

FINAL PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT

WALLOPS FLIGHT FACILITY SHORELINE RESTORATION AND INFRASTRUCTURE PROTECTION PROGRAM

VOLUME I OF II

Prepared for



National Aeronautics and Space Administration
Goddard Space Flight Center
Wallops Flight Facility
Wallops Island, VA 23337

In cooperation with

U.S. Department of the Interior, Bureau of Ocean Energy Management,
Regulation, and Enforcement and
U.S. Army Corps of Engineers

October 2010

Prepared by



URS Group, Inc.
200 Orchard Ridge Drive, Suite 101
Gaithersburg, MD 20878
15301785

This page intentionally left blank.

**FINAL PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT
SHORELINE RESTORATION AND INFRASTRUCTURE PROTECTION PROGRAM
WALLOPS FLIGHT FACILITY**

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GODDARD SPACE FLIGHT CENTER
WALLOPS FLIGHT FACILITY
WALLOPS ISLAND, VIRGINIA 23337**

Lead Agency: National Aeronautics and Space Administration (NASA)

Cooperating Agencies: U.S. Department of the Interior,
Bureau of Ocean Energy Management, Regulation, and
Enforcement (BOEMRE)
U.S. Army Corps of Engineers (USACE)

For Further Information: Joshua A. Bundick
NEPA Program Manager
Code 250.W
Goddard Space Flight Center's Wallops Flight Facility
National Aeronautics and Space Administration
Wallops Island, VA 23337
(757) 824-2319

Date: October 2010

Abstract: NASA has prepared a Final Programmatic Environmental Impact Statement (PEIS) for the Shoreline Restoration and Infrastructure Protection Program (SRIPP) at Wallops Flight Facility in accordance with the National Environmental Policy Act to assist in the decision making process for the SRIPP. The BOEMRE and USACE have served as Cooperating Agencies in the preparation of this PEIS. The purpose of the SRIPP is to reduce the potential for damage to, or loss of, existing NASA, U.S. Navy, and Mid-Atlantic Regional Spaceport assets on Wallops Island from storm-induced wave impacts. The potential effects to physical, biological, and socioeconomic environments were studied to determine how the Proposed Action Alternatives and the No Action Alternative could affect these resources. The Proposed Action would have both adverse and beneficial impacts on environmental resources. Adverse impacts would be mitigated to the greatest extent practicable.

This page intentionally left blank.

EXECUTIVE SUMMARY

This Programmatic Environmental Impact Statement (PEIS) has been prepared to evaluate the potential environmental impacts from the proposed National Aeronautics and Space Administration (NASA) Wallops Flight Facility (WFF) Shoreline Restoration and Infrastructure Protection Program (SRIPP). The SRIPP encompasses a 50-year planning horizon and is intended to reduce damage to Federal and State infrastructure on Wallops Island caused by the combination of sea-level rise and coastal storms.

This PEIS has been prepared in accordance with the National Environmental Policy Act of 1969 (NEPA), as amended (42 U.S. Code 4321-4347), the Council on Environmental Quality (CEQ) regulations for implementing NEPA (40 Code of Federal Regulations [CFR] 1500-1508), NASA's regulations for implementing NEPA (14 CFR Subpart 1216.3), and the *NASA Procedural Requirements for Implementing NEPA* and *Executive Order (EO) 12114* (NASA Procedural Requirements 8580.1).

The U.S. Department of the Interior Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE) and the U.S. Army Corps of Engineers (USACE) have served as Cooperating Agencies in preparing this PEIS, because they possess regulatory authority and specialized expertise pertaining to the Proposed Action. This PEIS has been developed to fulfill all three Federal agencies' obligations under NEPA. NASA, as the WFF property owner and project proponent, is the Lead Agency and responsible for ensuring overall compliance with applicable environmental statutes, including NEPA.

PURPOSE AND NEED FOR THE ACTION

The purpose of the Proposed Action is to reduce the potential for damage to, or loss of, NASA, U.S. Navy, and Mid-Atlantic Regional Spaceport (MARS) assets on Wallops Island from storm-induced wave impacts. The Proposed Action is needed to ensure the continued ability of NASA, the U.S. Navy, and MARS to serve the Nation's rapidly growing civil, defense, academic, and commercial aerospace requirements. The SRIPP would help reduce the risk to infrastructure on Wallops Island from storm wave and sea-level rise damage by restoring the beach profile in front of the present shoreline.

Wallops Island has experienced shoreline changes throughout the six decades that NASA has occupied the site. The existing seawall is being undermined because there is little or no protective sand beach remaining and storm waves break directly on the rocks. Sea-level rise is anticipated to increase the vulnerability of the Wallops Island shoreline to waves by contributing to shoreline erosion. In addition, average wave heights are increasing, which is believed to be associated with a gradual rise in the frequency and intensification of storm events. Currently, the south end of the island is unprotected except for a low revetment around the MARS launch pad and temporary geotextile tubes that extend from the southern end of the existing seawall south to camera stand Z-100.

The potential risks to infrastructure from wave impacts are two-fold: first is the interruption of NASA, U.S. Navy, and MARS missions supported from Wallops Island facilities due to temporary loss of facility functions; and second is the potential for complete loss of these unique facilities. If no protective measures are taken, then the assets on Wallops Island will be increasingly at risk from even moderate storm events.

Executive Summary

ADAPTIVE DESIGN AND MANAGEMENT STRATEGY

The SRIPP incorporates an adaptive design and management strategy that is defined by a range of alternatives explained in this PEIS with the understanding that one alternative is preferred as the initial action, but elements of the other alternatives may be adopted in the future if the monitoring program reveals them to be necessary. Alternatives presented in this PEIS are based on current conditions and knowledge of design and resources; however, as more information becomes available through monitoring, NASA would further evaluate its strategy for storm damage reduction measures.

ALTERNATIVES SCREENING PROCESS

NASA initially considered a range of alternatives to meet the purpose and need. The initial alternatives were screened based on five criteria: disruption to WFF operations, storm damage reduction, initial cost, maintenance costs, and anticipated change in sand availability for longshore sediment transport. The alternatives that passed the initial screening—extension of the seawall combined with beach fill and extension of the seawall combined with beach fill and sand retention structure (either groin or breakwater)—were evaluated in more detail and their components (i.e., location of sand retention structure, length and width of beach fill, renourishment frequency) were combined into 54 different potential alternatives. The secondary screening analysis resulted in the final three alternatives carried forward in this PEIS.

ALTERNATIVES EVALUATED IN DETAIL

The combination of options that would provide the maximum level of storm damage reduction while remaining within the limits of available funding were chosen to be evaluated in detail as the three Proposed Action Alternatives discussed below.

Project Elements Common to All Alternatives

A number of design and construction elements would be applicable to all three of the Proposed Action Alternatives: adaptive management, seawall extension, and beach fill. Differences among the alternatives (e.g., initial and renourishment fill volumes, type of sand retention structure, etc.) are discussed under each individual alternative below.

Adaptive Management Framework

This is a programmatic document but provides a detailed evaluation of potential impacts for the implementation of an initial project with future adaptive management and monitoring. As there is an inherent level of uncertainty in designing, constructing, and maintaining a long-term project subject to the effects of the open ocean environment, NASA may identify the need to modify its storm damage reduction measures in the future. Results of the adaptive management program would drive the specific future actions necessary to meet the SRIPP's purpose and need throughout its 50-year planning horizon. If monitoring shows that the Preferred Alternative by itself is not adequately meeting NASA's goals for the SRIPP, then the other Proposed Action Alternatives (or elements from them) would be reevaluated in the future; additional NEPA documentation may be prepared and appropriate permits and approvals would be obtained prior to implementation.

Seawall Extension

Wallops Island's existing rock seawall would be extended a maximum of 1,400 meters (m) (4,600 feet [ft]) south of its southernmost point. The seawall extension would be implemented in the first year of the SRIPP prior to the placement of the initial beach fill. At first, the seawall would be extended approximately 435 m (1,430 ft) south with additional extension (up to the maximum length) undertaken in the future as funding becomes available.

Beach Fill

Beach fill is a necessary component of all three Proposed Action alternatives as the new beach would provide a surface to dissipate wave energy, counteract sea-level rise effects, and contribute additional sediment to the nearshore system. The beach fill would start approximately 460 m (1,500 ft) north of the Wallops Island-Assawoman Island property boundary and extend north for 6.0 km (3.7 mi). The initial fill would be placed so that there would be a 1.8-m-high (6-ft-high) berm extending a minimum of 21 m (70 ft) seaward of the existing seawall. The remainder of the fill would slope underwater for an additional distance seaward; the amount of that distance would vary along the length of the beach fill, but would extend for a maximum of about 52 m (170 ft), so that the total distance of the fill profile from the seawall would be up to approximately 73 m (240 ft). The beach fill profile would also include a 4.3-m-high (14-ft-high) dune at the seawall.

Unnamed Shoal A only would be used to obtain initial fill volumes under all three alternatives. For renourishment fill volumes, up to one-half of the fill volume could be excavated from the north Wallops Island borrow site, and the remaining half, or the entire renourishment volume, would be dredged from either Unnamed Shoal A or Unnamed Shoal B.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

In the initial nourishment, NASA would place an estimated 2,446,000 m³ (3,199,000 yd³) of fill (minimum and advanced target fill combined) along the shoreline. The renourishment cycle is anticipated to involve approximately 616,000 m³ (806,000 yd³) of sand every 5 years. The initial fill, plus the total fill volume over nine renourishment events, would result in approximately 7,992,000 m³ (10,453,000 yd³) of sand being placed on the shoreline. The absence of sand retention structures (groin or breakwater) would result in a larger amount of sand being available for erosion and longshore transport.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

Beach fill would be placed along the same length of the shoreline as under Alternative One, but construction of a groin (described below) would result in more sand being retained along the Wallops Island shoreline, so less fill would be required for both the initial nourishment and renourishment volumes compared to Alternative One. The initial fill volume would be an estimated 2,229,000 m³ (2,916,000 yd³), and each renourishment fill volume would be approximately 552,000 m³ (722,000 yd³). The initial fill, plus the total fill volume over nine renourishment events, would result in approximately 7,198,000 m³ (9,414,000 yd³) of sand being placed on the shoreline.

A groin would be constructed at the south end of the Wallops Island shoreline and would involve the placement of rocks in a linear structure perpendicular to the shoreline at approximately 445 m (1,460 ft) north of the Wallops Island–Assawoman Island border. The structure would be

Executive Summary

approximately 130 m (430 ft) long and 15 m (50 ft) wide. Approximately two-thirds of the groin (80 m [265 ft]) would be installed on the beach once the fill has been placed, and the remaining one-third, approximately 50 m (165 ft), would extend beyond the beach into the ocean. It would take approximately 1 month to build.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

Beach fill would be placed along the same length of the shoreline as under Alternatives One and Two, but construction of a breakwater instead of a groin (Alternative Two) would result in the most sand being retained along the Wallops Island beach, so the least fill would be required for both the initial placement and renourishment volumes compared to Alternatives One and Two. The initial fill volume would be 2,170,000 m³ (2,839,000 yd³) and each renourishment fill volume would be 537,000 m³ (703,000 yd³). The initial fill plus the total fill volume over nine renourishment events would result in approximately 7,008,000 m³ (9,166,000 yd³) of sand being placed on the shoreline.

A single nearshore breakwater would be constructed at the south end of the Wallops Island shoreline and would involve placement of rocks in a linear structure parallel to the shoreline. The breakwater structure would be constructed approximately 230 m (750 ft) offshore. The breakwater would be approximately 90 m (300 ft) long and 35 m (110 ft) wide, and would take approximately 1 month to build. Construction would take place in the water using a barge and heavy lifting equipment.

No Action Alternative

Under the No Action Alternative for this PEIS, the SRIPP would not be conducted on Wallops Island, but maintenance and emergency repairs to existing structures would continue. Maintenance activities include repairs to the existing seawall and to the geotextile tubes. Emergency actions may include hauling in additional rock to add to the existing seawall, hauling and placing sand on the beach or behind existing shoreline protection, installing sheet piling in or near the high tide level, or emergency geotextile tube installation. Under this alternative, the seawall can be expected to continue to deteriorate and would be increasingly vulnerable to massive failure during large storm events as waves break directly on the structure and also undercut the leading edge of the seawall.

Over \$1 billion in NASA, U.S. Navy, and MARS equipment, buildings, and infrastructure would continue to be at increasing risk from storm damage. Maintenance and emergency repairs to structures and the seawall would continue to be required. Shoreline retreat would continue, exacerbated by rising sea levels, increased wave heights, and the expected increase in the frequency and intensity of storm events. Operations at facilities may be disrupted during severe storm events from flooding and waves overtopping the seawall. The danger to the MARS launch complex and Uninhabited Aerial Systems airstrip on the southern portion of the island would increase due to the rapidly retreating shoreline in that area.

SUMMARY OF ENVIRONMENTAL IMPACTS

A comparison of the potential impacts shown by resource for each alternative is provided in Table ES-1.

Table ES-1: Summary of Impacts from Proposed Action Alternatives

Resource	Alternative One: Full Beach Fill, Seawall Extension	Alternative Two: Full Beach Fill, Groin, Seawall Extension	Alternative Three: Full Beach Fill, Breakwater, Seawall Extension	No Action
<p>Geology and Geomorphology – Shoreline</p>	<p>Placement of beach fill (initial and renourishment) would create and maintain a beach approximately 21 m (70 ft) wide on Wallops Island. The addition of sediment to the longshore transport system would result in a reduction in the rate of erosion at the southern end of Wallops Island and northern end of Assawoman Island. Over the lifetime of the SRIPP, the seawall extension and beach fill would have long-term direct beneficial impacts on the Wallops Island shoreline by mitigating the current rate of shoreline retreat. Continued beach nourishment would add to this benefit.</p> <p>Long-term adverse impacts on geology would occur because placement of beach fill would prevent overwash, thereby causing some island narrowing.</p> <p>North Wallops Island sand removal would result in minor adverse impacts on sediments and would lower topography within the excavated areas.</p>	<p>Placement of beach fill (initial and renourishment) would create and maintain a beach approximately 21 m (70 ft) wide on Wallops Island. The addition of sediment to the longshore transport system would result in a reduction in the rate of erosion at the southern end of Wallops Island and northern end of Assawoman Island. Over the lifetime of the SRIPP, the seawall extension and beach fill would have long-term direct beneficial impacts on the Wallops Island shoreline by mitigating the current rate of shoreline retreat. Continued beach nourishment would add to this benefit.</p> <p>Long-term adverse impacts on geology would occur because placement of beach fill would prevent overwash, thereby causing some island narrowing.</p> <p>Construction of a groin would help to retain sand on the Wallops Island shoreline so that erosion and sediment transport from Wallops Island would be reduced and the beach created by the SRIPP would stay in place longer than under Alternative One.</p> <p>North Wallops Island sand removal would result in minor adverse impacts on sediments and would lower topography within the excavated areas.</p>	<p>Placement of beach fill (initial and renourishment) would create and maintain a beach berm approximately 21 m (70 ft) wide on Wallops Island. The addition of sediment to the longshore transport system would result in a reduction in the rate of erosion at the southern end of Wallops Island and northern end of Assawoman Island. Over the lifetime of the SRIPP, the seawall extension and beach fill would have long-term direct beneficial impacts on the Wallops Island shoreline by mitigating the current rate of shoreline retreat. Continued beach nourishment would add to this benefit.</p> <p>Long-term adverse impacts on geology would occur because placement of beach fill would prevent overwash, thereby causing some island narrowing.</p> <p>Construction of a breakwater would help to retain sand on the Wallops Island shoreline so that erosion and sediment transport from Wallops Island would be reduced and the beach created by the SRIPP would stay in place longer than under Alternative One.</p> <p>North Wallops Island sand removal would result in minor adverse impacts on sediments and would lower topography within the excavated areas.</p>	<p>Adverse impacts on land use, geology and sediments from continued loss of the shoreline. Climate change including sea-level rise and storm intensity and/or frequency is anticipated to increase the vulnerability of Wallops Island shoreline to storms by contributing to shoreline erosion. Negligible adverse impacts on sediments would be caused during emergency operations over the 50-year lifetime of the SRIPP.</p>
<p>Geology, Geomorphology and Bathymetry – Offshore Shoals and Nearshore Environment</p>	<p>Dredging would remove a total of approximately 3,057,500 m³ (3,998,750 yd³) of sand from Unnamed Shoal A for the initial beach fill. Each of the nine anticipated renourishment cycles would require 770,000 m³ (1,007,500 yd³) or a total of</p>	<p>Dredging would remove a total of approximately 2,786,250 m³ (3,645,000 yd³) of sand from Unnamed Shoal A for the initial beach fill. Each of the nine anticipated renourishment cycles would require 690,000 m³ (915,500 yd³) or a total of approximately</p>	<p>Dredging would remove a total of approximately 2,712,500 m³ (3,548,750 yd³) of sand from Unnamed Shoal A for the initial beach fill. Each of the nine anticipated renourishment cycles would require 671,250 m³ (878,750 yd³) or a total of approximately</p>	<p>No impacts.</p>

