**	**Status**	**Identification**
Caretta caretta	Loggerhead	T	documented
Chelonia mydas	Atlantic green turtle	E	documented
Dermochelys coriacea	Leatherback sea turtle	E	documented
Gopherus polyphemus	Gopher tortoise	C	documented
Drymarchon couperi	Eastern indigo snake	T	documented
Nerodia clarkii taeniata	Atlantic saltmarsh snake	T	historical
Aphelocoma coerulescens	Florida scrub-jay	T	documented
Peromyscus polionotus niveiventris	Southeastern beach mouse	T	documented

4.1 Current Conditions

Marine Turtles
Three species of marine turtles have been documented using KSC beaches for nesting. The loggerhead (*Caretta caretta*) and green sea turtle (*Chelonia mydas*) are abundant during their nesting season (May – October) and numbers of leatherback (*Dermochelys coriacea*) nests have increased over the past 20+ years; they are no longer considered rare. The KSC nesting beach is 10 km (6.2 mi) long; the Shoreline Protection Project boundary consists of the northernmost 7.6 km (4.7 mi) (Figure 1). Some disorientation of marine turtles related to lighting from nighttime space operations has occurred along the KSC beach over the last decade. The USFWS Endangered Species Office issued an interim Biological Opinion (BO) in 2009 (U.S. Fish and Wildlife Service 2009) that was applicable for the 2009 - 2011 nesting seasons. This BO was based upon the review of lighting impacts and management activities on nesting sea turtles and emerging hatchlings. The resulting rate of take (i.e., hatchling disorientation) allowed by the BO was 3% (USFWS 2009).

Table 3 shows the number of nests, by species, deposited on the KSC beach from 2008 through 2011. Nesting "hot spots" are typically km 26-27 and 32-33 (Figure 2) (Gann, S.L. 2011). The area between km 30-31 has the highest percentage of false crawls (emergences that do not result in a nest); this location is also where the dune is most highly eroded and wash overs have occurred several times in the past few years (Coastal Planning & Engineering, Inc. 2011).

Table 3. Sea turtle nesting data from the Kennedy Space Center beach, 2008 – 2011.

Loggerheads	**2008**	**2009**	**2010**	**2011**
nests	1072	789	1163	1089
false crawls	826	734	869	776
total emergences	1898	1523	2032	1865
Green Turtles				
nests	104	53	142	176
false crawls	136	71	219	302
total emergences	240	124	361	478
Leatherbacks				
nests	1	2	6	3
false crawls	0	0	0	1
total emergences	1	2	6	4

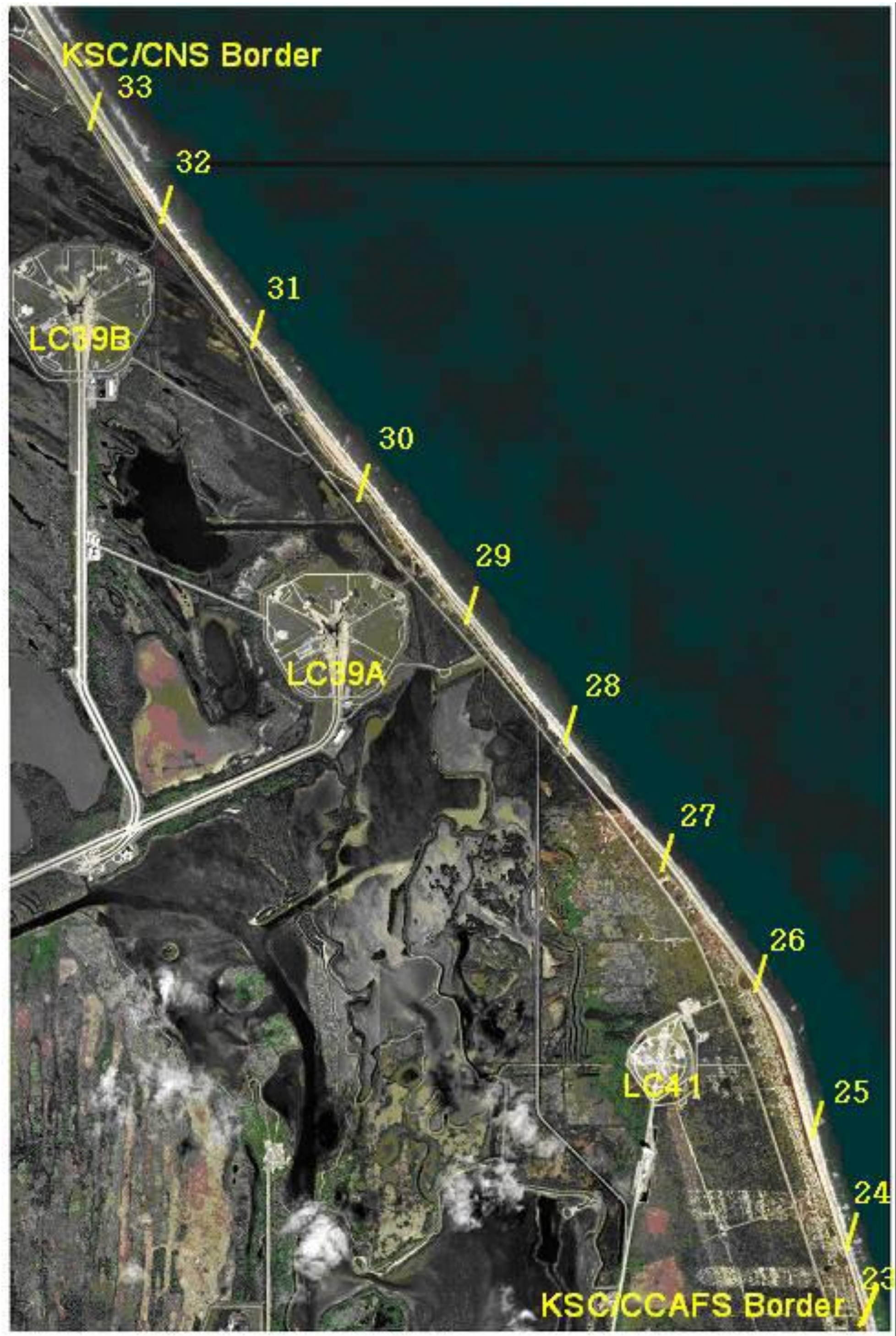

Figure 2. The Kennedy Space Center sea turtle nesting beach. Yellow numbers indicate the general locations of kilometer markers used for recording sea turtle nesting data for the Florida statewide Index Nesting Beach Survey.

Disorientation surveys for adults and hatchlings are performed every season. Adult disorientations for 2008, 2009, and 2010 were 0.3%, 0.4%, and 0.6%, respectively. Hatchling disorientation rates vary tremendously from year to year (Figure 3), depending on light pollution from facilities and the condition of the dunes between light sources and the nesting beach. The average rate for 2000 – 2009 is 5%, which is above the 3% take allowed by the interim BO issued in 2009. However, hatchling disorientation rates for 2008, 2009, and 2010 were 2.4%, 3.5%, and 2.4%, respectively, and it appears that the numerous activities and efforts being made to reduce impacts from lighting are improving conditions (Gann, S.L. 2011).

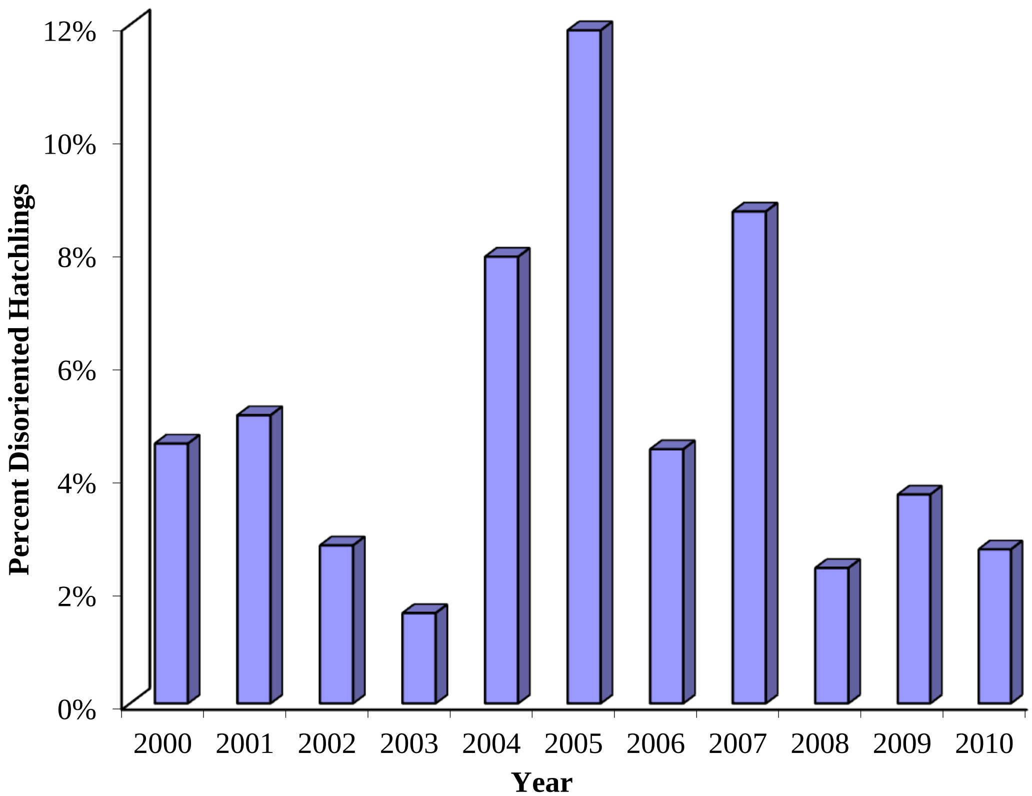

Figure 3. Disorientation rates of sea turtle hatchlings on the Kennedy Space Center beach for 2000 through 2010 nesting seasons.

Gopher Tortoise

The coastal dune habitat along the KSC shoreline is very suitable for gopher tortoises (*Gopherus polyphemus*). More than 1,000 tortoises have been captured, measured, and permanently marked from this area since the mid-1970s (R. Seigel, pers. comm.). Hatchling and juvenile tortoises are common, indicating a healthy, reproducing population. Studies to determine home range sizes have been done with radiotagged tortoises on KSC. Males' home ranges were between 0.3 and 5.3 ha (0.7 – 13.1 ac); the average size was 1.9 ha (4.7 ac) (Smith et al. 1997). Females' home ranges were smaller and they used between 0.3 and 1.1 ha (0.7 – 2.7 ac), with an average of 0.6 ha (1.5 ac). However, these studies were from scrub and scrubby flatwoods habitats where conditions are much different than those in coastal dune. KSC scrub and scrubby flatwoods have a dense shrub layer that tends to reduce the amount of light reaching the ground, which in turn reduces the herbaceous plant growth used as food by tortoises (Schmalzer and Hinkle 1992; Breininger et al. 1994). Tortoises in those less suitable habitats need larger home ranges in order to have sufficient resources (Ashton and Ashton 2008). The coastal dune is more open and the vegetation is primarily grasses and herbs, with plenty of documented species of tortoise food available (Ashton and Ashton 2008). Also, the soil of the coastal dune habitat is sandy and very suitable for burrowing. Because of these habitat characteristics, it is not surprising that the project area supports a large gopher tortoise population.

There are several man-made features within the project area that are potentially detrimental to tortoises. The railroad track is an effective trap for tortoises (and other turtle species) that crawl onto the tracks where they are flush with the road. Tortoises often cannot get out and will walk inside the tracks until they overheat or get too cold and die (B. Bolt pers. obs.; R. Seigel pers. obs.; Figure 4). Tortoise road kills are not unusual along Phillips Parkway because the tortoises feed on the grassy road shoulder and regularly cross the road. There are occasionally burrows on the shoulder that open directly onto the pavement. Another potentially unfavorable feature is the 0.5 ha (1.2 ac) of ditches in the project area. These ditches are narrow and extend over a long portion of the project, running parallel between the primary dune and the railroad track. In some places and under the right conditions, they are probably sufficient to hinder access by gopher tortoises to the various habitat types, resources, and other tortoises. All of these man-made features are likely harmful to the overall health and welfare of the tortoise population.

Figure 4. Shell from a gopher tortoise that was trapped inside the railroad tracks in the Shoreline Protection Project area, February 2012.

Eastern Indigo Snake

Eastern indigo snakes (*Drymarchon couperi*) on KSC have large home ranges, eat a wide variety of prey, and use many different habitat types (Stevenson et al. 2010, Breininger et al. 2011). Radio tagged indigos tracked in Brevard County 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. A radio tagged indigo from KSC had a home range located just south of the Shoreline Protection Project area on CCAFS (Figure 5). This male's home range was 117.8 ha (291 ac) and he used habitat types that are found within the project area, including coastal dune. Indigos have been documented on several occasions in the Shoreline Restoration Project footprint (R. Bolt pers. obs.). A female was captured, measured, tagged with a Passive Integrated Transponders (PIT tag), and released in November 2011 from the newly created secondary dune (Bolt et al. 2012) (see Section 3.3 of this document for a description of the created inland dune project).

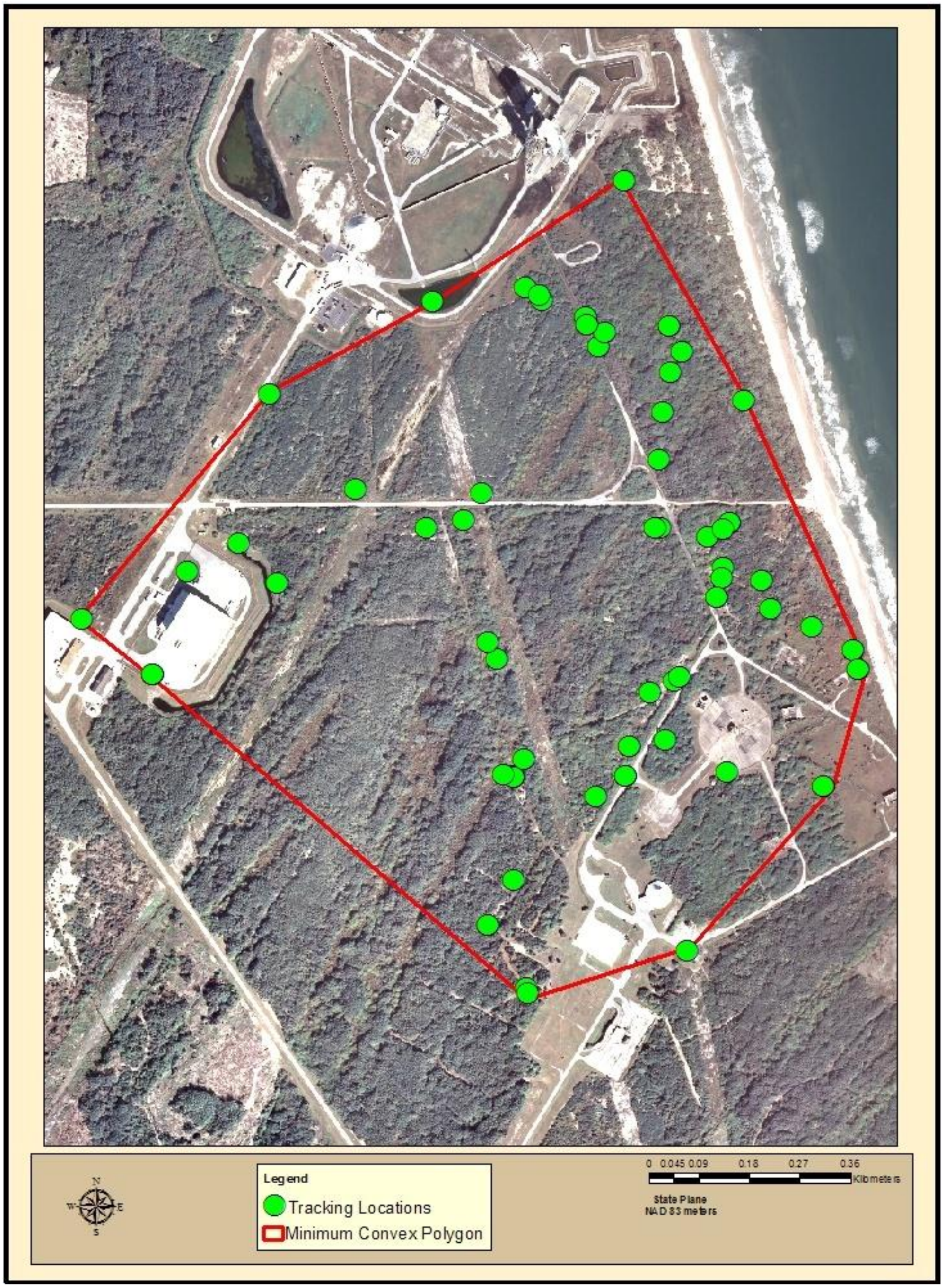

Figure 5. Radio tracking locations and the minimum convex polygon home range [117.8 ha (291 ac)] for a male eastern indigo snake tracked on Cape Canaveral Air Force Station just south of the Shoreline Protection Project boundary.