Executive Summary

Table ES-1: Summary of Impacts from Proposed Action Alternatives

Resource	Alternative One: Full Beach Fill, Seawall Extension	Alternative Two: Full Beach Fill, Groin, Seawall Extension	Alternative Three: Full Beach Fill, Breakwater, Seawall Extension	No Action
	<p>approximately 9,990,000 m³ (13,066,250 yd³) over the lifetime of the SRIPP. The renourishment material may be dredged from Unnamed Shoal A, Unnamed Shoal B, and/or the northern end of Wallops Island. Dredging would result in changes to the volume, shape, and elevation of the sediments on either shoal. Removal of shoal sediments would result in long-term adverse impacts on site-specific and regional geology.</p> <p>The newly created beach profile would extend underwater for a maximum of 52 m (170 ft), resulting in a new bathymetric profile within the subaqueous lands immediately east of Wallops Island.</p>	<p>8,997,500 m³ (11,767,500 yd³) over the lifetime of the SRIPP. The renourishment material may be dredged from Unnamed Shoal A, Unnamed Shoal B, and/or the northern end of Wallops Island. Dredging would result in changes to the volume, shape, and elevation of the sediments on either shoal. Removal of shoal sediments would result in long-term adverse impacts on site-specific and regional geology.</p> <p>The newly created beach profile would extend underwater for a maximum of 52 m (170 ft), resulting in a new bathymetric profile within the subaqueous lands immediately east of Wallops Island.</p>	<p>8,760,000 m³ (11,457,500 yd³) over the lifetime of the SRIPP. The renourishment material may be dredged from Unnamed Shoal A, Unnamed Shoal B, and/or the northern end of Wallops Island. Dredging would result in changes to the volume, shape, and elevation of the sediments on either shoal. Removal of shoal sediments would result in long-term adverse impacts on site-specific and regional geology.</p> <p>The newly created beach profile would extend underwater for a maximum of 52 m (170 ft), resulting in a new bathymetric profile within the subaqueous lands immediately east of Wallops Island.</p>	
Shoreline Change	<p>Placement of beach fill (initial and renourishment) would create a beach berm approximately 21 m (70 ft) wide on Wallops Island, resulting in long-term beneficial direct impacts. The addition of sediment to the longshore transport system would offset some ongoing erosion that is occurring at the northern end of Assawoman Island. Dredging of the offshore shoals would result in minimal change to local wave conditions and no impact to the Assateague Island shoreline. Sediment would continue to accrete along the northern end of Wallops Island.</p>	<p>Placement of beach fill (initial and renourishment) would create a beach berm approximately 21 m (70 ft) wide on Wallops Island, resulting in long-term beneficial direct impacts. The groin would be specifically designed to let some sand pass through the structure; according to U.S. Army Corps of Engineers (USACE) modeling, the combination of the groin with beach fill would result in accretion of sand on the north end of Assawoman Island. The greatest amount of erosion and accretion would occur immediately adjacent to the groin and would exponentially decrease with distance from the groin. Renourishing the beach would reduce the potential for downdrift erosion by providing continual sand on the Wallops Island shoreline, some of which would be available to the longshore sediment transport system.</p>	<p>Placement of beach fill (initial and renourishment) would create a beach berm approximately 21 m (70 ft) wide on Wallops Island, resulting in long-term beneficial direct impacts.</p> <p>The breakwater would be specifically designed to let some sand pass through the structure; according to USACE modeling, the combination of the breakwater with beach fill would result in accretion of sand on the north end of Assawoman Island. Renourishing the beach would reduce the potential for downdrift erosion by providing continual sand on the Wallops Island shoreline, some of which would be available to the longshore sediment transport system.</p> <p>Dredging of the offshore shoals would result in minimal change to local wave conditions and no impact to the Assateague Island</p>	<p>The shoreline along the southern portion of Wallops Island would continue to erode at a rate of approximately 3 m (10 ft) per year. The shoreline along the seawall would be held at its current location until erosional forces and undermining of the seawall would cause it to fail. The current seawall shows 13 areas of concern where the seawall has shown a vertical drop of at least 2 m (6 ft). Sediment would continue to accrete along the northern end of Wallops Island.</p>

Table ES-1: Summary of Impacts from Proposed Action Alternatives

Resource	Alternative One: Full Beach Fill, Seawall Extension	Alternative Two: Full Beach Fill, Groin, Seawall Extension	Alternative Three: Full Beach Fill, Breakwater, Seawall Extension	No Action
		Dredging of the offshore shoals would result in minimal change to local wave conditions and no impact to the Assateague Island shoreline. Sediment would continue to accrete along the northern end of Wallops Island.	shoreline. Sediment would continue to accrete along the northern end of Wallops Island.	
Water Resources	Elevated turbidity in marine waters at the offshore shoals from dredging and in the nearshore environment from sand placement.	Elevated turbidity in marine waters at the offshore shoals from dredging and in the nearshore environment from sand placement.	Elevated turbidity in marine waters at the offshore shoals from dredging and in the nearshore environment from sand placement.	No impacts.
Air Quality	Emissions from construction and dredging activities are not anticipated to cause long-term adverse impacts on air quality or climate change.	Emissions from construction and dredging activities are not anticipated to cause long-term adverse impacts on air quality or climate change.	Emissions from construction and dredging activities are not anticipated to cause long-term adverse impacts on air quality or climate change.	Emissions from construction and dredging activities are not anticipated to cause long-term adverse impacts on air quality or climate change.
Noise	Temporary, localized impacts during construction, dredging, and fill, but no adverse impacts. Temporary, localized impacts on marine mammals associated with increased noise from vessel activities (dredging).	Temporary, localized impacts during construction, dredging, and fill, but no adverse impacts. Temporary, localized impacts on marine mammals associated with increased noise from vessel activities (dredging).	Temporary, localized impacts during construction, dredging, and fill, but no adverse impacts. Temporary, localized impacts on marine mammals associated with increased noise from vessel activities (dredging).	Temporary, localized impacts during construction and/or maintenance activities.
Hazardous Materials	Beneficial impact by restoring the shoreline and increasing the distance between breaking waves and hazardous materials critical storage areas and accumulation points.	Beneficial impact by restoring the shoreline and increasing the distance between breaking waves and hazardous materials critical storage areas and accumulation points.	Beneficial impact by restoring the shoreline and increasing the distance between breaking waves and hazardous materials critical storage areas and accumulation points.	Potential adverse impacts from shoreline retreat and distance of hazardous materials critical storage areas and accumulation points from breaking waves.
Munitions and Explosives of Concern (MEC)	MEC are not anticipated to be encountered in the area of seawall construction or beach fill. Shoreline erosion would increase to the south of the seawall extension in the first one to two years of the SRIPP; MEC may migrate to the ocean if further beach erosion occurs in this area. The beach fill (starting in year two)	MEC are not anticipated to be encountered in the area of seawall construction or beach fill. Shoreline erosion would increase to the south of the seawall extension in the first one to two years of the SRIPP; MEC may migrate to the ocean if further beach erosion occurs in this area. The beach fill (starting in year	MEC are not anticipated to be encountered in the area of seawall construction or beach fill. Shoreline erosion would increase to the south of the seawall extension in the first one to two years of the SRIPP; MEC may migrate to the ocean if further beach erosion occurs in this area. The beach fill (starting in year two)	NASA would continue to follow the WFF MEC Avoidance Plan, conduct surveys, and remove MEC as necessary.

Executive Summary

Table ES-1: Summary of Impacts from Proposed Action Alternatives

Resource	Alternative One: Full Beach Fill, Seawall Extension	Alternative Two: Full Beach Fill, Groin, Seawall Extension	Alternative Three: Full Beach Fill, Breakwater, Seawall Extension	No Action
	would reduce the potential of MEC migration into the ocean. There is a potential that MEC would be encountered during excavation of the north Wallops Island borrow site. NASA would implement an MEC Avoidance Plan, conduct surveys, and remove MEC as necessary.	two) would reduce the potential of MEC migration into the ocean. There is a potential that MEC would be encountered during excavation of the north Wallops Island borrow site. NASA would implement an MEC Avoidance Plan, conduct surveys, and remove MEC as necessary.	would reduce the potential of MEC migration into the ocean. There is a potential that MEC would be encountered during excavation of the north Wallops Island borrow site. NASA would implement an MEC Avoidance Plan, conduct surveys, and remove MEC as necessary.	
Biological Resources – Birds	Temporary noise disturbances from the construction machinery used for seawall extension, movement of beach sand, excavation of the north Wallops Island borrow site, and the dredges are expected to adversely affect birds. Adverse effects may also occur from disturbance of beach habitat during the placement of sand on Wallops Island shoreline (initial fill and renourishment cycles) and excavation at north Wallops Island for renourishment. Disruption of feeding at offshore shoals during dredging and changes to shoal morphology that could impact foraging, but the impacts are not anticipated to be significant within a regional context given the hundreds of shoals and potential forage areas available to the birds within the mid-Atlantic region. The newly created beach could create suitable shorebird nesting habitat.	Temporary noise disturbances from the construction machinery used for seawall extension and groin, movement of beach sand, excavation of the north Wallops Island borrow site, and the dredges are expected to adversely affect birds. Adverse effects may also occur from disturbance of beach habitat during the placement of sand on Wallops Island shoreline (initial fill and renourishment cycles) and excavation at north Wallops Island for renourishment. Disruption of feeding at offshore shoals during dredging and changes to shoal morphology that could impact foraging, but the impacts are not anticipated to be significant within a regional context given the hundreds of shoals and potential forage areas available to the birds within the mid-Atlantic region. The newly created beach could create suitable shorebird nesting habitat.	Temporary noise disturbances from the construction machinery used for seawall extension and breakwater, movement of beach sand, excavation of the north Wallops Island borrow site, and the dredges are expected to adversely affect birds. Adverse effects may also occur from disturbance of beach habitat during the placement of sand on Wallops Island shoreline (initial fill and renourishment cycles) and excavation at north Wallops Island for renourishment. Disruption of feeding at offshore shoals during dredging and changes to shoal morphology that could impact foraging, but the impacts are not anticipated to be significant within a regional context given the hundreds of shoals and potential forage areas available to the birds within the mid-Atlantic region. The newly created beach could create suitable shorebird nesting habitat.	Maintenance and emergency repair activities could disrupt birds. It is reasonable to assume that substantial changes to the Wallops Island shoreline would continue to occur that would adversely affect shorebirds, seabirds, and migratory birds by decreasing the amount of beach habitat.
Biological Resources – Benthic Resources	Direct adverse impacts on bottom communities within dredging area. Benthic communities and habitat would be removed during dredging. Assuming the entire proposed borrow area of Shoal A would be dredged (uniform dredge depth of approximately 0.6 m [2 ft]) for the initial	Direct adverse impacts on bottom communities within dredging area. Benthic communities and habitat would be removed during dredging. Assuming the entire proposed borrow area of Shoal A would be dredged (uniform dredge depth of approximately 0.6 m [2 ft]) for the initial	Direct adverse impacts on bottom communities within dredging area. Benthic communities and habitat would be removed during dredging. Assuming the entire proposed borrow area of Shoal A would be dredged (uniform dredge depth of approximately 0.6 m [2 ft]) for the initial	No impacts.

Table ES-1: Summary of Impacts from Proposed Action Alternatives

Resource	Alternative One: Full Beach Fill, Seawall Extension	Alternative Two: Full Beach Fill, Groin, Seawall Extension	Alternative Three: Full Beach Fill, Breakwater, Seawall Extension	No Action
	<p>beach fill, approximately 518 hectares (ha) (1,280 acres [ac]) of benthic habitat would be removed. During each of nine renourishment cycles, approximately 140 ha (347 ac) of benthic habitat on Shoal A or Shoal B would be adversely impacted with a uniform dredging depth of approximately 0.6 m (2 ft).</p> <p>Placement of the initial fill would bury existing intertidal benthic community along an approximate 4,300 m (14,000 ft) length of the seawall. The mean tidal range is approximately 1.1 m (3.6 ft); therefore approximately 0.5 ha (1.2 ac) of hard-bottom, intertidal habitat would be permanently buried. In addition, approximately 91 ha (225 ac) of subtidal benthic community along the existing seawall would be buried during the initial fill placement. A new beach would be formed in front the seawall and a beach benthic community would become established.</p>	<p>beach fill, approximately 518 ha (1,280 ac) of benthic habitat would be removed. During each of nine renourishment cycles, approximately 116 ha (287 ac) of benthic habitat on Shoal A or Shoal B would be adversely impacted with a uniform dredging depth of approximately 0.6 m (2 ft).</p> <p>Placement of the initial fill would bury existing intertidal benthic community along an approximate 4,300 m (14,000 ft) length of the seawall. The mean tidal range is approximately 1.1 m (3.6 ft); therefore approximately 0.5 ha (1.2 ac) of hard-bottom, intertidal habitat would be permanently buried. Approximately 91 ha (225 ac) of subtidal benthic community along the existing seawall would also be buried during the initial fill placement. A new beach would be formed in front the seawall and a beach benthic community would become established.</p> <p>In addition, the construction of the groin would bury 0.08 ha (0.19 ac) of sandy, subtidal benthic habitat and replace it with hard substrate.</p>	<p>beach fill, approximately 518 ha (1,280 ac) of benthic habitat would be removed. During each of nine renourishment cycles, approximately 116 ha (287 ac) of benthic habitat on Shoal A or Shoal B would be adversely impacted with a uniform dredging depth of approximately 0.6 m (2 ft).</p> <p>Placement of the initial fill would bury existing intertidal benthic community along an approximate 4,300 m (14,000 ft) length of the seawall. The mean tidal range is approximately 1.1 m (3.6 ft); therefore approximately 0.5 ha (1.2 ac) of hard-bottom, intertidal habitat would be permanently buried. Approximately 91 ha (225 ac) of subtidal benthic community along the existing seawall would also be buried during the initial fill placement. A new beach would be formed in front the seawall and a beach benthic community would become established.</p> <p>In addition, the construction of the groin would bury 0.08 ha (0.19 ac) of sandy, subtidal benthic habitat and replace it with hard substrate.</p>	
Biological Resources – Fisheries	<p>Direct site-specific adverse effects on Essential Fish Habitat within: (1) the dredged area due to removal of benthic habitat and changes in shoal bathymetry and (2) the fill placement area due to burial of existing benthic habitat. However, the impacts would not be significant within a regional context. There would also be minor direct impacts to fisheries outside the dredging and fill footprints due to turbidity as a result of the</p>	<p>Direct site-specific adverse effects on Essential Fish Habitat within: (1) the dredged area due to removal of benthic habitat and changes in shoal bathymetry and (2) the fill placement area due to burial of existing benthic habitat. However, the impacts would not be significant within a regional context. There would also be minor direct impacts to fisheries outside the dredging and fill footprints due to turbidity as a result of the</p>	<p>Direct site-specific adverse effects on Essential Fish Habitat within: (1) the dredged area due to removal of benthic habitat and changes in shoal bathymetry and (2) the fill placement area due to burial of existing benthic habitat. However, the impacts would not be significant within a regional context. There would also be minor direct impacts to fisheries outside the dredging and fill footprints due to turbidity as a result of the</p>	No impacts.