Habitat fragmentation was found to be a critical factor impacting indigo snake population persistence (Breininger et al. 2012). 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 (Breininger et al. 2004). The project area is relatively intact along the length of the shoreline. However, Phillips Parkway is a potential source of road mortality; road mortality was found to be the most prevalent cause of death in the radio tagged indigos studied in Brevard County (Breininger et al. 2012).

Atlantic Salt Marsh Snake

Although the Atlantic salt marsh (*Nerodia clarkii taeniata*) snake historically occurred along the coastline from Volusia County through Brevard County south into Indian River County, it is now believed to be restricted to a limited coastal strip in Volusia County (USFWS 2005). Specimens found in Brevard and Indian River counties are believed to be intergrades between the Atlantic subspecies and the mangrove salt marsh snake (P. Moler pers. comm.). Little is known about the population size or status of Atlantic salt marsh snakes, but none are expected to occur within the project area.

Florida scrub-jay

Within the project area, there are 45.5 ha (112.4 ac) of coastal strand habitat that could potentially support Florida scrub-jays (*Aphelocoma coerulescens coerulescens*). However, in order for scrub-jays to occupy the habitat and persist, the habitat must have a narrow range of characteristics related to vegetation height and open space (Johnson et al. 2011). These conditions were historically maintained by wildfires, and along the coastline, by salt spray. Now, scrub-jay habitat types are typically kept suitable through controlled burning and mechanical treatment, although little controlled burning is done along the coast.

Depending on the alternative chosen for the Shoreline Protection Project (except for No Action), between 5.3 ha (13.1 ac) and 10.9 ha (26.8 ac) of coastal strand would be impacted. Most of the coastal strand within the project area does not support jays (Figure 6), likely because there is too little scrub oak of the appropriate height. There are two territories that have been documented on the southern end of the project area; territory A is 33.6 ha (83 ac) with two jays and territory B is 23.4 ha (57.8 ac) with four jays (Figure 6; G. Carter pers. comm.).

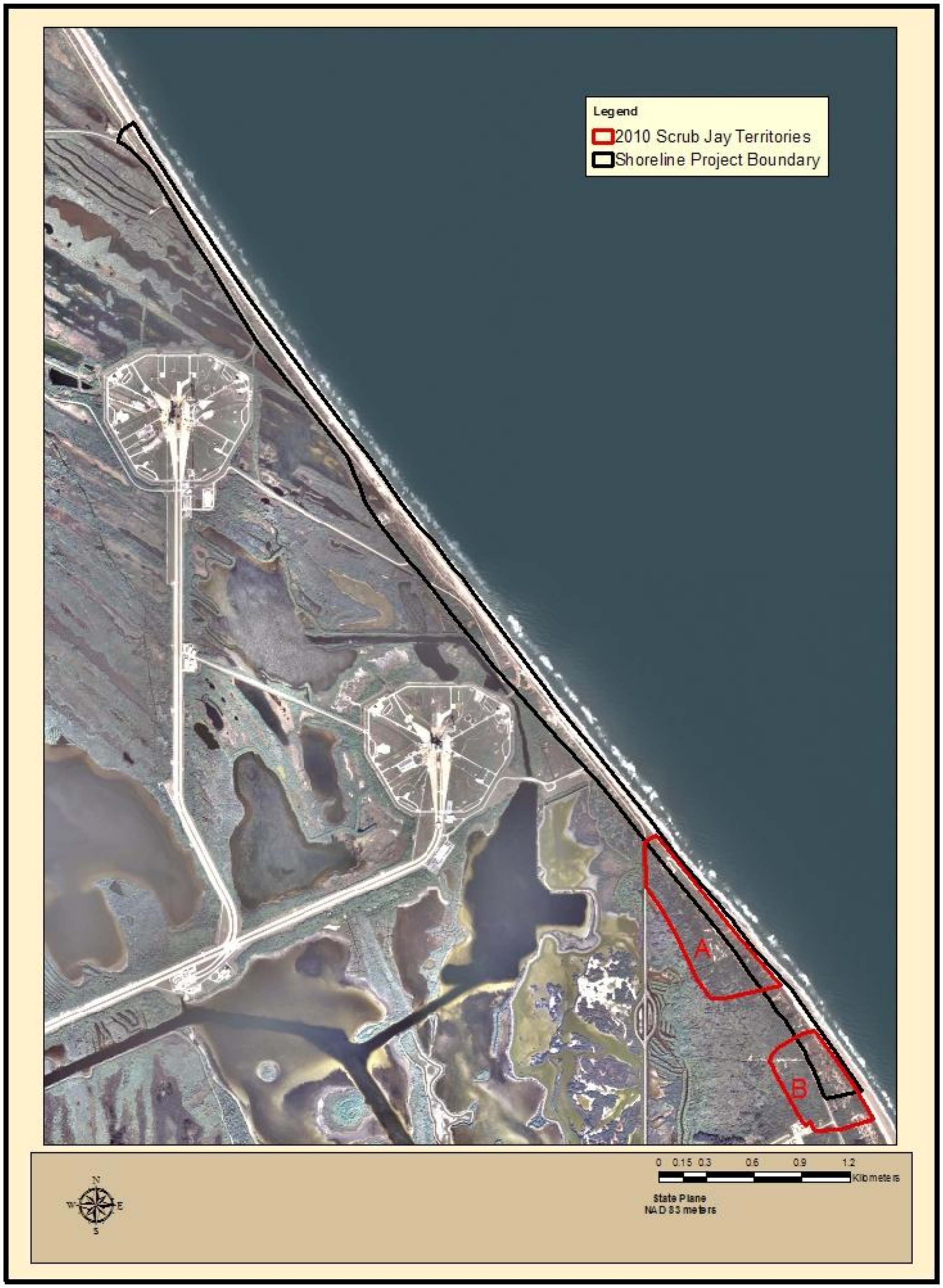

Figure 6. Florida scrub-jay territories located within the Shoreline Restoration Project boundary in 2010.

Southeastern beach mouse

Studies and surveys have been done on the southeastern beach mouse (*Peromyscus polionotus niveiventris*) 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 incidents. Four seasonal trapping events done between 2003 and 2005 at seven transects located in the Shoreline Restoration Project area yielded results similar to previous studies (Provancha et al 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 beach mice are distributed along the entire coastline of the project area (Figure 7; E. Stolen pers. comm.).

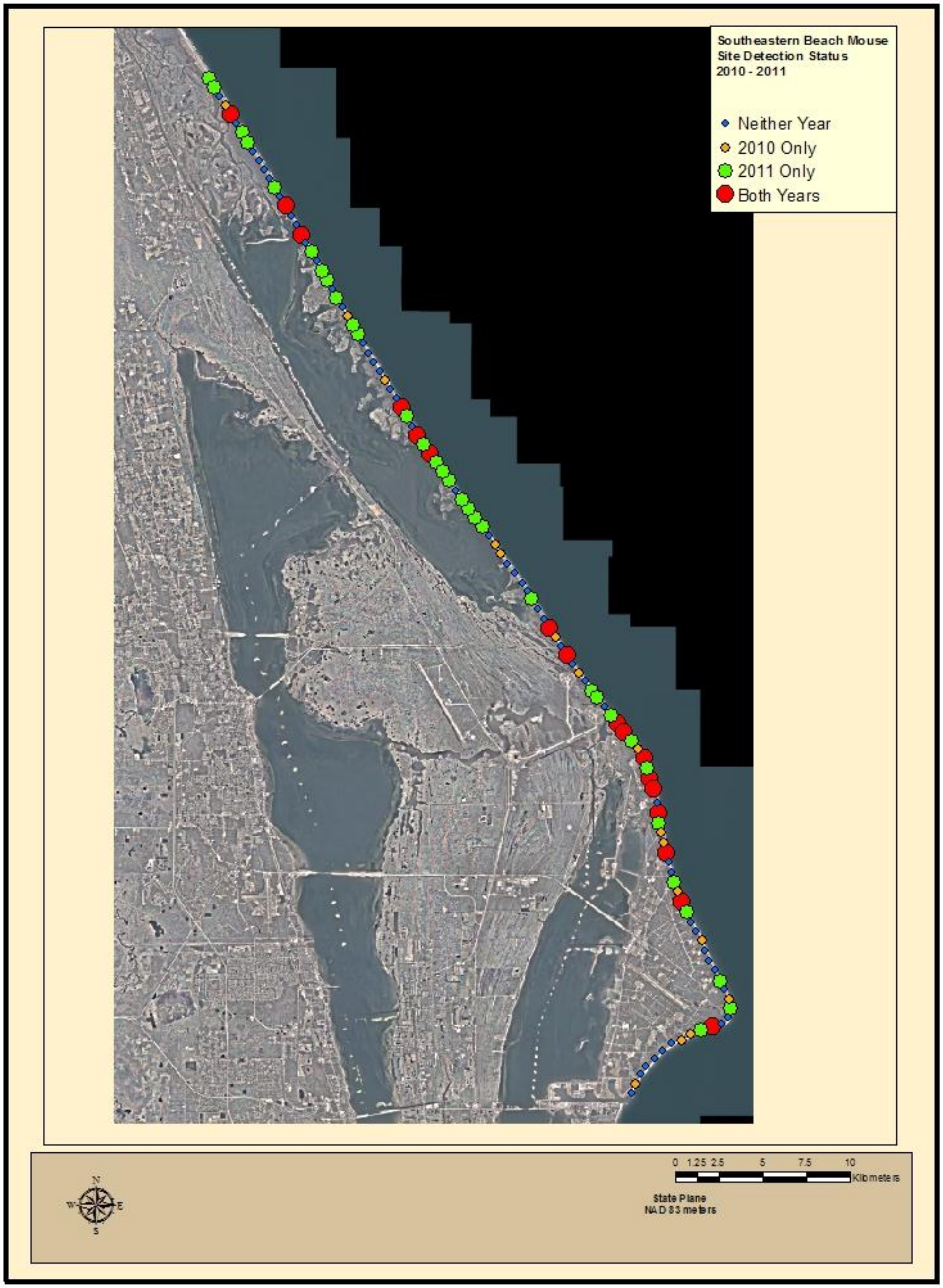

Figure 7. Detections via tracking tubes of southeastern beach mice on Canaveral National Seashore, Kennedy Space Center, and Cape Canaveral Air Force Station, 2010 and 2011.

Over the last 10 to 15 years, several significant hurricane and non-hurricane storm events resulted in over wash and severe erosion of the KSC dunes and beach (Coastal Planning & Engineering, Inc. 2011). In August and September 2004, three hurricanes directly hit Florida, and each affected the Shoreline Restoration Project area either by rainfall, winds and/or serious beach erosion. One of the transects established for the 2003-2005 beach mouse trapping study experienced overwash that eliminated much of the vegetation and some of the trapping stations; the primary dune at two other transects was eroded approximately 2 m (6.6 ft) on the ocean side. Sampling was conducted three weeks after the last storm, but no conclusions could be made as to the impact of the storm damage on beach mouse populations. Mice were trapped at all sampling locations, although numbers were lower at the transect that lost much of its vegetation (Provancha et al. 2005). Significant storms also caused damage within the project area in 2007 and 2008, but there were no corresponding mouse trapping surveys done after those storms. In 2005 and 2008, dune restoration projects were implemented to repair breaches and rebuild dune height in order to protect the beach from lighting from nearby facilities that could potentially disorient marine turtles. Sand was acquired on-site, either by digging out from the landward side of the primary dune (creating ditches and swales) or pulling sand from the ocean side. It is unknown how long the impacts from such activities will affect beach mouse populations, but these impacts are expected to be short term. Monitoring of a newly created secondary dune (see Section 3.3 of this document for a description of the created inland dune project) showed that at least 33 individual beach mice of all age classes were occupying the new dune within ten months of the bare sand being planted with native vegetation (Bolt et al. 2012).

As with the gopher tortoise, the railroad track and ditches located west of the primary dune may be impediments to beach mouse movements, obstructing access to habitat, as well as other sub-populations. If primary dune habitat is destroyed by storm surges, recolonization of those areas may be slowed down or prevented in areas where the railroad track and/or ditches hamper movement of mice from more inland populations.

Section 5 Impacts Analysis

Depending on the shoreline protection alternative chosen, or no action, impacts would differ for the seven federally protected wildlife species known to occur within the Shoreline Protection Project boundaries. Table 4 shows the potential impacts for each species for each action alternative and if no action is taken. These impacts are further broken down by impacts from construction (C) and the anticipated long-term impacts (L-t).

Table 4. Impact categories matrix for seven federally protected wildlife species documented as occurring within the Shoreline Protection Project boundaries on Kennedy Space Center. C = Construction impacts; L-t = Long-term impacts (i.e., after recovery from construction); Alternative descriptions and Impact Category descriptions are given below the table.

Species	Alt. 1		Alt. 2		Alt. 3		Alt. 4		No Action
	C	L-t	C	L-t	C	L-t	C	L-t	
Marine turtles	1	4	2	4	2	4	2	4	2
Gopher tortoise	2	4	2	4	2	4	2	4	2
Eastern indigo snake	2	4	2	4	2	4	2	4	2
Florida scrub-jay	2	4	2	4	2	4	2	4	2
Southeastern beach mouse	2	4	2	4	2	4	2	4	2

Alternative Descriptions (see Section 2 for more detail):

- Alternative 1 involves construction of a large secondary dune behind existing primary dunes in areas where the primary dunes are highly eroded or non-existent.
- Alternative 2 involves renourishing the beach with sand to restore beach width lost to erosion over time, bringing it back to a condition that existed 15-20 years ago. The primary dunes would be reinforced as needed.
- Alternative 3 incorporates renourishing the beach as in Alternative 2, but in this alternative, the entire primary dune would be reconstructed or reinforced.
- Alternative 4 is a hybrid of proposed Alternatives 1, 2, and 3.

Impact Category Descriptions:

1. Minimal – impacts are not expected to be measurable, or are too small to cause any discernable degradation to the environment
2. Moderate – impacts would be measureable, but not substantial, because the impacted system is capable of absorbing the change, or impacts could be reduced through appropriate mitigation
3. Major – impacts could individually or cumulatively be substantial

4. Beneficial – impacts would be positive in nature

5.1 Construction Impacts

Alternative 1 - Construction impacts to marine turtles are expected to be minimal because none of the work would be done on the beach. Most of the secondary dune would be constructed on the west side of the primary dune. In areas where the primary dune is severely degraded, the secondary dune would be extended eastward to the beach to replace the primary dune. For the other four species, construction impacts are predicted to be moderate because of the loss of coastal dune habitat from the placement of sand for the dune.

Alternative 2 - Impacts to all seven species are expected to be moderate. Construction would be limited to the beach, except where the primary dune is already severely degraded. No sand would be placed on the beach during the marine turtle nesting season so as to avoid disrupting adult females coming to shore or covering existing nests.

Alternative 3 – In this alternative, the entire primary dune would be rebuilt, or at least reinforced. Therefore, impacts to all species are expected to be the same for Alternative 3 as they would be for Alternative 2 (moderate).

Alternative 4 – This alternative is a combination of the other three alternatives, so construction impacts to all species would be moderate.

No cumulative impacts are expected to occur from construction, regardless of the alternative chosen. Once construction was completed, the habitat would recover to a condition that was at least the same, if not improved, as compared to pre-construction conditions.