Executive Summary

Table ES-1: Summary of Impacts from Proposed Action Alternatives				
Resource	Alternative One: Full Beach Fill, Seawall Extension	Alternative Two: Full Beach Fill, Groin, Seawall Extension	Alternative Three: Full Beach Fill, Breakwater, Seawall Extension	No Action
	dredging and fill placement operations.	dredging and fill placement operations. The groin would provide hard bottom habitat within the nearshore area. The introduction of hard substrate would provide diverse habitat and prey to the nearshore fish assemblage.	dredging and fill placement operations. The breakwater would provide hard bottom habitat within the nearshore area. The introduction of hard substrate would function similar to an artificial reef and provide diverse habitat and prey to the nearshore fish assemblage.	
Biological Resources – Marine Mammals	Potential temporary, localized adverse impacts associated with (1) physical disturbance to habitats during dredging and fill, (2) vessel strike, and (3) increased noise from vessel activities (dredging).	Potential temporary, localized adverse impacts associated with (1) physical disturbance to habitats during dredging and fill, (2) vessel strike, and (3) increased noise from vessel activities (dredging).	Potential temporary, localized adverse impacts associated with (1) physical disturbance to habitats during dredging and fill, (2) vessel strike, and (3) increased noise from vessel activities (dredging).	No impacts.
Biological Resources – Threatened & Endangered Species	May affect, not likely to adversely affect vegetation, whales, sea turtles (except for loggerhead), and the Red Knot. May affect, likely to adversely affect loggerhead sea turtle, Piping Plover. No adverse affect to other bird species.	May affect, not likely to adversely affect vegetation, whales, sea turtles (except for loggerhead), and the Red Knot. May affect, likely to adversely affect loggerhead sea turtle, Piping Plover. No adverse affect to other bird species.	May affect, not likely to adversely affect vegetation, whales, sea turtles (except for loggerhead), and the Red Knot. May affect, likely to adversely affect loggerhead sea turtle, Piping Plover. No adverse affect to other bird species.	No impacts.
Socioeconomics	Beneficial impacts from reducing damages to infrastructure, reducing losses of work days and jobs, and from temporary construction-related job creation. Temporary minor adverse effects on surf clams and fisheries at dredge site from smothering and elevated turbidity, temporary impacts on commercial and recreational fishing resources during the placement of beach fill material on Wallops Island due to elevated turbidity levels in the nearshore environment and disruption of the benthos, which would cause fish to avoid the disturbed areas. No long-term adverse impacts on commercial and recreational fisheries. No disproportionate impacts to minority and low-income persons.	Beneficial impacts from reducing damages to infrastructure, reducing losses of work days and jobs, and from temporary construction-related job creation. Temporary minor adverse effects on surf clams and fisheries at dredge site from smothering and elevated turbidity, temporary impacts on commercial and recreational fishing resources during the placement of beach fill material on Wallops Island due to elevated turbidity levels in the nearshore environment and disruption of the benthos, which would cause fish to avoid the disturbed areas. No long-term adverse impacts on commercial and recreational fisheries. No disproportionate impacts to minority and low-income persons.	Beneficial impacts from reducing damages to infrastructure, reducing losses of work days and jobs, and from temporary construction-related job creation. Temporary minor adverse effects on surf clams and fisheries at dredge site from smothering and elevated turbidity, temporary impacts on commercial and recreational fishing resources during the placement of beach fill material on Wallops Island due to elevated turbidity levels in the nearshore environment and disruption of the benthos, which would cause fish to avoid the disturbed areas. No long-term adverse impacts on commercial and recreational fisheries. No disproportionate impacts to minority and low-income persons.	Potential adverse impacts from interruption in WFF activities or loss of infrastructure. No disproportionate impacts to minority and low-income persons.

Table ES-1: Summary of Impacts from Proposed Action Alternatives

Resource	Alternative One: Full Beach Fill, Seawall Extension	Alternative Two: Full Beach Fill, Groin, Seawall Extension	Alternative Three: Full Beach Fill, Breakwater, Seawall Extension	No Action
Cultural Resources	No archaeological (below ground or underwater) resources or above-ground historic properties are present within the project area; therefore no archeological resources or above-ground historic properties would be impacted.	No archaeological (below ground or underwater) resources or above-ground historic properties are present within the project area; therefore no archeological resources or above-ground historic properties would be impacted.	No archaeological (below ground or underwater) resources or above-ground historic properties are present within the project area; therefore no archeological resources or above-ground historic properties would be impacted.	No archaeological (below ground) or above-ground historic properties affected.
Transportation	Temporary increase in upland and maritime traffic, no adverse impacts.	Temporary increase in upland and maritime traffic, no adverse impacts.	Temporary increase in upland and maritime traffic, no adverse impacts.	Increase in upland traffic for emergency/repair measures.
Cumulative Impacts	Dredging operations would contribute incrementally to the overall removal of sand resources from shoals located on the inner continental shelf in the Mid-Atlantic region offshore of Maryland and Virginia. The SRIPP would contribute incrementally to the overall beneficial impacts of shoreline restoration efforts within the region by adding sand to the nearshore sediment transport system. Incremental contribution to cumulative water resource impacts would be negligible. The cumulative reduction in benthic invertebrate fauna would indirectly affect fish that forage on these benthic species; however, nearby shoals would provide alternate foraging grounds for marine species and mitigate adverse cumulative impacts. Negligible cumulative impacts on air quality, marine mammals. Adverse and beneficial impacts on birds and sea turtles; NASA would implement mitigation measures required by U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) through SRIPP Section 7 consultation. Beneficial impacts on socioeconomics.	Dredging operations would contribute incrementally to the overall removal of sand resources from shoals located on the inner continental shelf in the Mid-Atlantic region offshore of Maryland and Virginia. The SRIPP would contribute incrementally to the overall beneficial impacts of shoreline restoration efforts within the region by adding sand to the nearshore sediment transport system. Incremental contribution to cumulative water resource impacts would be negligible. The cumulative reduction in benthic invertebrate fauna would indirectly affect fish that forage on these benthic species; however, nearby shoals would provide alternate foraging grounds for marine species and mitigate adverse cumulative impacts. Negligible cumulative impacts on air quality, marine mammals. Adverse and beneficial impacts on birds and sea turtles; NASA would implement mitigation measures required by USFWS and NMFS through SRIPP Section 7 consultation. Beneficial impacts on socioeconomics.	Dredging operations would contribute incrementally to the overall removal of sand resources from shoals located on the inner continental shelf in the Mid-Atlantic region offshore of Maryland and Virginia. The SRIPP would contribute incrementally to the overall beneficial impacts of shoreline restoration efforts within the region by adding sand to the nearshore sediment transport system. Incremental contribution to cumulative water resource impacts would be negligible. The cumulative reduction in benthic invertebrate fauna would indirectly affect fish that forage on these benthic species; however, nearby shoals would provide alternate foraging grounds for marine species and mitigate adverse cumulative impacts. Negligible cumulative impacts on air quality, marine mammals. Adverse and beneficial impacts on birds and sea turtles; NASA would implement mitigation measures required by USFWS and NMFS through SRIPP Section 7 consultation. Beneficial impacts on socioeconomics.	Potential adverse impacts on socioeconomics from interruption of WFF activities or loss of infrastructure.

This page intentionally left blank.

TABLE OF CONTENTS

EXECUTIVE SUMMARY	ES-I
ACRONYMS AND ABBREVIATIONS	ix
CHAPTER ONE: MISSION, PURPOSE AND NEED, BACKGROUND INFORMATION	1
1.1 Introduction.....	1
1.2 Background.....	2
1.2.1 Wallops Flight Facility Mission	2
1.2.2 Environmental Management System	2
1.2.3 Site Location	2
1.2.4 Facilities, Tenants, and On-Site Organizations at Wallops Island.....	5
1.2.5 Shoreline Erosion and Past Erosion Reduction Measures at Wallops Island	9
1.2.6 The Coastal Sand Transport System.....	14
1.3 Purpose and Need for the Proposed Action	14
1.3.1 Purpose.....	14
1.3.2 Need	17
1.4 Adaptive Design and Management Strategy.....	18
1.5 Scope of this Programmatic Environmental Impact Statement	18
CHAPTER TWO: DESCRIPTION AND COMPARISON OF ALTERNATIVES	19
2.1 Overview of Proposed Action.....	19
2.2 Description of Range of Alternatives Considered	20
2.2.1 Relocating At-Risk Infrastructure.....	21
2.2.2 Seawall Extension Only	26
2.2.3 Sand Dunes with Various Cores	26
2.2.4 Beach Fill Only	26
2.2.5 Beach Fill and Seawall Extension.....	29
2.2.6 Beach Fill, Seawall Extension and Sand Retention Structures.....	29
2.2.7 No Action.....	33
2.3 Initial Screening of the Alternatives	33
2.3.1 Screening Criteria	33
2.3.2 Screening Results.....	34
2.3.3 Alternatives Eliminated After Initial Screening	35
2.4 Secondary Screening of Alternatives.....	37
2.4.1 Detailed Options within Alternatives Carried Forward	37
2.4.2 Secondary Screening Results.....	38
2.4.3 Sources Considered for Beach Fill Material	44
2.5 Proposed Action Alternatives	59
2.5.1 Project Elements Common to All Alternatives.....	59
2.5.2 Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension.....	68
2.5.3 Alternative Two: Full Beach Fill, Groin, Seawall Extension	69
2.5.4 Alternative Three: Full Beach Fill, Breakwater, Seawall Extension.....	69
2.5.5 Summary of Dredge and Fill Volumes for Each of the Alternatives	70

TABLE OF CONTENTS

2.5.6	Delineation of Shoal Study Areas.....	73
2.5.7	Dredging and Sand Placement Operation.....	73
2.6	Summary and Comparison of Alternatives.....	79
2.6.1	Implementation Schedule.....	79
2.6.2	Consideration of Costs and Benefits.....	80
2.6.3	Comparison of Costs of Dredging from Shoal A versus Shoal B	82
2.6.4	Comparison of Impacts.....	82
2.7	Summary of Mitigation Measures for Proposed Action Alternatives	91
CHAPTER THREE: AFFECTED ENVIRONMENT.....		93
3.1	Physical Environment.....	93
3.1.1	Meteorology.....	94
3.1.2	Climate Change.....	95
3.1.3	Bathymetry.....	97
3.1.4	Geology and Geomorphology.....	109
3.1.5	Physical Oceanography and Coastal Processes	116
3.1.6	Water Resources	122
3.1.7	Floodplains.....	131
3.1.8	Coastal Zone Management	132
3.1.9	Air Quality	133
3.1.10	Noise	138
3.1.11	Hazardous Materials and Hazardous Waste	141
3.1.12	Munitions and Explosives of Concern.....	142
3.2	Biological Environment.....	147
3.2.1	Vegetation.....	147
3.2.2	Wildlife	151
3.2.3	Submerged Aquatic Vegetation	158
3.2.4	Plankton	159
3.2.5	Benthos	160
3.2.6	Invertebrate Nekton	170
3.2.7	Finfish	170
3.2.8	Essential Fish Habitat	172
3.2.9	Marine Mammals.....	174
3.2.10	Threatened and Endangered Species	181
3.3	Social and Economic Environment.....	194
3.3.1	Land Use	195
3.3.2	Recreation	195
3.3.3	Fisheries	195
3.3.4	Population	197
3.3.5	Employment and Income	197
3.3.6	Health and Safety	199
3.3.7	Cultural Resources	199
3.3.8	Environmental Justice.....	208
3.3.9	Transportation.....	209
CHAPTER FOUR: ENVIRONMENTAL CONSEQUENCES.....		215
4.1	Introduction.....	215
4.2	Physical Environment.....	215

TABLE OF CONTENTS

4.2.1	Bathymetry.....	215
4.2.2	Geology and Geomorphology.....	217
4.2.3	Physical Oceanography and Coastal Processes	232
4.2.4	Water Resources	242
4.2.5	Floodplains.....	247
4.2.6	Coastal Zone Management	248
4.2.7	Air Quality	249
4.2.8	Noise	261
4.2.9	Hazardous Materials and Hazardous Waste Management.....	262
4.3	Biological Environment.....	264
4.3.1	Vegetation.....	264
4.3.2	Wildlife	266
4.3.3	Submerged Aquatic Vegetation	272
4.3.4	Plankton	272
4.3.5	Benthos	273
4.3.6	Invertebrate Nekton	278
4.3.7	Finfish.....	279
4.3.8	Essential Fish Habitat	281
4.3.9	Marine Mammals.....	284
4.3.10	Threatened and Endangered Species	290
4.4	Social and Economic Environment.....	302
4.4.1	Land Use	302
4.4.2	Infrastructure and Facilities	302
4.4.3	Recreation	303
4.4.4	Fisheries	303
4.4.5	Population, Employment and Income.....	305
4.4.6	Health and Safety.....	306
4.4.7	Environmental Justice.....	307
4.4.8	Cultural Resources	307
4.4.9	Transportation.....	311
4.5	Relationship Between Short-Term Use of The HuMan Environment and Maintenance and Enhancement of Long-Term Productivity.....	314
4.6	Irreversible or Irrecoverable Commitment of Resources	315
4.7	Cumulative Effects.....	316
4.7.1	Actions Affecting Resources of Concern	316
4.7.2	Potential Cumulative Effects	334
4.8	Permits, Licenses, and Approvals.....	364
CHAPTER FIVE: MITIGATION AND MONITORING		365
5.1	Mitigation.....	365
5.1.1	Physical Environment.....	365
5.1.2	Threatened and Endangered Species	367
5.1.3	Essential Fish Habitat	371
5.1.4	Cultural Resources	371
5.2	Monitoring	372
5.2.1	Threatened and Endangered Species	372
5.2.2	Beach Profile.....	373

TABLE OF CONTENTS

5.2.3 Offshore Shoals.....	378
CHAPTER SIX: LIST OF PREPARERS	379
CHAPTER SEVEN: AGENCIES, ORGANIZATIONS, AND PERSONS CONSULTED	383
7.1 Introduction.....	383
7.2 Scoping Process	383
7.3 Fisheries Survey.....	384
7.4 Web Site.....	385
7.5 Draft PEIS.....	385
7.6 Final PEIS.....	387
7.7 Record of Decision	387
7.8 Summary.....	387
CHAPTER EIGHT: REFERENCES.....	397
CHAPTER NINE: INDEX.....	423

Appendices

Appendix A	Storm Damage Reduction Project Design for Wallops Island, VA
Appendix B	SRIPP Benthic Video Survey Technical Memorandum
Appendix C	Biological Assessment
Appendix D	U.S. Fish and Wildlife Service Biological Opinion
Appendix E	National Marine Fisheries Service Biological Opinion
Appendix F	SRIPP Cultural Resource Remote Sensing Survey of Two Proposed Offshore Sand Borrow Locations in Federal Waters
Appendix G	SRIPP Proposed Groin, Breakwater, and Shoreline Cultural Resources Surveys, Accomack County, VA
Appendix H	Federal Consistency Determination and Virginia Department of Environmental Quality Response
Appendix I	Essential Fish Habitat Assessment
Appendix J	Essential Fish Habitat Consultation
Appendix K	Section 106 Consultation
Appendix L	Comments Received on Draft PEIS
Appendix M	Response to Comments Received on Draft PEIS

Figures

Figure 1: Vicinity Map..... 3

Figure 2: Wallops Island Existing Facilities..... 7

Figure 3: Wallops Island Viewed from the South 11

Figure 4: Aerial of Geotextile Tubes and Old Groin Placement 15

Figure 5: Current WFF Layout and Impacts to Public 23

Figure 6: Hypothetical WFF Layout and Impacts to Public..... 27

Figure 7: Example Groin Placement and Effect on the Shoreline..... 30

Figure 8: Example Breakwater Placement and Effect on the Shoreline..... 31

Figure 9: Secondary Alternative Screening Process Flow..... 43

Figure 10: Offshore Disposal Site for Chincoteague Inlet Dredged Material 44

Figure 11: Nearshore Sediment Sample Locations East of Wallops Island 47

Figure 12: Vibracore Sampling and Shoal Locations 49

Figure 13: North Wallops Island Borrow Site 55

Figure 14: Seawall Extension and Beach Fill Overview 61

Figure 15: Cross-Section View of the Seawall and Dune..... 63

Figure 16: Fill Material Conceptual Diagrams (Profiles for Initial Nourishment and Renourishment)..... 65