5.2 Long-term Impacts

Regardless of the action alternative chosen, long-term impacts are anticipated to be beneficial. The beach and primary dune are expected to continue to degrade over time (Coastal Planning & Engineering 2011) and intervention of some sort will be necessary if the beach and dune habitats are to persist. Alternative 1 represents a managed retreat scenario in which resources are put into providing new habitat away from the source of degradation (i.e., the ocean). Initial results from the secondary dune created in 2010-2011(see Section 3 for a more detailed description) indicate that in less than one year after the original construction, the created secondary dune has become a functioning ecosystem. Alternatives 2 and 3 are stop-gap measures designed to buy time before the eventual destruction of the beach and primary dune system; both of these alternatives would require maintenance every six to ten years to continue to be useful. Alternative 4 would provide both short-term and long-term benefits after recovery from the initial construction.

Cumulative long-term impacts from Alternative 1 are expected to be beneficial as new habitat is created and becomes self-sustaining. Alternatives 2, 3, and 4 are also expected to produce long-term beneficial cumulative impacts, but will require periodic maintenance to ensure the continued integrity of the beach and primary dune. In the event of intense or persistent storm events, additional maintenance may be required.

5.3 No Action

Failure to take any action would result in the continued degradation and loss of the beach and inland dune habitats, as well as the wildlife that depends on them. These impacts would likely take decades to manifest, so would be classified as moderate for the time-scale of this assessment.

Section 6 Conservation Measures

A variety of conservation measures designed to lessen impacts of the restoration activities are being proposed. These include:

- Work that directly impacts the beach will be done from November 1 through the end of February, outside the sea turtle nesting/hatching season.
- Work that occurs in areas other than the beach will only occur in daylight hours during the sea turtle nesting/hatching season to avoid light pollution from construction activities.
- Laydown sites for equipment and materials will be carefully chosen and placed in already developed areas or degraded habitat, as will access points between the existing road (Phillips Parkway) and construction sites. The number and size of the areas will be dependent on the alternative chosen.
- Activities will be limited as much as possible to areas that are degraded with little value as wildlife habitat. There may be instances, depending on the alternative chosen, when impacts to habitats that are potentially occupied by protected species are unavoidable. Reasonable efforts will be made to relocate southeastern beach mice (*Peromyscus polionotus niveiventris*) and gopher tortoises (*Gopherus polyphemus*) from those areas to nearby suitable habitat.
- Beach restoration that most closely approximates the historic, natural conditions will be attempted. The beach fill slope will be designed to a) promote nesting by marine turtles, b) block artificial light from reaching the beach and disorienting nesting marine turtles and hatchlings, and c) reduce the threat of back beach flooding.

The Shoreline Protection Project, regardless of the alternative chosen (other than No Action), would have a positive effect on conservation of wildlife habitat, once the area has recovered from the initial restoration work. The No Action alternative would allow the continued erosion of the beach and inundation of back dune areas, compromising space operations-related infrastructure and degrading and eventually destroying vital wildlife habitat.

Section 7 Determination of Effects

Compliance with Section 7 of the Endangered Species Act dictates that the impacts (i.e., effects) to the protected wildlife species for each alternative and the No Action alternative be determined so that the appropriate response from the USFWS can be initiated. Below are the descriptions for the effects that are applicable for this BA, and the Alternatives descriptions:

Effects Descriptions

- “May affect, but not likely to adversely affect” – All effects are beneficial, insignificant, or discountable, or can be made so by using conservation-oriented construction practices and/or mitigation.
- “May affect, and is likely to adversely affect” – Protected species are likely to be impacted by the action or its environmental consequences, and will respond in a negative manner.

Alternatives Descriptions (see Section 2 for more detail):

- Alternative 1 involves construction of a large secondary dune behind existing primary dunes in areas where the primary dunes are highly eroded or non-existent.
- Alternative 2 involves renourishing the beach with sand to restore beach width lost to erosion over time, bringing it back to a condition that existed 15-20 years ago. The primary dunes would be reinforced as needed.
- Alternative 3 incorporates renourishing the beach as in Alternative 2, but in this alternative, the entire primary dune would be reconstructed or reinforced.
- Alternative 4 is a hybrid of Alternatives 1, 2, and 3.

Below, a determination of effects is made for the seven species for each of the four alternatives (construction impacts and long-term impacts), and the No Action alternative in the Shoreline Protection Project. Marine turtles are combined into one group as the impacts to them are expected to be the same for the three species. Gopher tortoises, eastern indigo snakes, Florida scrub-jays, and southeastern beach mice are also grouped together; impacts to them from all of the alternatives are anticipated to be very similar.

Marine Turtles

Anticipated impacts from construction of any of the four alternatives are either minimal or moderate, and are not expected to adversely affect marine turtles. Construction done on the beach habitat itself (Alternatives 2, 3, or 4) would be done outside of the marine turtle nesting season. Any material added to the beach would first be deemed compatible with current sand conditions, and the construction would be done in such a way as to mimic the historic beach profile. Although declines in the number of marine turtle nests have been documented during the first season after restoration, this phenomenon appears to be short-lived (Brock et al. 2007; Rumbold et al. 2001).

Long-term impacts from any of the four action alternatives would be anticipated to be beneficial because the continued degradation of the shoreline without intervention will eventually result in loss of the nesting beach (Coastal Planning and Engineering, 2011).

Gopher Tortoise, Eastern Indigo Snake, Florida Scrub-jay, Southeastern Beach Mouse
Construction impacts to these species would be from direct loss of habitat and are not expected to have adverse effects. If Alternative 1, 3, or 4 were chosen, much of the existing primary dune would be covered with new sand and then planted. Impacts would be measurable (moderate), but could be reduced through a variety of conservation-oriented construction practices and mitigation. If Alternative 2 were chosen, most of the construction would occur on the beach and the existing primary dune would only be restored in areas where it is already severely degraded.

As with the marine turtles, long-term impacts from any of the action alternatives would be beneficial once there was recovery from the initial construction. Results from the created inland dune project (see Section 3.3 for details) indicate that ecosystem recovery can occur quickly (less than one year) once the bare sand is planted with vegetation (Bolt et al. 2012).

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Section 9 Preparers and Contributors

Name	Title	Affiliation	Contribution
Bolt, Rebecca	Wildlife Ecologist	InoMedic Health Applications (IHA)	Writing
Breininger, David	Wildlife Ecologist	IHA	Eastern indigo snake data
Cancro, Resa	Senior GIS Analyst	IHA	GIS mapping
Carter, Geoff	Wildlife Ecologist	IHA	Florida scrub-jay data
Dankert, Don	Biological Scientist	NASA Environmental Management Branch	Document review
Gann, Shanon	Wildlife Biologist	IHA	Marine turtle data
Hall, Patrice	Environmental Engineer	IHA	Document review
Kozusko, Tim	Ecologist	IHA	Habitats section writing
Lloyd, Ralph	Assistant Refuge Manager	U.S. Fish and Wildlife Service, Merritt Island National Wildlife Refuge	KSC beach projects information
Mercadante, Mark	Environmental Engineer	IHA	Document review
Moler, Paul	Herpetologist, retired	Florida Fish and Wildlife Conservation Commission	Atlantic salt marsh snake information
Moore, Michelle	Environmental Engineer	IHA	Document administration
Provancha, Jane	Environmental Projects Manager	IHA	Project administration; document review
Seigel, Rich	Herpetologist; Professor	Towson University, Baltimore, MD	Gopher tortoise data
Schaub, Ron	Ecologist/Geographer	IHA	GIS information
Shaffer, John	Lead, Environmental Planning	NASA Environmental Management Branch	Facilities information
Stolen, Eric	Wildlife Ecologist	IHA	Southeastern beach mouse data

APPENDIX H

Mailed to:

NASA-TA/B1B
TA/A48 JEFFERY BOBERSKY
KENNEDY SPACE CENTER

A daily publication by:

FLORIDA TODAY
THE SPACE COAST'S NEWSPAPER
PUBLISHED IN BREVARD COUNTY

STATE OF FLORIDA
COUNTY OF BREVARD

Before the undersigned authority personally appeared Kim Curro, who on oath says that she is **LEGAL ADVERTISING SPECIALIST** of the **FLORIDA TODAY**, a newspaper published in Brevard County, Florida; that the attached copy of advertising being a

LEGAL NOTICE

Ad # (	**520537**	**$**	**466.70**	**the matter of:**
Acct. #(	**6NS528)**			
the		**Court**		**NOTICE-KSC-01-15**
				NATIONAL ENVIRONMENTAL POLICY ACT.....

as published in the **FLORIDA TODAY** in the issue(s) of:

June 12, 2015

Affiant further says that the said **FLORIDA TODAY** is a newspaper in said Brevard County, Florida, and that the said newspaper has heretofore been continuously published in said Brevard County, Florida, regularly as stated above, and has been entered as periodicals matter at the post office in **MELBOURNE** in said Brevard County, Florida, for a period of one year next preceding the first publication of the attached copy of advertisement; and affiant further says that she has neither paid nor promised any person, firm or corporation any discount, rebate, commission or refund for the purpose of securing this advertisement for publication in said newspaper.

(Signature of Affiant)

Sworn to and subscribed before this: **12th day of June 2015**

RUBY ROYER
NOTARY PUBLIC
STATE OF FLORIDA
Comm# FF088043
Expires 1/30/2018

FLORIDA NOTARY ASSOCIATION SINCE 1978

(Signature of Notary Public)

Ruby Royer

Personally Known X or Produced Identification ____________
Type Identification Produced: ____________

AD#520537 06/12/2015

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NOTICE: KSC-01-15

National Environmental Policy Act: John F. Kennedy Space Center, Kennedy Space Center (KSC), Florida

AGENCY: National Aeronautics and Space Administration (NASA)

ACTION: Availability of the KSC Shoreline Protection Draft Environmental Assessment (EA), KSC, Florida

SUMMARY: Pursuant to the National Environmental Policy Act (NEPA) of 1969, as amended (42 United States Code 4321 et seq.), the Council on Environmental Quality Regulations for Implementing the Procedural Provisions of NEPA; 40 Code of Federal Regulations (CFR) §1500–1508; and NASA policy and procedures (14 CFR §1216.3), NASA has prepared and issued a Draft EA for the KSC Shoreline Protection Project, KSC, Florida. The purpose of NASA's Proposed Action is to reduce shoreline erosion and protect critical launch infrastructure and valuable threatened and endangered species habitats along the KSC coastline from storm wave and sea-level rise damage. The Proposed Action would place various amounts of sand fill along the KSC shoreline and include subsequent dune construction and vegetation planting. The four Action Alternatives evaluated seek to establish an increased dune elevation and sand volume within the dune/beach barrier system for purposes of erosion control and flood prevention.

DATES: Interested parties are invited to submit written comments on environmental concerns on or before July 20, 2015 or 30 days from the date of this notice publication, whichever is later.

ADDRESSES: Address written comments or questions to:

Mr. Donald Dankert
KSC Environmental Management Branch
Mail Code: SI-E3
Kennedy Space Center, FL 32899
E-mail: donald.j.dankert@nasa.gov

The Draft EA can be reviewed at the following locations:

1. Central Brevard Public Library and Reference Center
2. Cocoa Beach Public Library
3. Melbourne Public Library
4. Merritt Island Public Library
5. Port St. John Public Library
6. Titusville Public Library

The Draft EA is also available in Acrobat® format at http://environmental.ksc.nasa.gov/projects/nepa.htm

FOR FURTHER INFORMATION CONTACT:

Mr. Donald Dankert
KSC Environmental Management Branch
Mail Code: SI-E3
Kennedy Space Center, FL 32899
E-mail: donald.j.dankert@nasa.gov
Telephone: 321.861.1196

SUPPLEMENTAL INFORMATION: The KSC Shoreline Protection EA addresses potential impacts associated with the Proposed Action and No Action Alternative. The following project alternatives are being evaluated for purposes of reducing flooding and long-term loss of land along the KSC shoreline due to impacts of beach erosion. Four alternatives and the No Action Alternative were identified and carried forward for further evaluation.

Alternative One, the locally preferred alternative, establishes a new secondary dune immediately inland of the existing dune, and allows the existing dune and beach to serve as an erosion buffer. Alternative Two reestablishes the historical condition existing 10 to 20 years ago, and employs beach renourishment to maintain that condition. In Alternative Three, the dune is reinforced at its current eroded location and beach renourishment is employed to maintain that location. Alternative Four is a hybrid approach that utilizes partial restoration of the primary dune and beach as a near-term strategy, and establishes a secondary inland dune as a long-term strategy.

Under the No Action Alternative, the KSC beach would be left as it is in its current state. Without an intervening measure the natural and storm induced erosion along the KSC shoreline will continue and further threaten and potentially compromise KSC infrastructure and critical coastal habitat. The historical progression of dune and beach erosion along the northern 7.4 km (4.6 mi) of the KSC shoreline documented over the past decades, combined with the continuation or possible acceleration of sea level rise, strongly indicates that the beach and dune will continue to degrade in the absence of intervening actions. In the No Action Alternative, overtopping and breaching of the primary dune are likely to occur in the near future, which could result in large-scale inundation, habitat alteration, and land loss along the coastal strand.

Florida Department of Environmental Protection

Marjory Stoneman Douglas Building
3900 Commonwealth Boulevard
Tallahassee, Florida 32399-3000

Rick Scott
Governor

Carlos Lopez-Cantera
Lt. Governor

Jonathan P. Steverson
Secretary

August 12, 2015

Mr. Donald J. Dankert, Biological Scientist
NASA KSC Environmental Management Branch
Mail Code: TA-A4C
John F. Kennedy Space Center
Kennedy Space Center, FL 32899

RE: National Aeronautics and Space Administration – Draft Environmental Assessment for Kennedy Space Center Shoreline Protection Project – Cape Canaveral, Brevard County, Florida.
SAI # FL201506197332C

Dear Don:

The Florida State Clearinghouse has coordinated a review of the subject Draft Environmental Assessment (EA) under the following authorities: Presidential Executive Order 12372; Section 403.061(42), *Florida Statutes*; the Coastal Zone Management Act, 16 U.S.C. §§ 1451-1464, as amended; and the National Environmental Policy Act, 42 U.S.C. §§ 4321-4347, as amended.

The Florida Department of Environmental Protection's (DEP) Division of Water Resource Management staff advises that the Kennedy Space Center's (KSC) preferred alternative proposing construction of a dune landward of the Mean High Water Line is consistent with the state's Strategic Beach Management Plan. The proposed dune restoration project is exempt from DEP Coastal Construction Control Line permitting, but may require an Environmental Resource Permit from the DEP or St. Johns River Water Management District if proposed construction activities impact wetlands.

The Florida Fish and Wildlife Conservation Commission (FWC) reports that a number of listed species have been documented within or in close proximity to KSC's beach and primary dune, coastal strand, estuarine scrub-shrub wetland, manmade ditch, and herbaceous rudera1 area habitats. In general, FWC staff recommends that the Final EA include specific information, in addition to the avoidance and minimization measures identified in the Biological Assessment, to assure that the proposed project will be implemented to avoid, minimize and mitigate any potential impacts to state-listed species and their habitats. The FWC has provided comments and recommendations on gopher tortoises, seabirds and shorebirds and beach mice in the enclosed letter for KSC's consideration in preparing the Final EA. Please refer to the enclosed FWC letter for further details.

The Florida Department of State's (DOS) review of the Florida Master Site File indicated that the NASA KSC Railroad Track (8BR2931) and two archaeological sites (8BR79 and 8BR84) lie within the proposed project area. In addition, the Canaveral Shoals I and II borrow areas, developed for the Brevard County Shore Protection project area, contain potentially significant submerged anomalies. The archaeological survey conducted for the Post-Sandy Dune Repair Project confirmed the destruction of archaeological site 8BR79. Although DOS has insufficient information to determine whether site 8BR84 is eligible for the *National Register of Historic Places*, staff does not believe the project will affect this site. Previous correspondence with DOS has determined that the portions of the NASA KSC railroad tracks within the project area do not contribute to the *National Register*-eligible KSC Railroad System historic district, therefore, the proposed undertaking will have no effect on this resource. In 2014, the USACE designated dredge exclusion areas around each of the potential sites of submerged rocket cylinders in the Canaveral Shoals borrow areas. As such, the four proposed alternatives will have no effect on historic properties. Please refer to the enclosed DOS letter for additional information.

Based on the information contained in the Draft EA and enclosed state agency comments, the state has determined that, at this stage, the proposed activities are consistent with the Florida Coastal Management Program (FCMP). To ensure the project's continued consistency with the FCMP, the concerns identified by our reviewing agencies must be addressed prior to project implementation. The state's continued concurrence will be based on the activities' compliance with FCMP authorities, including federal and state monitoring of the activities to ensure their continued conformance, and the adequate resolution of issues identified during this and any subsequent regulatory reviews. The state's final concurrence of the project's consistency with the FCMP will be determined during the environmental permitting process, in accordance with Section 373.428, *Florida Statutes*, if applicable.