Figure 17: Proposed Groin, Breakwater and Seawall Extension..... 71

Figure 18: Dredging Areas of Shoal A and B..... 77

Figure 19: Northeast Continental Shelf Subregions 94

Figure 20: Bathymetry of Chincoteague Shoals and Chincoteague Bight 98

Figure 21: Offshore Bathymetry 99

Figure 22: Profile 1 - View of Bathymetry from Assateague Island East to Shoal A 101

Figure 23: Profile 2 - View of Bathymetry from Assateague Island East to Shoal B 103

Figure 24: Plan View Bathymetry of Shoals A and B 105

Figure 25: Oblique View of Shoal Bathymetry 107

Figure 26: Wallops Island Shoreline Changes between 1849 and 2005..... 112

Figure 27: Growth of Fishing Point..... 114

Figure 28: Average Yearly Gross Sediment Transport Rates along Wallops Island..... 118

Figure 29: Net Sediment Transport Rates along Wallops Island..... 119

Figure 30: Wallops Island Sediment Budget 120

Figure 31: Surface Waters 123

Figure 32: Wetlands..... 127

Figure 33: Wetlands Identified along Seawall July 2009 & July 2010 129

Figure 34: MEC Locations..... 145

Figure 35: Vegetation Types..... 149

Figure 36: North Wallops Island Vegetation Communities 153

Figure 37: Benthic Video Survey Station Locations 165

Figure 38: Protected Species in the Vicinity of Wallops Island 185

Figure 39: Wallops Mainland and Wallops Island Historic Archaeological Site Sensitivity..... 201

Figure 40: Wallops Mainland and Wallops Island Prehistoric Archaeological Site Sensitivity..... 203

Figure 41: Minority Persons by Census Block in Accomack County, Virginia..... 211

Figure 42: Shoreline Positions in Response to Seawall Extension without Beach Fill..... 222

List of Tables and Figures

Figure 43: Shoreline Positions over Time for Alternative One	223
Figure 44: Unnamed Shoal A: Plane and Contour Dredge Method Profiles	226
Figure 45: Unnamed Shoal B: Plane and Contour Dredge Method Profiles	227
Figure 46: Shoreline Positions over Time for Alternative Two	229
Figure 47: Shoreline Positions over Time for Alternative Three	230
Figure 48: Net Sediment Transport Rates over Time for Alternative One.....	235
Figure 49: Shoreline Position in Year 5 for Alternative One	236
Figure 50: Net Sediment Transport Rates over Time for Alternative Two	238
Figure 51: Shoreline Position in Year 5 for Alternative Two.....	239
Figure 52: Net Sediment Transport Rates over Time for Alternative Three	240
Figure 53: Shoreline Position in Year 5 for Alternative Three.....	241
Figure 54: Historical Impacts and Wetlands at Wallops Island between 1938 and 1994.....	323
Figure 55: Onshore Present and Future Activities and Projects	325
Figure 56: Offshore Present and Future Activities and Projects.....	329
Figure 57: Watersheds in the Vicinity of WFF.....	339
Figure 58: Proposed Mainland Wetland Compensation Areas.....	345
Figure 59: Proposed Wallops Island Wetland Compensation Areas	346

Photos

Photo 1: 1991 aerial photo of Wallops Island showing 2005 extent of shoreline erosion.....	9
Photo 2: 1983 view looking north along Wallops Island showing wood groins (in poor condition) – the southernmost groins in this photo are approximately 100 m (330 ft) long	10
Photo 3: Damage to the south end of Wallops Island caused by the	13
Photo 4: Experimental “Beach Prism” sand retention units moved out of alignment during an April 1988 storm on Wallops Island.....	32
Photo 5: “Beach Beam” units partially sunken into seabed during an April 1988 storm on Wallops Island.....	32
Photo 6: Schematic of a self-propelled trailer suction hopper dredge	74
Photo 7: Example of a pan excavator	79
Photo 8: Groin field located at north central part of Wallops Island showing sediment transport direction to the north – photo taken March 20, 1994.....	120
Photo 9: Groin field located along central Wallops Island showing sediment transport direction to the south – photo taken in March 1969.....	121
Photo 10: Close-up of seawall on Wallops Island	162
Photo 11: Ripple marks characteristic of Station #20 from Unnamed Shoal B at a depth of approximately 14 m (45 ft). (Photo contains the date and time of collection in upper left and easting and northing coordinates in upper right)	167
Photo 12: Ripple marks characteristic of Station #39 from Unnamed Shoal B at a depth of approximately 17 m (56 ft)	167
Photo 13: Shell hash and absence of bedforms characteristic of Station #2 from Unnamed Shoal A at a depth of approximately 17 m (55 ft).....	168
Photo 14: Shell hash and absence of bedforms characteristic of Station #17 from Unnamed Shoal A at a depth of approximately 19 m (64 ft).....	168

List of Tables and Figures

Photo 15: Sand dollars (<i>Echinarachinus parma</i>) from Station #14 from Unnamed Shoal B at a depth of approximately 15 m (48 ft).....	169
Photo 16: Sea robin (<i>Prionotus</i> spp.) in lower right of photo from Station #39 from Unnamed Shoal B at a depth of approximately 17 m (56 ft).....	169
Photo 17: Gunboat Point Range on North Wallops Island	318
Photo 18: Newly constructed causeway in 1959	319
Photo 19: 1965 photograph showing large rectangular fill area on south end of Wallops Island.....	320

Tables

Table 1: Initial Screening Analysis of the Alternatives	35
Table 2: Summary of Options for Components Carried Forward	37
Table 3: Analysis of the 54 Potential Alternatives	39
Table 4: Grain Size in Samples Taken from Blackfish Bank, Unnamed Shoal A, and Unnamed Shoal B	51
Table 5: Grain Size in Samples Collected from North Wallops Island	57
Table 6: Summary of Borrow Site Options Carried Forward for Analysis	58
Table 7: Fill Volumes for the Alternatives	70
Table 8: Dredge Volumes for Alternatives	70
Table 9: Implementation Schedule	80
Table 10: Approximate Cost Reduction by Dredging Sand from Shoal A versus Shoal B.....	82
Table 11: Summary of Impacts from the Proposed Action Alternatives.....	83
Table 12: Summary of Mitigation Measures for the Proposed Action Alternatives	91
Table 13: Characteristics of Unnamed Shoals A and B Relative to Cross-Shore Sediment Transport	122
Table 14: National Ambient Air Quality Standards	134
Table 15: Calendar Year 2008 Air Emissions at Wallops Island/Mainland.....	135
Table 16: Calendar Year 2008 Greenhouse Gas Air Emissions at Wallops Island/Mainland	137
Table 17: Calendar Year 2008 Greenhouse Gas Emissions at Wallops Island/Mainland in Metric Tonnes per Year (Tons per Year).....	138
Table 18: Typical Noise Levels of Familiar Noise Sources and Public Responses	139
Table 19: Accomack County Noise Guidelines by Land Use	140
Table 20: Potential MEC Locations within Project Area	143
Table 21: Organisms Collected by Slacum et al. (2006) in Trawls Collected on Shoals Offshore of Maryland.....	163
Table 22: NMFS Managed Species that May Occur in Waters Surrounding Wallops Island, VA and Proposed Offshore Borrow Sites	173
Table 23: Marine Mammals Likely to Occur Offshore of Wallops Island.....	174
Table 24: Protected Species that May Occur in the SRIPP Project Area	183
Table 25: Occupational Distribution (percent)	198
Table 26: Income and Poverty	198
Table 27: Environmental Justice Concerns – by Census Tract, Accomack County, VA.....	209
Table 28: Erosion Volumes South of Existing Seawall.....	217
Table 29: Average Shoreline Change Rate at Assawoman Inlet.....	220

List of Tables and Figures

Table 30: Erosion Volumes South of Existing Seawall.....	221
Table 31: Offshore Borrow Site Impacts	231
Table 32: Federal Consistency Determination.....	248
Table 33: Emissions from Construction Activities Associated with Seawall Extension.....	250
Table 34: Alternative One Emissions from Dredging and Initial Beach Fill	252
Table 35: Alternative One Emissions from Dredging and Renourishment Fill.....	252
Table 36: Emissions from North Wallops Island Renourishment Activities.....	253
Table 37: Alternative One Emissions Summary for Initial Beach Fill.....	254
Table 38: Alternative One Emissions Summary for Renourishment Beach Fill	254
Table 39: Alternative One Construction Emissions for Wallops Mainland/Island	254
Table 40: Emissions from Groin Construction Activities.....	255
Table 41: Alternative Two Emissions from Dredging and Initial Beach Fill.....	256
Table 42: Alternative Two Emissions from Dredging and Renourishment Fill	257
Table 43: Alternative Two Emissions Summary for Initial Beach Fill	257
Table 44: Alternative Two Emissions Summary for Renourishment Beach Fill	258
Table 45: Emissions from Breakwater Construction Activities	259
Table 46: Alternative Three Emissions from Dredging and Initial Beach Fill.....	259
Table 47: Alternative Three Emissions from Dredging and Renourishment Fill.....	260
Table 48: Alternative Three Emissions Summary for Initial Beach Fill	260
Table 49: Alternative Three Emissions Summary for Renourishment Beach Fill	261
Table 50: Marine Mammals Hearing Groups	287
Table 51: Threatened and Endangered Species Not Affected by SRIPP.....	290
Table 52: Determination of Effects to Federally Protected Species	301
Table 53: Summary of Hectares (Acres) Affected by Various Actions at Wallops Island 1938 to 2010+	322
Table 54: Volume of Potential Suitable Sand Resources for Shoreline Restoration in Maryland and Virginia	336
Table 55: Area of Wetlands Affected from Recent Past Projects on Wallops Island and Mainland	342
Table 56: Estimated Area of Wetlands Affected for Current Proposed Projects on Wallops Island and Mainland.....	343
Table 57: Areas Identified for Wetland Compensation	345
Table 58: WFF Cumulative Project Criteria Pollutant Emissions in Tons.....	348
Table 59: Emissions Reduction Resulting from Central Boiler Plant Decentralization	349
Table 60: WFF Cumulative Project Greenhouse Gas Emissions	349
Table 61: Cumulative Sea Turtle Takes by Month and Species between 1980 and 2009, USACE Norfolk District.....	359
Table 62: Responses to Scoping by Comment Topic	384
Table 63: Comments by Category Received on Draft PEIS.....	386
Table 64: Agencies, Organizations, and Individuals Consulted for the SRIPP PEIS.....	389

Acronyms and Abbreviations

°C	Degrees Celsius
°F	Degrees Fahrenheit
ACHP	Advisory Council on Historic Preservation
amsl	Above Mean Sea Level
APE	Area of Potential Effect
AST	Aboveground Storage Tank
BA	Biological Assessment
BMAP	Beach Morphology Analysis Package
BMP	Best Management Practice
BO	Biological Opinion
BOEMRE	Bureau of Ocean Energy Management, Regulation, and Enforcement
CAA	Clean Air Act
CAD	Computer-Assisted Design
CBRA	Coastal Barrier Resources Act
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CH ₄	Methane
CMA	Coastal Management Area
CNWR	Chincoteague National Wildlife Refuge
CO	Carbon Monoxide
CO ₂	Carbon Dioxide
CO _{2e}	Carbon Dioxide Equivalent
COLREGS	Collision Regulations
CRA	Cultural Resources Assessment
CWA	Clean Water Act
CZM	Coastal Zone Management
dB	Decibel
dBA	Decibel Weighted to the A-scale
DFO	Distance Focused Overpressure
DGPS	Digital Global Positioning System
DMM	Discarded Military Munitions
EA	Environmental Assessment
EFH	Essential Fish Habitat
EG&G	EG&G Technical Services
EIS	Environmental Impact Statement
EJIP	Environmental Justice Implementation Plan
ELV	Expendable Launch Vehicle
EMS	Environmental Management System
EO	Executive Order
EOD	Explosive Ordnance Disposal
EPA	U.S. Environmental Protection Agency

Acronyms and Abbreviations

ESA	Endangered Species Act
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FMP	Fisheries Management Plan
FR	Federal Register
GB	Georges Bank
GHG	Greenhouse Gas
GOM	Gulf of Maine
GPS	Global Positioning System
GSFC	Goddard Space Flight Center
GWP	Global Warming Potential
HAP	Hazardous Air Pollutant
ICP	Integrated Contingency Plan
JPA	Joint Permit Application
LHA	Launch Hazard Area
LiDAR	Light Detection and Ranging
MAB	Mid-Atlantic Bight
MARS	Mid-Atlantic Regional Spaceport
MACT	Maximum Achievable Control Technology
MBTA	Migratory Bird Treaty Act
MEC	Munitions and Explosives of Concern
MHWL	Mean High Water Level
MLW	Mean Low Water
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
MOA	Memorandum of Agreement
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSDS	Material Safety Data Sheet
MSL	Mean Sea Level
NAAQS	National Ambient Air Quality Standards
NACA	National Advisory Committee for Aeronautics
NARWC	North Atlantic Right Whale Consortium
NASA	National Aeronautics and Space Administration
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service

Acronyms and Abbreviations

N ₂ O	Nitrous Oxide
NO ₂	Nitrogen Dioxide
NOAA	National Oceanic and Atmospheric Administration
NO _x	Nitrogen Oxides
NPS	National Park Service
NRHP	National Register of Historic Places
NSR	New Source Review
NSPS	New Source Performance Standards
NTL	Notice to Lessee
O ₃	Ozone
OCS	Outer Continental Shelf
OSHA	Occupational Safety and Health Administration
Pb	Lead
PEIS	Programmatic Environmental Impact Statement
PLDA	Pre-Launch Danger Area
PM	Particulate Matter
PM ₁₀	Particulate Matter Less Than or Equal to 10 micrometers
PM _{2.5}	Particulate Matter Less Than or Equal to 2.5 micrometers
POV	Personally Owned Vehicle
ppm	Parts per Million
ppt	Parts per Thousand
PSD	Prevention of Significant Deterioration
PTE	Potential to Emit
RHA	Rivers and Harbors of Act of 1899
RNA	Regulated Navigation Area
SAV	Submerged Aquatic Vegetation
SCSC	Surface Combat Systems Center
SGCN	Species of Greatest Conservation Need
SNE	Southern New England
SO ₂	Sulfur Dioxide
SRIPP	Shoreline Restoration and Infrastructure Protection Program
TSS	Traffic Separation Scheme
UAS	Uninhabited Aerial Systems
URS	URS Group, Inc.
USACE	U.S. Army Corps of Engineers
U.S.C.	U.S. Code
USCG	U.S. Coast Guard
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
UST	Underground Storage Tank

Acronyms and Abbreviations

UXO	Unexploded Ordnance
VAC	Virginia Administrative Code
VACAPES	Virginia Capes Operating Area
OPAREA	
VDCR	Virginia Department of Conservation and Recreation
VDEQ	Virginia Department of Environmental Quality
VDGIF	Virginia Department of Game and Inland Fisheries
VDHR	Virginia Department of Historic Resources
VEC	Virginia Employment Commission
VIMS	Virginia Institute of Marine Science
VMRC	Virginia Marine Resources Commission
VOC	Volatile Organic Compound
WFF	Wallops Flight Facility

Common Metric/British System Equivalents

Linear

1 centimeter (cm) = 0.3937 inch (in)

1 inch = 2.54 cm

1 centimeter = 0.0328 foot (ft)

1 foot = 30.48 cm

1 meter (m) = 3.2808 feet

1 ft = 0.3048 m

1 meter = 0.0006 mile (mi)

1 mi = 1609.3440 m

1 kilometer (km) = 0.6214 mile

1 mi = 1.6093 km

1 kilometer = 0.53996 nautical mile (nmi)

1 nmi = 1.8520 km

1 mi = 0.87 nmi

1 nmi = 1.15 mi

Area

1 square centimeter (cm²) = 0.1550 square inch (in²)

1 in² = 6.4516 cm²

1 square meter (m²) = 10.7639 square feet (ft²)

1 ft² = 0.09290 m²

1 square kilometer (km²) = 0.3861 square mile (mi²)

1 mi² = 2.5900 km²

1 hectare (ha) = 2.4710 acres (ac)

1 ac = 0.4047 ha

1 hectare (ha) = 10,000 square meters (m²)

1 ft² = 0.000022957 ac

Volume

1 cubic centimeter (cm³) = 0.0610 cubic inch (in³)

1 in³ = 16.3871 cm³

1 cubic meter (m³) = 35.3147 cubic feet (ft³)

1 ft³ = 0.0283 m³

1 cubic meter (m³) = 1.308 cubic yards (yd³)

1 yd³ = 0.76455 m³

1 liter (l) = 1.0567 quarts (qt)

1 qt = 0.9463264 l

1 liter = 0.2642 gallon (gal)

1 gal = 3.7845 l

1 kiloliter (kl) = 264.2 gal

1 gal = 0.0038 kl

Mass

1 gram (g) = 0.0353 ounce (oz)

1 oz = 28.3495 g

1 kilogram (kg) = 2.2046 pounds (lb)

1 lb = 0.4536 kg

1 metric tonne (mt) = 1.1023 tons

1 ton = 0.9072 mt

This page intentionally left blank.