Thank you for the opportunity to review the draft document. Should you have any questions regarding this letter, please don't hesitate to contact me at Lauren.Milligan@dep.state.fl.us or (850) 245-2170.

Yours sincerely,

Lauren P. Milligan

Lauren P. Milligan, Coordinator
Florida State Clearinghouse
Office of Intergovernmental Programs

Enclosures

cc: Roxane Dow, DEP, DWRM
Scott Sanders, FWC
Tim Parsons, DOS

Project Information	
Project:	FL201506197332C
Comments Due:	07/30/2015
Letter Due:	08/17/2015
Description:	NATIONAL AERONAUTICS AND SPACE ADMINISTRATION - DRAFT ENVIRONMENTAL ASSESSMENT FOR KENNEDY SPACE CENTER SHORELINE PROTECTION PROJECT - CAPE CANAVERAL, BREVARD COUNTY, FLORIDA.
Keywords:	NASA - DEA, KENNEDY SPACE CENTER SHORELINE PROTECTION PROJECT - BREVARD CO.
CFDA #:	43.000

Agency Comments:

FISH and WILDLIFE COMMISSION - FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION

The FWC reports that a number of listed species have been documented within or in close proximity to KSC's beach and primary dune, coastal strand, estuarine scrub-shrub wetland, manmade ditch, and herbaceous rudera1 area habitats. In general, FWC staff recommends that the Final EA include specific information, in addition to the avoidance and minimization measures identified in the Biological Assessment, to assure that the proposed project will be implemented to avoid, minimize and mitigate any potential impacts to state-listed species and their habitats. The FWC has provided comments and recommendations on gopher tortoises, seabirds and shorebirds and beach mice in the enclosed letter for KSC's consideration in preparing the Final EA.

ENVIRONMENTAL PROTECTION - FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION

The DEP's Division of Water Resource Management staff advises that the Kennedy Space Center's preferred alternative proposing construction of a dune landward of the Mean High Water Line is consistent with the State's Strategic Beach Management Plan. The proposed dune restoration project is exempt from DEP Coastal Construction Control Line permitting, but may require an Environmental Resource Permit from the DEP or St. Johns River Water Management District if proposed construction activities impact wetlands.

STATE - FLORIDA DEPARTMENT OF STATE

The DOS' review of the Florida Master Site File indicated that the NASA KSC Railroad Track (8BR2931) and two archaeological sites (8BR79 and 8BR84) lie within the proposed project area. In addition, the Canaveral Shoals I and II borrow areas, developed for the Brevard County Shore Protection project area, contain potentially significant submerged anomalies. The archaeological survey conducted for the Post-Sandy Dune Repair Project confirmed the destruction of archaeological site 8BR79. Although DOS has insufficient information to determine whether site 8BR84 is eligible for the National Register of Historic Places, staff does not believe the project will affect this site. Previous correspondence with DOS has determined that the portions of the NASA KSC railroad tracks within the project area do not contribute to the National Register eligible KSC Railroad System historic district, therefore, the proposed undertaking will have no effect on this resource. In 2014, the USACE designated dredge exclusion areas around each of the potential sites of submerged rocket cylinders in the Canaveral Shoals borrow areas. As such, the four proposed alternatives will have no effect on historic properties.

For more information or to submit comments, please contact the Clearinghouse Office at:

3900 COMMONWEALTH BOULEVARD, M.S. 47
TALLAHASSEE, FLORIDA 32399-3000
TELEPHONE: (850) 245-2170
FAX: (850) 245-2189

Visit the Clearinghouse Home Page to query other projects.

Florida Fish and Wildlife Conservation Commission

620 South Meridian Street
Tallahassee, Florida
32399-1600
Voice: (850) 488-4676

Hearing/speech-impaired:
(800) 955-8771 (T)
(800) 955-8770 (V)

MyFWC.com

August 7, 2015

Lauren P. Milligan, Coordinator
Florida State Clearinghouse
Florida Department of Environmental Protection
3900 Commonwealth Blvd, M.S. 47
Tallahassee, FL 32399-3000
Lauren.Milligan@dep.state.fl.us

Re: SAI #FL201506197332C, National Aeronautics and Space Administration, Draft Environmental Assessment, Kennedy Space Center Shoreline Protection Project, Cape Canaveral, Brevard County

Dear Ms. Milligan:

Florida Fish and Wildlife Conservation Commission (FWC) staff has reviewed the above-referenced project, and provides the following comments and recommendations for your consideration in accordance with Chapter 379, Florida Statutes, and the Coastal Zone Management Act, Florida's Coastal Management Program.

Project Description

The National Aeronautics and Space Administration (NASA) proposes to place sand fill and vegetation to create new dune or reinforce the existing dune and beach at the Kennedy Space Center (KSC) in order to reduce shoreline erosion, protect launch infrastructure, and protect threatened and endangered species habitat. The draft Environmental Assessment (DEA) for the KSC Shoreline Protection Project, dated March 2015, focuses on the northern 4.7 miles of the 6.2-mile KSC ocean shoreline and evaluates five alternatives:

1. Create a new secondary dune immediately inland of the existing dune in areas most vulnerable to erosion and flooding, and allow the existing dune and beach to continue to serve as an erosion buffer. Salt-tolerant vegetation would be planted on the dune crest and side slopes.
2. Reestablish the historical condition that existed approximately 10 to 15 years ago (1999-2004) and employ beach renourishment to maintain that condition. The dune improvements would be planted with salt-tolerant vegetation.
3. Reinforce the dune at its current eroded location and employ beach renourishment to maintain that location. The dune improvements would be planted with salt-tolerant vegetation.
4. Utilize a hybrid approach with partial restoration of the primary dune and beach as a near-term strategy, and creation of a secondary inland dune as a long-term strategy. Salt-tolerant vegetation would be planted on the crest and face of both the primary and inland dunes.
5. No action, leaving the beach in its current condition.

The KSC has selected Alternative 1 as the preferred alternative, which is a managed retreat strategy that establishes a shore protection dune landward of the existing dune and beach berm. While the alternative has been designed to minimize impacts to the existing beach, dune, and wetland habitats, and to reduce the need for periodic renourishment within the project area, unavoidable impacts are expected to occur from the initial dune construction in back-beach habitats, as discussed in Section 2.1 of the DEA. Sand sources would be trucked from upland sources yet to be determined. Truck access locations would be located on existing roads or coincide with the footprint of the construction area. Mechanical excavators, bulldozers, and payloaders would be used for construction.

Potentially Affected Resources

Section 3.2 of the DEA, Biological Environment, identifies major habitat types occurring within the project area: beach and primary dune, coastal strand, estuarine scrub-shrub wetland, man-made ditch, and herbaceous ruderal areas. The following listed species have been document on the KSC within or in close proximity to these habitats, and could potentially be affected by the proposed project:

- Atlantic saltmarsh snake (*Nerodia clarkia taeniata*, Federally Threatened [FT]; noted as an historical occurrence)
- Black skimmer (*Rynchops niger*, State Species of Special Concern [SSC])
- Brown pelican (*Pelecanus occidentalis*, SSC)
- Eastern indigo snake (*Drymarchon corais couperi*, FT)
- Florida scrub-jay (*Aphelocoma coerulescens*, FT)
- Florida mouse (*Podomys floridanus*, SSC)
- Florida pine snake (*Pituophis melanoleucus mugitus*, SSC)
- Florida sandhill crane (*Grus canadensis pratensis*, State Threatened [ST])
- Florida scrub-jay (*Aphelocoma coerulescens*, FT)
- Florida manatee (*Trichechus manatus latirostris*, FE)
- Gopher frog (*Lithobates capito*, SSC)
- Gopher tortoise (*Gopherus polyphemus*, ST)
- Green sea turtle (*Chelonia mydas*, Federally Endangered [FE])
- Least tern (*Sterna antillarum*, ST)
- Leatherback sea turtle (*Dermochelys coriacea*, FE)
- Little blue heron (*Egretta caerulea*, SSC)
- Loggerhead sea turtle (*Caretta caretta*, FT)
- Northern right whale (*Eubalaena glacialis*, FE)
- Piping plover (*Charadrius melodus*, FT)
- Reddish egret (*Egretta rufescens*, SSC)
- Roseate spoonbill (*Platalea ajaja*, SSC)
- Roseate tern (*Sterna dougallii dougallii*, FT)
- Rufa red knot (*Calidris canutus rufa*, FT)
- Snowy egret (*Egretta thula*, SSC)
- Southeastern American kestrel (*Falco sparverius paulus*, ST)
- Southeastern beach mouse (*Peromyscus polionotus niveiventris*, FT)
- Tricolored heron (*Egretta tricolor*, SSC)
- White ibis (*Eudocimus albus*, SSC)