CHAPTER ONE: MISSION, PURPOSE AND NEED, BACKGROUND INFORMATION

1.1 INTRODUCTION

This Programmatic Environmental Impact Statement (PEIS) has been prepared to evaluate the potential environmental impacts from the proposed Wallops Flight Facility (WFF) Shoreline Restoration and Infrastructure Protection Program (SRIPP). The SRIPP encompasses a 50-year planning horizon and is intended to reduce damage to Federal and State infrastructure on Wallops Island caused by the combination of sea-level rise and coastal storms.

In May 2007, the National Aeronautics and Space Administration (NASA) released for public comment a Draft Programmatic Environmental Assessment (EA) for Goddard Space Flight Center's (GSFC's) WFF SRIPP. Since that time, NASA's Proposed Action has changed (the proposed borrow sites moved from State to Federal waters, and extension of the seawall was added along with more details on placement of sand-retention structures), and as a result, NASA has prepared this PEIS for the Proposed Action currently under consideration.

This PEIS has been prepared in accordance with the National Environmental Policy Act of 1969 (NEPA), as amended (42 U.S. Code [U.S.C.] 4321–4347), the Council on Environmental Quality (CEQ) regulations for implementing NEPA (40 Code of Federal Regulations [CFR] 1500–1508), NASA's regulations for implementing NEPA (14 CFR Subpart 1216.3), and the *NASA Procedural Requirements for Implementing NEPA and Executive Order (EO) 12114* (NASA Procedural Requirements 8580.1).

The availability of the Draft PEIS for public comment was published in the *Federal Register* on February 26, 2010 (75 FR 8997) and the public comment period closed on April 19, 2010. A public meeting to discuss the Draft PEIS was held on March 16, 2010.

The U.S. Department of the Interior's Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE) (formerly the Minerals Management Service (MMS) and renamed the BOEMRE under Secretarial Order 3302, issued June 18, 2010) and the U.S. Army Corps of Engineers (USACE) have served as Cooperating Agencies in preparing this PEIS because they both possess regulatory authority and specialized expertise pertaining to the Proposed Action. This PEIS has been developed to fulfill all three Federal agencies' obligations under NEPA. NASA, as the WFF property owner and project proponent, is the Lead Agency and responsible for ensuring overall compliance with applicable environmental statutes, including NEPA.

NASA would require authorizations from both the USACE and the BOEMRE for the SRIPP. Under Section 404 of the Clean Water Act (CWA), the USACE has jurisdiction over the disposal of dredged and fill material in Waters of the U.S. In addition, under Section 10 of the Rivers and Harbors of Act of 1899 (RHA), the USACE has jurisdiction over the placement of structures and work, such as dredging, conducted in navigable waters of the U.S. The USACE Norfolk District is designing the SRIPP and would serve in a construction management capacity during project implementation, including hiring construction contractors. The BOEMRE has jurisdiction over mineral resources on the Federal Outer Continental Shelf (OCS). Public Law 103-426, enacted October 31, 1994, gave BOEMRE the authority to convey, on a noncompetitive basis, the rights to OCS sand, gravel, or shell resources for shore protection, beach or wetlands restoration projects, or for use in construction projects funded in whole or part or authorized by the Federal government. A Memorandum of Agreement (MOA) pursuant to section 8(k)(D) of the OCS

Mission, Purpose and Need, Background Information

Lands Act, 43 U.S.C. § 1337(k)(2) would be negotiated among BOEMRE, USACE and NASA to allow NASA to dredge sand from the OCS.

In developing this PEIS, NASA consulted multiple stakeholders and agencies and engaged an Independent Technical Review team of scientists to provide input regarding development of the alternatives, description of the affected environment, and assessment of environmental impacts from implementation of the SRIPP. The Independent Technical Review team comments on the Draft PEIS are provided in Appendix L.

This PEIS will be reviewed for adequacy at any time that major changes to the Proposed Action are under consideration or substantial changes to the environmental conditions in the project area occur. As such, the document may be supplemented in the future to assess new proposals or to address changes in existing conditions, impacts, and mitigation measures. Additionally, as this PEIS considers the effects of the SRIPP over a 50-year time frame, some project details (e.g., renourishment frequencies, volumes, and sources) are only generally known at the current time. Tiered NEPA documents would be prepared in the future for implementation of certain aspects of the SRIPP once project details become more refined.

1.2 BACKGROUND

1.2.1 Wallops Flight Facility Mission

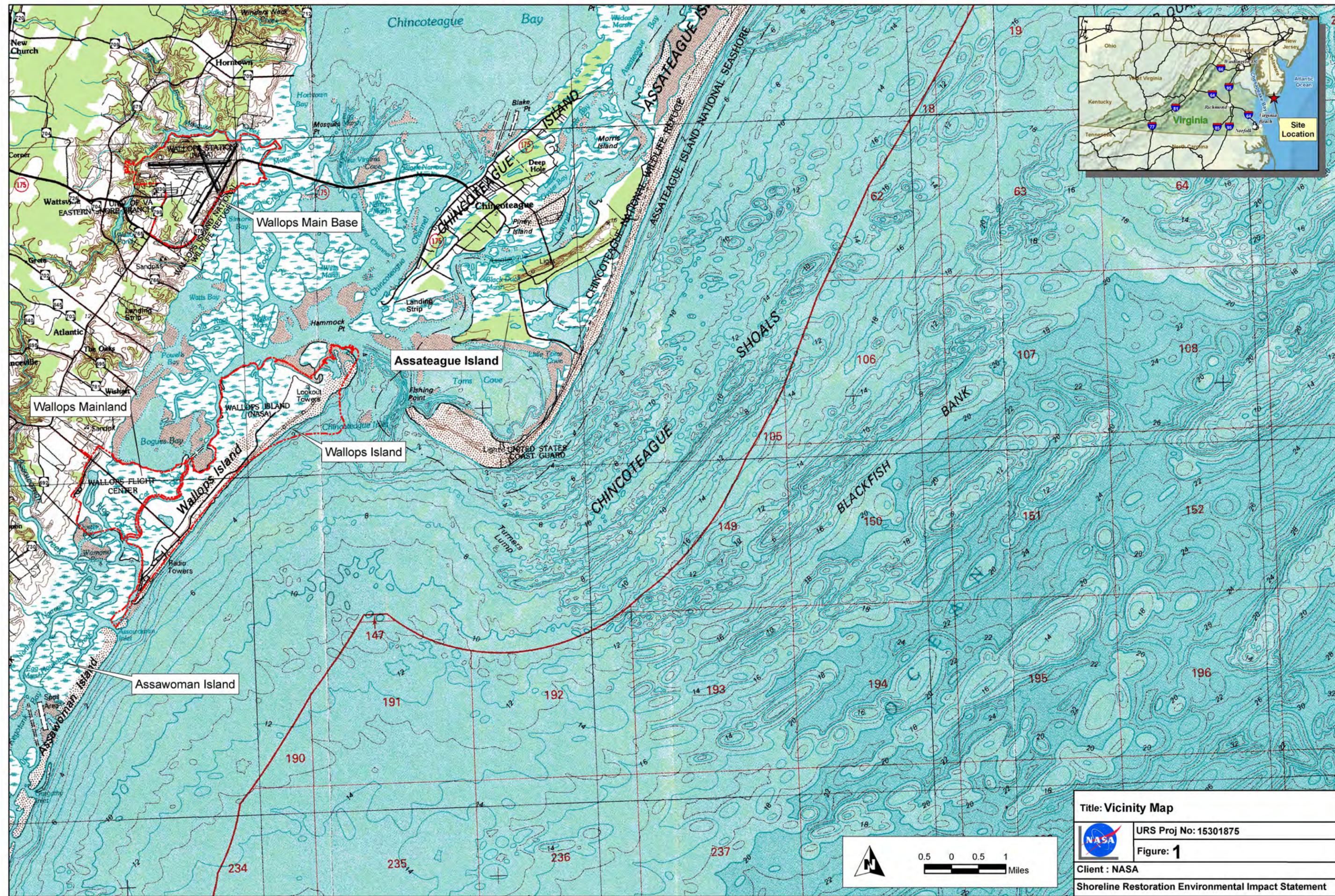
During its early history, the mission of the GSFC's WFF was primarily to serve as a test site for aerospace technology experiments. Over the last several decades, the WFF mission has evolved toward a focus of supporting scientific research through carrier systems (i.e., airplanes, balloons, rockets, and uninhabited aerial systems [UAS]) and mission services. WFF is a NASA facility under the management of GSFC. NASA is the land owner with multiple tenants, including the U.S. Navy, U.S. Coast Guard (USCG), Mid-Atlantic Regional Spaceport (MARS), and the National Oceanic and Atmospheric Administration (NOAA). Each tenant partially relies on NASA for institutional and programmatic services, but also has its own missions. WFF is a fully capable launch range for rockets and scientific balloons, and includes a research airport. In addition, WFF personnel provide mobile range capabilities, range instrumentation engineering, range safety, flight hardware engineering, and mission operations support to a variety of civil, defense, and academic customers.

1.2.2 Environmental Management System

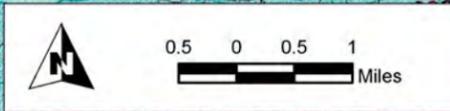
NASA is committed to carrying out its research and projects at WFF in an environmentally sustainable manner. The Wallops Environmental Office (Code 250) ensures that the facility obtains the appropriate environmental permits, prepares documentation for compliance with NEPA and other environmental regulations and EOs, conducts employee and supervisor training, and implements the facility's Environmental Management System (EMS). WFF's EMS is a coherent, integrated approach to environmental management. WFF manages environmental risks through the application of the WFF EMS, which covers such topics as pollution prevention, energy and water management, maintenance of natural (green) infrastructure, and sustainable building practices.

1.2.3 Site Location

WFF is located in the northeastern portion of Accomack County, VA, on the Delmarva Peninsula, and is comprised of the Main Base, Wallops Mainland, and Wallops Island (Figure 1).



Title: Vicinity Map	
	URS Proj No: 15301875
	Figure: 1
Client : NASA	
Shoreline Restoration Environmental Impact Statement	



This page intentionally left blank.

Wallops Island is bounded by the Chincoteague Inlet to the north, the Assawoman Inlet to the south (which is presently filled in), the Atlantic Ocean to the east, and estuaries to the west.

1.2.4 Facilities, Tenants, and On-Site Organizations at Wallops Island

The facilities on Wallops Island are shown on Figure 2 and described below.

1.2.4.1 *Tenants and On-Site Organizations*

NASA has several tenants and customers that use the WFF range, its facilities, and airspace. Two of these tenants, the U.S. Navy and MARS, have facilities on Wallops Island that are at risk from storm damages, which would be reduced by the Proposed Action. The activities of these tenants are described below.

U.S. Navy Surface Combat Systems Center

The U.S. Navy Surface Combat Systems Center (SCSC) is WFF's largest partner. The SCSC's mission is to "provide live integrated warfare systems in a maritime environment for fleet operations, testing, evaluation, training, research and development," and its vision is to be "the premier maritime proving ground for fielding and sustainment of joint, combined, and coalition capabilities in support of national interests." There are no alternative land-based sites for performing many of the mission roles assigned to SCSC. SCSC provides a maritime test environment, operational team, and combat systems of high fidelity to conduct realistic test events in support of Lifetime Support Engineering activities and the upgrade of tactical computer programs. SCSC provides key services for performing systems developmental and operational tests and for research & development of potential system upgrades in all areas of detection, control, and engagement. The SCSC Wallops Island location provides the best value to the U.S. Navy for testing and support of deployed surface combat systems, advanced systems under development, and warfare systems integration (such as systems planned for deployment aboard U.S. Navy ship programs).

Wallops Island is home to the unique replica of an AEGIS cruiser and its destroyer combat systems, as well as the experimental radar deck of the DDG 1000 class destroyer. These systems are used to train naval officers and enlisted personnel in the operation and maintenance of sophisticated equipment used by the fleet onboard their AEGIS cruisers and destroyers. The systems are also used to test concepts and solve operational problems.

Other technical missions include lifetime support engineering, in-service engineering, systems level operations, and maintenance training. The SCSC supports the AEGIS Training Unit by providing equipment on which replacement crew training is held. The U.S. Navy Ship Self Defense System Facility on Wallops Island conducts research, development, testing, and evaluation elements of shipboard systems, integration, and demonstrations of new shipboard systems. WFF also provides missile launch support for the U.S. Navy. Drone vehicles are used for target tracking and are engaged by both the AEGIS facility and operational naval forces.

Mid-Atlantic Regional Spaceport

The Virginia Commercial Space Flight Authority is responsible for the development and operation of MARS, a Federal Aviation Administration (FAA)-licensed commercial spaceport on Wallops Island. MARS currently provides launch support services and facilities to NASA, the U.S. Department of Defense's Defense Advanced Research Projects Agency, the U.S. Air Force,

Mission, Purpose and Need, Background Information

and commercial and academic users. MARS is a full-service spaceport, offering two FAA licensed launch pads as well as access to three suborbital rail launchers, vehicle/payload storage, processing and launch facilities, a Federal launch range and experienced space technicians and engineers.

MARS' mission is to develop and operate a multi-user spaceport at WFF that provides low-cost, safe, reliable, "schedule friendly" space access for commercial, government, and academic users (MARS, 2008). MARS operates the orbital Launch Complex 0, which includes launch pads 0-A and 0-B, and provides facilities and services for commercial launches of payloads into space.

NASA and MARS are currently constructing new facilities on Wallops Island to support launching of orbital rockets from Pad 0-A that will carry payloads to the International Space Station beginning in calendar year 2011. These facilities include: a Liquid Fueling Facility, launch ramp, and rocket mount at Pad 0-A; a Horizontal Integration Facility that will support the pre-flight processing, horizontal integration, and preparation of launch vehicles and payloads; a Payload Fueling Facility; a Payload Processing Facility; and transportation infrastructure improvements.