A Biological Assessment (BA) was conducted in November 2012 for the proposed project. The BA considered the gopher tortoise, a candidate for federal listing, and seven existing federally listed species documented as occurring within the project area: loggerhead sea turtle, green sea turtle, leatherback sea turtle, Eastern indigo snake, Florida scrub-jay, and Southeastern beach mouse. For the preferred project alternative, Alternative 1, the BA concluded that cumulative long-term benefits could be expected for each of these species as new beach dune habitat is created and becomes self-sustaining. Potential impacts due to construction activities could be expected to be minimal, as construction would be occurring on the landward side of the primary dune. Construction impacts to the remaining species could be expected to be moderate, but temporary in nature, with loss of habitat from placement of sand.

The DEA and BA propose the following measures to avoid and minimize adverse impacts to the noted federally listed species during construction activities:

1. Educate personnel on recognizing protected species and their habitats so avoidance and minimization measures could be incorporated into the work.
2. Construction directly on the beach would take place from November 1 through February, outside sea turtle nesting season.
3. Construction in areas other than the beach would occur only during daylight hours.
4. Staging areas and access points would be placed in developed areas or degraded habitats.
5. Construction activities will be limited to degraded areas with little wildlife habitat value, as much as possible. Acknowledgement is made that impacts to potentially occupied habitat may be unavoidable in some instances. It is noted that efforts would be made to relocated gopher tortoises and Southeastern beach mice to suitable habitat in the area.
6. When applicable, the terms and conditions of the U.S. Fish and Wildlife Service's (USFWS) Statewide Programmatic Biological Opinion (SPBO, revised March 13, 2015) for the U.S. Army Corps of Engineers and sand placement activities and their effects on sea turtles and beach mice, and designated terrestrial critical habitat for the loggerhead sea turtle.

Comments and Recommendations

In general, FWC staff recommend that the final EA include specific information, in addition to the avoidance and minimization measures mentioned above, to assure that the proposed project will be implemented to avoid, minimize, and mitigate any potential impacts to state-listed species and their habitat. FWC staff provides the following comments and recommendations, related to the preferred alternative, for consideration in preparing the final Environmental Assessment.

Gopher Tortoises

The BA discusses gopher tortoise studies that took place along the KSC shoreline, and that more than 1,000 tortoises have been captured and permanently marked since the mid-1970s. We recommend that the final EA also make reference to the Gopher Tortoise Permitting Guidelines (revised February 2015) and commit to adhering to conditions contained therein. Additional information can be found on the FWC Gopher Tortoise website (http://myfwc.com/wildlifehabitats/managed/gopher-tortoise/).

Seabirds and Shorebirds

State-listed seabirds and shorebirds and habitat necessary for essential behaviors are protected under Florida's Rules Relating to Endangered and or Threatened species, Chapter 68A-27, Florida Administrative Code (F.A.C.). The final EA should include avoidance and minimization measures designed to reduce the potential for "take" as defined in Chapter 68A-27, F.A.C., including maintaining buffers around nesting colonies and conducting work on the beach outside of the nesting season. Shorebird nesting season in this area of Florida is March 15 through September 1. FWC staff is available to assist with determining avoidance and minimization measures specific to the proposed project.

Beach Mice

This project could potentially impact between 3.6 and 4.7 miles of occupied Southeastern beach mouse (SEBM) habitat. The DEA states that the terms and conditions of the SPBO would be followed as applicable. The USFWS can provide additional, specific actions to minimize and avoid adverse impact to SEBM habitat. We recommend that the applicant contact the USFWS North Florida Ecological Services Office at (904) 731-3336.

We appreciate the opportunity to review the DEA and FWC staff is available to provide technical assistance as needed in preparation of the final EA to ensure that potential impacts to fish and wildlife resources are minimized. We find the information submitted in the DEA consistent with FWC's authorities under Chapter 379, F.S. If you need any further assistance, please do not hesitate to contact Jane Chabre either by phone at (850) 410-5367 or by email at FWCConservationPlanningServices@MyFWC.com. If you have specific technical questions regarding the content of this letter, please contact Laura DiGruttolo by phone at (352) 732-1225 or by email at Laura.Digruttolo@MyFWC.com.

Sincerely,

Jennifer D. Goff

Jennifer D. Goff
Land Use Planning Administrator
Office of Conservation Planning Services

jdg/ld
ENV 1-3-2
Kennedy Space Center Shoreline Protection Draft EA_21352_080715

cc: Donald Dankert
National Aeronautics and Space Administration
John F. Kennedy Space Center
Environmental Branch Management
Mail Code TA-A4C
Donald.j.dankert@nasa.gov

Bill Brooks
U.S. Fish & Wildlife Service
North Florida Ecological Services Office
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Bill_brooks@fws.com

FLORIDA DEPARTMENT of STATE

RICK SCOTT
Governor

KEN DETZNER
Secretary of State

Florida State Clearinghouse
Agency Contact and Coordinator (SCH)
Attn: Lauren Milligan
3900 Commonwealth Blvd. MS-47
Tallahassee, Florida 32399-3000

July 08, 2015

RE: DHR Project File No.: 2015-2990/ Received by DHR: June 23, 2015
Application No.: SAI FL201506197332C
Project: *Draft Environmental Assessment for Kennedy Space Center Shoreline Protection Project*
County: Brevard County

Dear Ms. Milligan,

The Florida State Historic Preservation Officer reviewed the referenced project for possible effects on historic properties listed, or eligible for listing, on the *National Register of Historic Places.* The review was conducted in accordance with Section 106 of the *National Historic Preservation Act of 1966*, as amended, and its implementing regulations in *36 CFR Part 800: Protection of Historic Properties.*

A review of the Florida Master Site File (FMSF) indicates that the NASA KSC Railroad Track (8BR2931), and two archaeological sites (8BR79 & 8BR84) lie within the proposed project area. In addition, the Canaveral Shoals I and II borrow areas, developed for the Brevard County Shore Protection project area contain potentially significant submerged anomalies.

In 2013, Archaeological Consultants, Inc. (ACI) conducted an archaeological survey at the John F. Kennedy Space Center for the Post-Sandy Dune Repair Project. ACI confirmed the destruction of archaeological site (8BR79). In addition, a historic context and predictive model for the pre-Space Age historic period sites at the John F. Kennedy Space Center was conducted by ACI in 2008 and 2009. Documented archaeological site (8BR84) was not relocated during the 2009 ACI study. Our office has insufficient information to determine whether 8BR84 is eligible for the *National Register,* however it is our opinion that this project will not effect this site.

Previous correspondence with the SHPO (DHR# 2012-4670B) has determined that the portion of the NASA KSC railroad tracks within the project area do not contribute to the National Register eligible KSC Railroad System historic district (8BR2932); therefore the proposed undertaking will have no effect on this resource.

An updated 2014 submerged cultural resources remote sensing survey was conducted by PanAmerican Consultants, Inc. PCI identified six locations in Canaveral Shoals borrow areas I and four locations in area II as potential sites of rocket cylinders. In 2014, the USACE designated dredge exclusion areas described by a 200-ft radical buffer around each of these locations within the Canaveral Shoals borrow areas.

Based on the information provided, it is the opinion of this office that the four proposed alternatives will have no effect on historic properties.

If prehistoric or historic artifacts are encountered at any time within the project area, the permitted project should cease all activities involving disturbance in the immediate vicinity of such discoveries. The permittee should contact this office, as well as the appropriate permitting agency

For any questions concerning our comments, please contact Mary Berman, Historic Sites Specialist, by phone at 850.245.6333 or by electronic mail at Mary.Berman@dos.myflorida.com.

Sincerely,

Robert F. Bendus, Director
Division of Historical Resources
and State Historic Preservation Officer