1.2.4.2 Location of Facilities

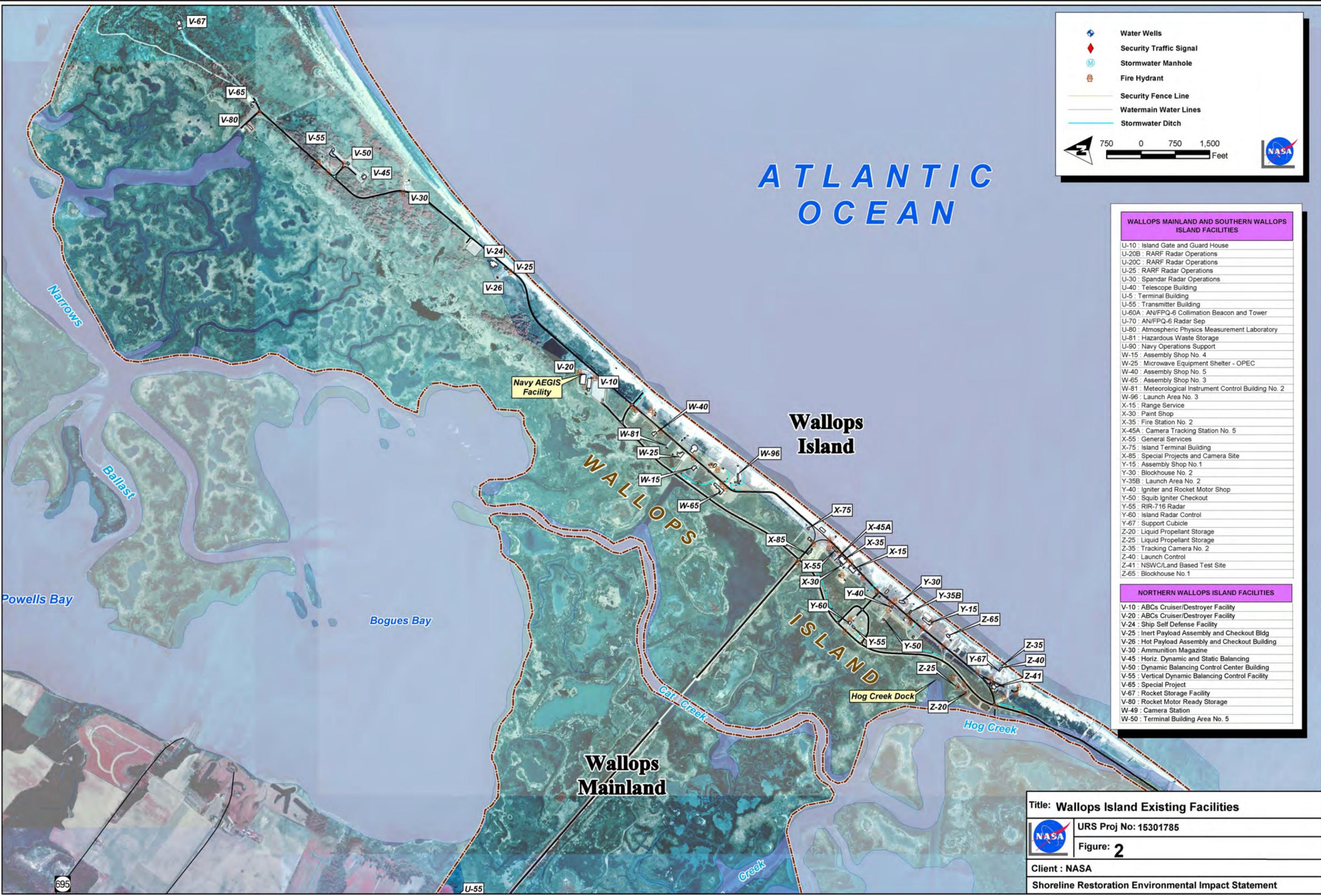
Multiple constraints to siting at WFF limit the development of new facilities and infrastructure. These constraints include current land use (potential for conflict with known or reasonably foreseeable mission-related uses), interference with communications and radar, established hazard arcs surrounding some buildings and launch areas, and sensitive resources such as wetlands and cultural resources.

Of approximately 50 NASA buildings on Wallops Island, two can be considered administrative in nature; these buildings house a small number of employees, all of whom are associated with the day-to-day upkeep and coordination of Wallops Island's launch support assets. The U.S. Navy's facilities on Wallops Island, although not directly associated with launch operations, were originally sited immediately on the ocean as they must routinely interact with ships at sea and train sailors in a real-time maritime environment.

The primary function of most buildings on Wallops Island is to enable operations leading up to, during, and following the execution of a flight. The launch pad is the core of the launch range infrastructure and is characteristically the most difficult to site because it is the location at which the most hazardous operations take place. Launch support structures are generally built as close to the launch pad as possible, because 1) the systems they house (e.g., high speed cameras, noise level monitors, etc.) must be close to the pad to effectively collect data and 2) to provide the shortest travel distance once the launch vehicle and spacecraft are ready to be transported to the pad for final pre-launch preparations.

The facilities on Wallops Island are grouped geographically and are described below.

North Wallops Island: Solid-propellant rocket motors, which are both a fire and explosive hazard, are stored on the north end of Wallops Island, so in the event of a mishap, it would have minimal impact on the public or employees on Wallops Island. Spacecraft fueling and processing facilities, which are the primary locations for handling toxic and flammable propellants, are proposed for this remote area for the same reason.



ATLANTIC OCEAN

WALLOPS MAINLAND AND SOUTHERN WALLOPS ISLAND FACILITIES

- U-10 : Island Gate and Guard House
- U-20B : RARF Radar Operations
- U-20C : RARF Radar Operations
- U-25 : RARF Radar Operations
- U-30 : Spandar Radar Operations
- U-40 : Telescope Building
- U-5 : Terminal Building
- U-55 : Transmitter Building
- U-60A : AN/FPQ-6 Collimation Beacon and Tower
- U-70 : AN/FPQ-6 Radar Sep
- U-80 : Atmospheric Physics Measurement Laboratory
- U-81 : Hazardous Waste Storage
- U-90 : Navy Operations Support
- W-15 : Assembly Shop No. 4
- W-25 : Microwave Equipment Shelter - OPEC
- W-40 : Assembly Shop No. 5
- W-65 : Assembly Shop No. 3
- W-81 : Meteorological Instrument Control Building No. 2
- W-96 : Launch Area No. 3
- X-15 : Range Service
- X-30 : Paint Shop
- X-35 : Fire Station No. 2
- X-45A : Camera Tracking Station No. 5
- X-55 : General Services
- X-75 : Island Terminal Building
- X-85 : Special Projects and Camera Site
- Y-15 : Assembly Shop No. 1
- Y-30 : Blockhouse No. 2
- Y-35B : Launch Area No. 2
- Y-40 : Igniter and Rocket Motor Shop
- Y-50 : Squib Igniter Checkout
- Y-55 : RIR-716 Radar
- Y-60 : Island Radar Control
- Y-67 : Support Cubicle
- Z-20 : Liquid Propellant Storage
- Z-25 : Liquid Propellant Storage
- Z-35 : Tracking Camera No. 2
- Z-40 : Launch Control
- Z-41 : NSWC/Land Based Test Site
- Z-65 : Blockhouse No. 1

NORTHERN WALLOPS ISLAND FACILITIES

- V-10 : ABCs Cruiser/Destroyer Facility
- V-20 : ABCs Cruiser/Destroyer Facility
- V-24 : Ship Self Defense Facility
- V-25 : Inert Payload Assembly and Checkout Bldg
- V-26 : Hot Payload Assembly and Checkout Building
- V-30 : Ammunition Magazine
- V-45 : Horiz. Dynamic and Static Balancing
- V-50 : Dynamic Balancing Control Center Building
- V-55 : Vertical Dynamic Balancing Control Facility
- V-65 : Special Project
- V-67 : Rocket Storage Facility
- V-80 : Rocket Motor Ready Storage
- W-49 : Camera Station
- W-50 : Terminal Building Area No. 5

Title: Wallops Island Existing Facilities

URS Proj No: 15301785

Figure: 2

Client : NASA

Shoreline Restoration Environmental Impact Statement

This page intentionally left blank.

Central Wallops Island: Central Wallops Island contains the U.S. Navy's ship training facilities, storage and assembly buildings, and the launch blockhouses. This mid-island area typically contains the least hazardous of operations, and is the most densely populated by employees supporting the U.S. Navy's SCSC.

South Wallops Island: The south end of Wallops Island contains WFF's launch pads, additional hazardous materials storage areas, and the facility's UAS runway. Currently, there are three sounding rocket pads operated by NASA and two orbital pads operated by MARS. These pads are located on south Wallops Island to minimize potential impacts to Chincoteague, Accomack County's most populated town and home to its busiest commercial fishing route (Chincoteague Inlet and Channel).

1.2.5 Shoreline Erosion and Past Erosion Reduction Measures at Wallops Island

Wallops Island was subject to the effects of shoreline retreat well before NASA's presence was established on the island in the 1940s. Between 1857 and 1994, the southern part of Wallops Island retreated approximately 400 m (1,300 ft). The ocean has encroached substantially toward launch pads, infrastructure, and test and training facilities belonging to NASA, the U.S. Navy, and MARS (see Figure 3). Photo 1 below shows the extent of shoreline retreat from 1991 to 2005. Assawoman Island to the south has been impacted even more, with a shoreline retreat rate between 4.9 and 5.2 m (16 and 17 ft) per year.

Photo 1: 1991 aerial photo of Wallops Island showing 2005 extent of shoreline erosion



Mission, Purpose and Need, Background Information

Since the 1960s, NASA has made several attempts to keep sand on the Wallops Island beach and prevent shoreline retreat. Various measures such as wooden groins, construction of a stone seawall, temporary geotextile tubes (long cylinders of durable textile material that are filled with sand – see Figure 4), and others have been installed along the shoreline to slow the transportation of sand off the beach and help protect onshore assets from wave action.

Photo 2 shows the wooden groins NASA installed in the early 1960s and 1970s. These groins were almost completely gone by the mid-1980s; their failure has been linked to the lack of a beach fill at the time of construction, along with the lack of a regular monitoring and maintenance program and renourishment plan.

Photo 2: 1983 view looking north along Wallops Island showing wood groins (in poor condition) – the southernmost groins in this photo are approximately 100 m (330 ft) long



In 1992, NASA obtained permits to construct an approximate 4,840-m (15,900-ft) rock seawall along the center of the island where the majority of infrastructure is located (see Figure 3). The seawall was thought to be a solution to the high rate of shoreline retreat and currently provides protection from storm surge. The seawall has provided substantial protection to the island's infrastructure. Although this structure has halted the shoreline retreat, wave action continually scours and undercuts the seafloor at the base of the seawall and has left the seawall vulnerable to storm damage. The seawall has deteriorated due to settling and dislodgement of armor stone. In addition, the structure is highly permeable due to large voids; these voids allow scouring on the landward side, and additional sand loss. Because of shoreline retreat, an approximately 3.7-kilometer (km) (2.3-mile [mi]) portion of the seawall currently fronts directly on the ocean with waves continually breaking on it.



U.S. Navy AEGIS Facility

W-20: Blockhouse/
Launch Control Center

Horizontal Integration Facility (HIF)

Y-039 HAD 8K Launcher

Y-035B ARC 12K Launcher

Existing Rock
Seawall

Z-071 50K Pad 1 Launcher

Launch Pad A

Geotextile
Tubes

Launch Pad B



Title: Wallops Island Viewed from the South	
	URS Proj No:15301785
Figure: 3	
Client : NASA	
Shoreline Restoration Environmental Impact Statement	

This page intentionally left blank.

Mission, Purpose and Need, Background Information

The structures placed on Wallops Island in the past, including the seawall, have reduced the effect of overwash processes. Overwash is the flow of water and sediment over a beach crest that does not directly return to the ocean. Overwash maintains beach and dune systems, is a form of coastal flooding that can move sediment landward, and is a precursor to barrier breaching. It is a regional and recurring natural process responsible for large-scale coastal change in low-profile coastal areas, and is an integral part of the sediment budget in such areas (USACE, 2004). When coastal structures prevent overwash, beach sediment in front of them can be transported offshore during storms causing the island to narrow; however, if overwash is allowed to occur, the net volume of sand is often maintained and the island migrates landward (Donnelly et al., 2006).

In 2007, NASA installed geotextile tubes (Figure 4) along the shoreline as an emergency measure to slow down the transport of sand off the beach and help protect onshore assets from wave action. Despite these efforts, the ocean has continued to encroach substantially toward the infrastructure on Wallops Island. In mid-November 2009, Hurricane Ida combined with a coastal storm to produce a nor'easter (commonly referred to as "Nor'Ida") with winds peaking at 95 km per hour (59 mi per hour) at Wallops Island (NOAA, 2009c). The storm caused island flooding and substantial damage to the geotextile tubes (Photo 3). Following the Nor'Ida storm, NASA installed an additional 730 m (2,400 ft) of geotextile tubes to replace a portion of those that were damaged until a more long-term solution can be implemented.

Photo 3: Damage to the south end of Wallops Island caused by the November 2009 Nor'easter



Mission, Purpose and Need, Background Information

Reducing storm damage has always been a formidable component of maintaining facilities on Wallops Island. Moreover, looking toward the future, as sea-level rises and climate change increases the magnitude of storms (IPCC, 2007), the vulnerability of the Wallops Island shoreline to storm waves and erosion will continue to be a challenge for NASA and its partners.

1.2.6 The Coastal Sand Transport System

Wallops Island is part of a 200-km-long (125-mi-long) chain of coastal barrier islands that stretches from Fenwick Island, on the Maryland-Delaware border, to Fisherman's Island at the mouth of the Chesapeake Bay. Beach sand is driven alternately in either direction along the shore as well as offshore or onshore by the combined action of ocean waves, longshore currents, and tidal currents along this system. Evidence from the shape of the shorelines and other landform features in the region indicates that there is a clearly defined overall net direction to this sand transport that is from the north to the south. However, due to Wallops Island's location directly south of Fishing Point, sand transport within the SRIPP project area is generally from south to north.

The numerous tidal inlets along the Maryland and Virginia coastal island chain locally disrupt this coastal sand transport system but, in general, the sand works its way across these interruptions in the north-to-south direction. At any given time, the rate of longshore sand transport can be much higher or lower and either to the north or south depending on whether storm or calm conditions prevail. The sum of these short-term transports is called the gross rate and it is about an order of magnitude greater than the net southward rate.

The longshore transport of sand in this coastal system also varies considerably with location due to changes in shoreline orientation, proximity of a tidal inlet, and the amount of local sand storage in dunes and nearshore sand bars. Areas of chronic beach erosion generally correspond to places where there is a relative shortage of longshore sediment coming into the zone compared to that which is transported out. This process makes it essential to understand the details of the local and regional sand transport patterns to design effective beach erosion control measures.

Although the geomorphological features and numerous local studies indicate that the regional sand transport is to the south (Shepard and Wanless, 1971) the patterns on Wallops Island and adjoining shores is more complicated. A more detailed description of the patterns of sand transport on the island is provided in Section 3.1.5.4 (Longshore Sediment Transport).

1.3 PURPOSE AND NEED FOR THE PROPOSED ACTION

1.3.1 Purpose

The purpose of the Proposed Action is to reduce the potential for damage to, or loss of, NASA, U.S. Navy, and MARS assets on Wallops Island from wave impacts associated with storm events.



Title: Aerial of Geotubes and Old Groin Point	
	URS Proj No:15301785
	Figure: 4
Client : NASA	
Shoreline Restoration Environmental Impact Statement	

This page intentionally left blank.

The BOEMRE and the USACE, as cooperating Federal agencies, are each undertaking a “connected action” (40 CFR 1508.25) that is related, but unique from NASA’s proposed action, the construction of the project. The purpose of BOEMRE’s proposed action is to authorize use of OCS sand resources in beach nourishment and coastal restoration projects undertaken by Federal, State or local government agencies, and/or in other federally authorized construction projects. The purpose of USACE’s proposed action is to authorize the discharge of fill material into waters of the U.S. under Section 404 of the CWA and to authorize work in U.S. navigable waters under Section 10 of the RHA.

1.3.2 Need

The Proposed Action is needed to ensure the continued ability of NASA, the U.S. Navy, and MARS to serve the Nation’s rapidly growing civil, defense, academic, and commercial aerospace requirements. WFF and MARS are located within the only research range in the United States that is wholly controlled by NASA, and as a result, WFF is the only research range in the world that is solely under NASA control and focused on NASA’s schedule, budget, and mission objectives. Under Title II of the Omnibus Appropriations Act of 2009 (Public Law 111-8), the U.S. Congress stated that “WFF is an important national asset that can be better utilized by focusing on emerging technologies that meet national needs and NASA priorities.”

Wallops Island has experienced shoreline changes throughout the six decades that NASA has occupied the site. The existing seawall is being undermined because there is little or no protective sand beach remaining and storm waves break directly on the rocks. Currently, the south end of the island is unprotected except for a low revetment around the MARS launch pad and temporary geotextile tubes that extend from the southern end of the existing seawall south to camera stand Z-100 (shown in Photo 1).

At the present time, assets on Wallops Island are valued at over \$1 billion. The NASA facilities at greatest risk are the south UAS Runway and the Launch Control Center (building W-20), both located within 30 m (100 ft) of the shoreline, and all three sounding rocket launch pads, which are approximately 75 m (250 ft) from the shoreline (Figure 3). U.S. Navy assets at greatest risk include the AEGIS and Ship Self Defense System Facilities, also shown on Figure 3. MARS Launch Pads 0-A and 0-B are located within 75 m (250 ft) of the shoreline, and are also at a high level of risk (Figure 3).

The potential risks to infrastructure from wave impacts (that will only be exacerbated by sea-level rise) are two-fold: first is the interruption of NASA, U.S. Navy, and MARS missions supported from Wallops Island facilities due to temporary loss of facility functions; and second is the potential for complete loss of these unique facilities. If no protective measures are taken, the assets on Wallops Island will be increasingly at risk from even moderate storm events. According to a study by Komar and Allan (2008), wave heights have gradually increased over a 30-year period and are expected to continue to increase. This is believed to be associated with the rise in frequency and intensification of storm events.

The BOEMRE and USACE proposed actions are needed to fulfill each agency’s jurisdictional responsibilities under the OCS Lands Act and the CWA and RHA, respectively.

Mission, Purpose and Need, Background Information

1.4 ADAPTIVE DESIGN AND MANAGEMENT STRATEGY

In spite of considerable recent advancements in the fields of coastal engineering and coastal geomorphology, the ability to predict changes in coastal morphology over long time intervals (decades) and large scales (tens of kilometers/miles) remains limited. A major portion of this uncertainty comes from the variability of weather patterns during both ordinary and storm conditions. Consequently, it is prudent to recognize these limitations by providing a project design that can be modified over time so that it can continue to successfully accomplish its goal as unpredicted changes occur. This, in turn, requires an active long-term management strategy that utilizes a suitable monitoring program to detect developments as they approach a problematic state. With adaptive design, alternative measures that have been previously planned can be adapted or constructed at the time that they become necessary.

The SRIPP incorporates an adaptive design and management strategy that is defined by a range of alternatives explained in this PEIS with the understanding that one alternative is preferred as the initial action, but elements of the other alternatives may be adopted in the future if the monitoring program reveals them to be necessary. Alternatives presented in this PEIS are based on current conditions and knowledge of design and resources; however, as more information becomes available through monitoring, NASA would further evaluate its strategy for storm damage reduction measures.

1.5 SCOPE OF THIS PROGRAMMATIC ENVIRONMENTAL IMPACT STATEMENT

Both CEQ and NASA NEPA regulations allow the preparation of NEPA documents for broad actions, such as agency programs and sets of related or similar actions. Broad actions can often be grouped by geographic location; relevant similarities; and state of technical development. These NEPA documents are referred to as “Programmatic,” and are often broad in scope, and may be followed by more site- or action-specific documents as appropriate. This approach, referred to as “tiering,” can be compared to a funnel, with the broader, Programmatic NEPA document at the top, with the more focused documents below it.

This PEIS covers a 50-year planning horizon. Despite the programmatic nature of this document, NASA has included detailed information on the three Proposed Action Alternatives that it is considering for the SRIPP. Given the severity of shoreline erosion at Wallops Island and WFF’s vulnerability to storms, it is imperative that a storm damage reduction project be implemented as soon as possible. As a result, this PEIS includes such detail as structure dimensions and locations so that the selected alternative could be implemented and permitted without the need for additional NEPA documentation. In addition to structure dimensions and locations, this information includes beach fill volumes, dredging locations, and dredging operations. Proposed sand retention structures have been modeled and potential impacts evaluated at specific locations within the project area based on current conditions at Wallops Island. Utilizing an adaptive management approach, NASA would evaluate future actions that may include variations of the alternatives evaluated in this PEIS.

Future tiered NEPA documents may be prepared for specific actions (i.e., renourishment cycles) related to the SRIPP. Additionally, due to the variability and unpredictability of the open ocean environment, and through its monitoring efforts, NASA may identify additional storm damage reduction measures that are not analyzed in this PEIS. As such, NASA would supplement this PEIS in the future to consider the effects of these alternatives prior to their implementation.

CHAPTER TWO: DESCRIPTION AND COMPARISON OF ALTERNATIVES

This chapter presents the range of alternatives that were considered to meet the purpose and need of the project.

Several studies have been conducted at Wallops Island to evaluate the effectiveness of previous shoreline protection efforts, to model sediment transport conditions, to conduct site assessments of existing conditions, and to recommend methods for shoreline restoration. The studies include:

- 1986 Wallops Island Shore Protection Study (Moffatt & Nichol)
- 1987 Shore Protection Alternatives (Moffatt & Nichol)
- 1989 Study of Wallops Island Seawall Repair Alternatives Phase B (Moffatt & Nichol)
- 1992 Wallops Island Shoreline Evolution Modeling Study (Moffatt & Nichol)
- 1998 Wallops Island Seawall Study (Moffatt & Nichol)
- 1999 USACE Engineering Research and Development Center and USACE, Norfolk District investigation
- 2006 Beach Erosion Mitigation and Sediment Management Alternatives at Wallops Island, VA (USACE)
- 2007–2009 USACE, Norfolk District, evaluation of potential SRIPP alternatives
- 2010 Storm Damage Reduction Project Design Report for Wallops Island, Virginia (USACE Research and Development Center and USACE Norfolk District; Appendix A of this PEIS)

The 2006 report evaluated four levels of shore protection scenarios: 1) no project, 2) no new project but continued minor maintenance to existing seawall, 3) project with restricted initial construction budget (primarily beach fill), and 4) optimum project (sand retention structures combined with beach fill).

Based on the recommendations in the 2006 report, the USACE further evaluated existing conditions at Wallops Island and provided a range of alternatives considered technically and economically feasible. This range of initial alternatives was screened to determine which would be carried forward. The alternatives that passed the initial screening—extension of the seawall, beach fill only, or beach fill combined with sand retention structures (groin or breakwater)—were then evaluated by USACE in more detail. A variety of detailed options for implementing beach fill and sand retention structures were then combined, resulting in 54 different potential alternatives, all of which included extension of the seawall. From these 54 alternatives, NASA and the USACE conducted a secondary screening analysis that resulted in the final three Proposed Action Alternatives carried forward for a full evaluation in this PEIS.

2.1 OVERVIEW OF PROPOSED ACTION

NASA's Proposed Action is intended to use a multi-tiered approach to reduce damages to Wallops Island facilities from ongoing beach erosion and storm waves incurred during normal coastal storms and nor'easters. NASA would initiate a 50-year program with an initial

Description and Comparison of Alternatives

construction phase and subsequent renourishment/maintenance cycles that would be determined through monitoring and adaptive management.

The goal of the Proposed Action is to move the zone of breaking waves well away from vulnerable infrastructure. This plan is not intended to protect against inundation and other impacts during major hurricanes and exceptional nor'easters, when water levels can rise several meters/feet. The SRIPP is also not intended to protect infrastructure from flooding, which occurs both from the estuaries west of Wallops Island and from waves overtopping the existing beach and seawall. Since it began its operations on Wallops Island in the mid-1940s, NASA and its tenants have implemented flood damage reduction measures such as elevating critical structures above Federal Emergency Management Agency (FEMA) flood levels (3.6 m [11 ft] above mean sea level [amsl]) and not storing equipment or materials on first floors that are not elevated or otherwise protected. Under all of the alternatives considered in this PEIS, NASA would continue to implement such mitigation measures as necessary to provide storm damage reduction from flooding.

A project's design life is most commonly selected on the basis of project costs and cost effectiveness. The Handbook of Coastal Engineering (Herbich, 2000), which was utilized by the USACE in the design methodology of the SRIPP, was the basis for establishing the 50-year project design life. The 50-year project life cycle is employed by the USACE when designing projects that protect infrastructure against wave-induced damages. The life cycle analysis requires that projects be analyzed in terms of cost of repair, periodic replacements, and rehabilitation (Herbich, 2000). Large coastal engineering projects are often designed based on an optimized approach in which a balance is obtained between initial construction costs and the maintenance costs associated with storm-induced damages.

Because the SRIPP encompasses a 50-year planning horizon, effectiveness of storm damage reduction measures would be evaluated on a regular basis through a monitoring program. Monitoring would assess shoreline changes and the level of storm damage reduction provided by the SRIPP. A monitoring program of the shoreline would include both beach and nearshore surveys to assess shoreline changes. Pre- and post-dredging surveys would be conducted at the borrow site(s) to assess morphological changes of the shoals. The monitoring results would be reviewed and the project planning modified as needed for the SRIPP to remain effective in reducing storm damages to Wallops Island infrastructure. In addition, the monitoring plan itself would be modified as needed (i.e., frequency of surveys) to provide adequate information to make informed decisions.

NASA, as with all Federal agencies, is subject to appropriations from Congress, so there is no guarantee that the project would be continually funded over the 50-year planning horizon. However, for its 2012 construction of facilities budget, the SRIPP was NASA's highest priority project. Given this commitment, and the growing need for WFF to assume a larger role in enabling NASA's mission, the agency would continue to advocate for long-term project funding. If funding for future SRIPP actions was not available, NASA would re-evaluate existing conditions and determine appropriate actions at that time.

2.2 DESCRIPTION OF RANGE OF ALTERNATIVES CONSIDERED

The Proposed Action is to implement a 50-year program to allow NASA and its partners to continue to safely utilize Wallops Island and complete their missions with a reduced threat of

storm-related loss of facilities. NASA considered a range of alternatives to meet the purpose and need; each of the alternatives listed below is discussed in this section.

- Relocating At-Risk Infrastructure
- Seawall Extension Only
- Sand Dunes With Various Cores
- Beach Fill Only
- Beach Fill and Seawall Extension
- Beach Fill, Seawall Extension, and Sand Retention Structures
- No Action

2.2.1 Relocating At-Risk Infrastructure

This alternative would involve moving critical infrastructure on Wallops Island (including launch pads) farther inland to a nearby location less susceptible to storm damage. This alternative included an evaluation of the existing conditions including an inventory and assessment of the functions of Wallops Island facilities, safety considerations, interrelationship among Wallops Island, Wallops Mainland, and Main Base facilities, and multiple mission support with the existing facilities layout. Then NASA evaluated the same criteria based on a hypothetical move of Wallops Island's orbital launch pads to Wallops Mainland, approximately 3.5 kilometers (km) (2.2 miles [mi]) west of their current location. The analysis is described below.

2.2.1.1 Existing Conditions

Reason for Location of Facilities at Wallops Island

WFF's geographic location has been a critical factor in its continued ability to safely and successfully conduct science, technology, and educational flight projects aboard rockets, balloons, and UAS, using the Atlantic Ocean for operations on almost a daily basis. WFF's location immediately on the Atlantic Ocean, its controlled airspace above it, and its direct access to the Department of Defense-managed Virginia Capes (VACAPES) Operating Area (OPAREA) provide a unique ability for WFF to perform all aspects of its mission (e.g., testing unproven flight vehicles, handling explosive and toxic materials, etc.) that could not be done elsewhere.

As Wallops Island is the WFF landmass farthest away from the general public, it is also the safest part of WFF for hazardous operations. NASA's primary concern is limiting the risk of harm to private property, its employees, and the general public resulting from hazardous operations. Regarding public safety, one concept prevails: the farther the hazardous activity is from the general public, the smaller the risk of harm. NASA's safety policy is that such activities must be conducted as far away from the public as possible.

Safety Considerations

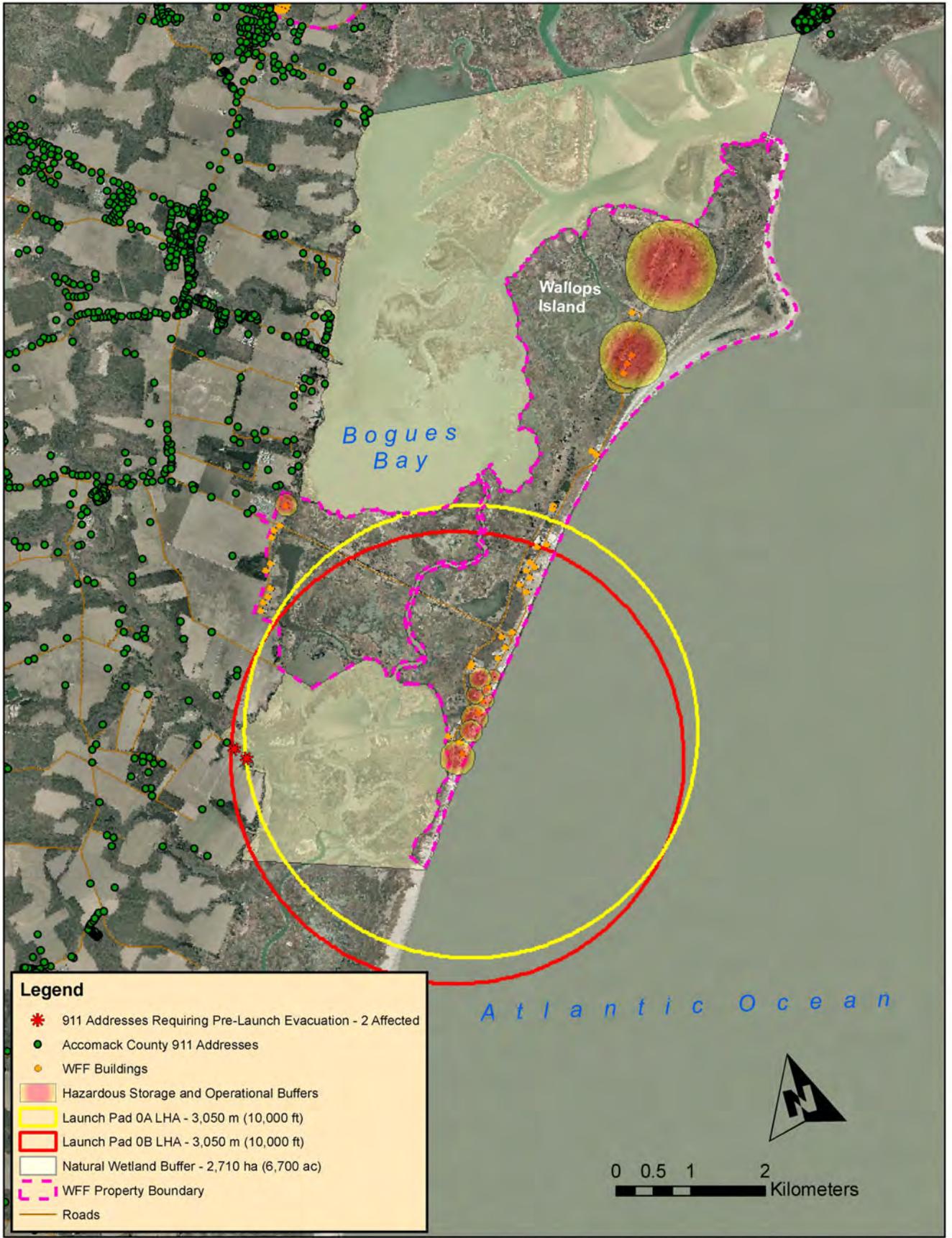
When a rocket is being prepared for launch, it possesses certain hazards based upon the types and quantities of explosive charges and propellants onboard. To ensure employee and public safety, an off-limits area is established as a radius around the pad. Only specially trained, mission-essential personnel are allowed within this off-limits area once established. This area is

Description and Comparison of Alternatives

commonly referred to as the Pre-Launch Danger Area (PLDA), and can range from several hundred feet for small weather rockets to more than 380 meters (m) (1,250 feet [ft]) for larger orbital rockets. A PLDA can be in effect as long as the hazard exists on the launch pad, but is typically established for several weeks preceding the launch.

Several hours prior to launch, a Launch Hazard Area (LHA) is established. The purpose of the LHA is to protect the general public from direct harm from the launch (i.e., debris from a rocket flying off course). These areas are sized based on the types and quantities of propellant onboard, rocket reliability, flight trajectory, and types of debris expected if the flight were terminated. The LHAs are considerably larger than PLDAs (Figure 5). LHAs can range in size from 380 m (1,250 ft) for small sounding rockets up to more than 3,050 m (10,000 ft) for larger orbital rockets. LHAs must be clear of people prior to launch; this is part of the go/no-go criteria during a launch countdown. The LHA typically requires evacuation several hours prior to launch until liftoff. Recent orbital launches have had several postponements when conditions do not permit a launch at the originally scheduled time. Postponed launches would require hazard area clearance at the next launch window until either the launch is completed or completely rescheduled.

In addition to the hazards presented by explosion or debris, other safety considerations include distance focused overpressure (DFO) and toxic materials dispersion. DFO is a term that refers to acoustical energy transferred through the atmosphere that would result from a rocket explosion, the primary hazard being injuries inflicted by shattered windows. Toxics include a variety of hazardous materials that could be transported through the atmosphere from either a normal or terminated flight, and may include rocket exhaust products such as hydrogen chloride and carbon monoxide (CO), or propellants such as hydrazines and oxides of nitrogen. The effects of DFO and toxic materials cannot be contained within a certain pre-defined hazard area as they are dictated by atmospheric conditions. As such, the effects of these hazards are analyzed real-time during launch countdown using industry accepted computer models. As the extent of potential hazards could change with the weather, the areas requiring clearance are also subject to change. To ensure maximum operational flexibility while also upholding NASA's rigorous safety standards during variable weather conditions, one concept prevails: the farther the hazardous activity is from the general public, the smaller the risk of harm. It is standing NASA safety policy that such activities must be conducted as absolutely far away from the public as possible. Figure 5 shows the current conditions and safety buffers including the PLDA, referred to as the "Pre-Launch Evacuation" on the figure. Under current conditions, assuming an LHA of 3,050 m (10,000 ft), two addresses would require evacuation prior to launching a large orbital rocket, such as Orbital Sciences Corporation's Minotaur V. Approximately 75 hectares (ha) (186 acres [ac]) of private lands are within the LHA, and 2,710 ha (6,700 ac) of uninhabited wetland buffer remains between Wallops Island and mainland residences.



Legend

- * 911 Addresses Requiring Pre-Launch Evacuation - 2 Affected
- Accomack County 911 Addresses
- WFF Buildings
- Hazardous Storage and Operational Buffers
- Launch Pad 0A LHA - 3,050 m (10,000 ft)
- Launch Pad 0B LHA - 3,050 m (10,000 ft)
- Natural Wetland Buffer - 2,710 ha (6,700 ac)
- WFF Property Boundary
- Roads

Title: Current WFF Layout and Impacts to Public	
	URS Proj No:15301785
Figure: 5	
Client : NASA	
Shoreline Restoration Environmental Impact Statement	

This page intentionally left blank.

Interrelationship among Facilities

In addition to safety considerations, facilities on Wallops Island have been sited to properly interface with facilities on WFF's Mainland and Main Base landmasses, and to support the necessary steps in preparing and launching a rocket. For example, Wallops Mainland infrastructure consists primarily of radar and telemetry systems that are sited specifically to be able to track and process information from rockets launched from Wallops Island. Main Base assets that support Wallops Island operations include the range control center and additional radar and telemetry systems. The location of Wallops Island infrastructure is directly linked to the placement of these range support assets; movement of Wallops Island infrastructure would result in the need to move these facilities as well.

Multiple Mission Support

The geographic locations of the facilities on Wallops Island allow them to support multiple launch operations at once. For example, hazardous storage facilities are located such that their location does not preclude fueling or processing and assembly. Fueling facilities are located such that operations on Wallops Island may continue while a fueling operation is taking place. Rocket launch pads are sited far enough apart to allow simultaneous pre-launch work to occur on multiple pads. To meet the required safety offsets, these facilities must be appropriately distant from one another. To meet both safety and mission needs, the assets on Wallops Island must remain in their same general configuration. When evaluating suitable launch sites to the west of Wallops Island, NASA considered these needs as firm requirements for continued ability to successfully carry out its mission.

Toxics Dispersion Hazards

NASA recently conducted a toxic dispersion hazards analysis for its Launch Range Expansion EA (NASA, 2009a)—this analysis is applicable to a facility relocation assessment because it can portray the potential effects of moving a current Wallops Island-based fueling facility to a different location. The WFF Range Safety Office predicted hazard areas ranging from 0.38 km (0.24 mi) to 1.47 km (0.91 mi) for a small release of toxics and up to 2.1 km (1.3 mi) to 5.1 km (3.2 mi) for a large release of toxics. Assuming a small release occurred within existing spacecraft fueling facilities on the north end Wallops Island, no addresses would be affected. Under worst-case existing conditions, a large release could affect up to 67 addresses.

2.2.1.2 Hypothetical Facility Relocation

Figure 6 shows a hypothetical scenario with the launch pads and support facilities moved to Wallops Mainland. To maintain the same general size and layout of the current facilities, 166 addresses would be displaced. Of these addresses, 26 would be within a hazardous storage and operational buffer. Eighty-seven addresses would be within a 3,050 m (10,000 ft) LHA and would require evacuation as part of go/no go criteria for a Minotaur V-type launch. 1,815 ha (4,480 ac) of private land would also be within the LHA, and 645 addresses would be within an area of equivalent size as the current unpopulated natural wetland buffer between Wallops Island and Mainland.

If the same small release of toxics described above under existing conditions occurred at a hypothetical fueling facility on Wallops Mainland, 24 addresses could be affected. Additionally,

Description and Comparison of Alternatives

a large release at the hypothetical location could result in up to 770 addresses potentially requiring evacuation or shelter if it occurred on Wallops Mainland.

2.2.2 Seawall Extension Only

Under this alternative, the seawall extension would be constructed on the beach parallel to the shoreline in the approximate location of the geotextile tubes shown on Figure 3. The new seawall would be constructed landward of the shoreline and would extend a minimum of 400 m (1,300 ft) up to a maximum of 1,400 m (4,600 ft) south of the existing seawall. The southern end of the 1,400 m (4,600 ft) extension would be at camera stand Z-100 (see Figure 4 for location of Z-100). The seawall extension would be constructed in this location because the infrastructure on this part of Wallops Island is relatively close to the shoreline and there are no long-term storm damage reduction measures currently in place.

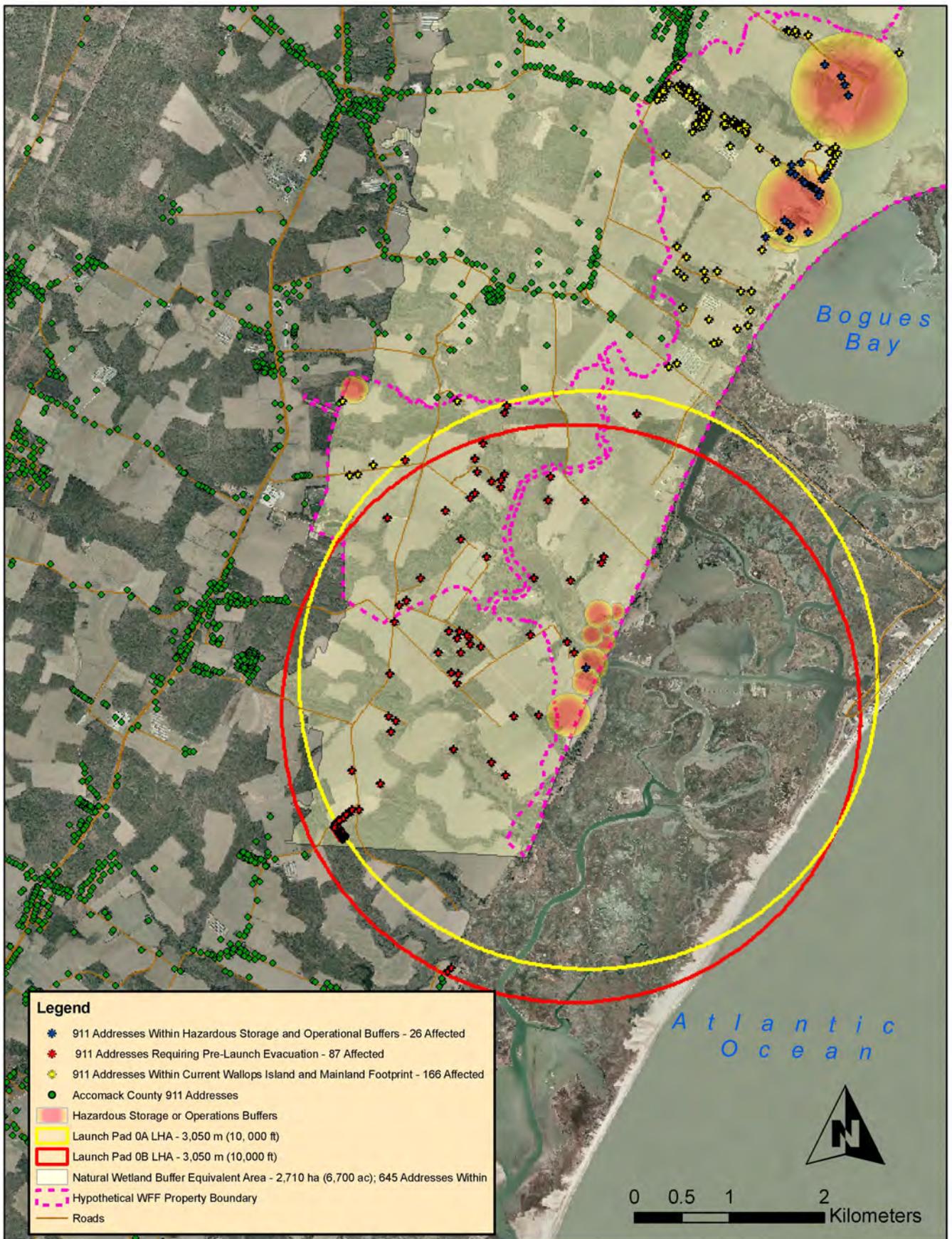
The seawall extension would consist of the placement of 4.5- to 6.4-metric-tonne (mt) (5- to 7-ton) rocks and would be constructed on a 1 to 1.5 slope. It would be placed in the beach, and the top of the seawall would be approximately 5 m (14 ft) above the normal high-tide water level after completion, depending on the extent of existing shoreline retreat at that time. The seawall would be designed to survive a 100-year storm event.

2.2.3 Sand Dunes with Various Cores

Under this alternative, NASA would create vegetated sand dunes with one of the following cores: rock core, semi-rigid geotextiles filled with rock or sand, or geotextile tubes filled with sand. The core would help stabilize and strengthen the dunes during larger than normal storm events. The sand dunes would be constructed parallel to the shoreline in the area of the existing seawall, and would utilize the existing seawall as a core material. Additionally, the sand dunes with various cores would be constructed on the beach parallel to the shoreline in the approximate location of geotextile tubes in Figure 3. The constructed dunes would extend 1,400 m (4,600 ft) from the southern end of the existing seawall.

2.2.4 Beach Fill Only

Beach fill (also referred to as beach nourishment) would involve removing sand from either upland, nearshore, or offshore borrow sites and placing the material onto the beach. Beaches serve as a natural function of the floodplain, allowing flood tides to spread over a large area to provide water storage and reduce wind and wave velocity impact to areas beyond the beach. Currently, there is no beach in front of the existing seawall along 4.6 km (2.9 mi) of the Wallops Island shoreline. Creating a beach would provide a shallow water surface for storm waves to break upon, thus reducing wave energy at the seawall (USACE, 2010a).



Title: Hypothetical WFF Mainland Layout and Impacts to Public



URS Proj No:15301785

Figure: 6

Client : NASA

Shoreline Restoration Environmental Impact Statement

This page intentionally left blank.

Initial nourishment would occur, followed by periodic renourishment of sand as the beach erodes. The timing of the renourishment cycles would vary depending on the frequency and magnitude of storm events. The beach fill would be designed to withstand a 30-year storm event. During storm events, a portion of the new beach would provide a surface to dissipate wave energy as well as add sediment to the nearshore system. This design would allow the existing beach and shoreline to remain relatively protected in larger storm events while the new beach fill is sacrificed. The beach fill would start approximately 460 m (1,500 ft) north of the Wallops Island-Assawoman Island property boundary (near camera stand Z-100 shown on Figure 4) and extend north for 6.0 km (3.7 mi).

2.2.5 Beach Fill and Seawall Extension

This alternative would be a combination of the beach fill and seawall extension alternatives described above. This alternative would provide a multi-tiered defense against storm damage. The beach fill would provide the majority of protection against smaller, more common storms. The rock seawall would provide wave damage reduction against the largest storms expected over the lifetime of the project. The seawall would reduce potential wave heights; however, flooding would still result in minor damages to infrastructure from both water overtopping the seawall and from the marsh/wetland areas on west side of Wallops Island.

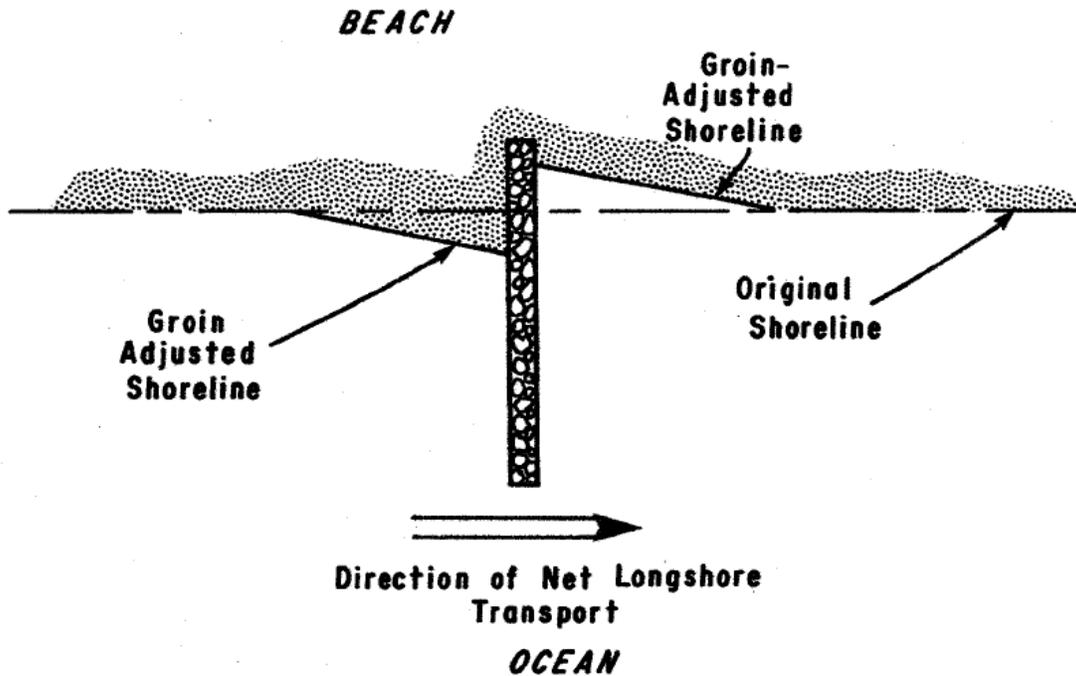
2.2.6 Beach Fill, Seawall Extension and Sand Retention Structures

This alternative would be a combination of the beach fill and seawall extension alternative described above, with the addition of sand retention structures. Beach fill could be combined with one or more sand retention structures. The USACE 2006 report concluded that the optimal “engineering solution that would mitigate the ongoing erosion and loss of sand from Wallops Island and protect against the disruption to operations and potential damage to infrastructure caused by ordinary storms and northeasters” is implementation of beach fill along with sand retention structures. The 2006 report stated, “The purpose of the sand-retention structures is to provide additional reduction of damages from storm waves and reduce the volumes of sand needed for maintenance renourishing compared to placing fill alone” (USACE, 2006). Sand retention structure options are described below.

Groins

Groins are structures built from the shoreline out into the ocean and perpendicular to the beach. A groin functions by slowing the littoral currents to a point where suspended sediment drops out of the water column and accumulates on the updrift side of the structure (Figure 7). Groin structures would be semi-permanent in nature and could be removed if necessary.

The installation of groins can temporarily interrupt longshore transport patterns, and may lead to some shoreline erosion on the downdrift beach. The extent of the erosion depends on the geometry of the groin field and the local longshore transport rates. Eventually, the groin field will saturate with sand and the previous transport rates will be recovered and the downdrift beach will stop eroding. Renourishing the beach in conjunction with a groin or groin field can reduce the potential for downdrift erosion.

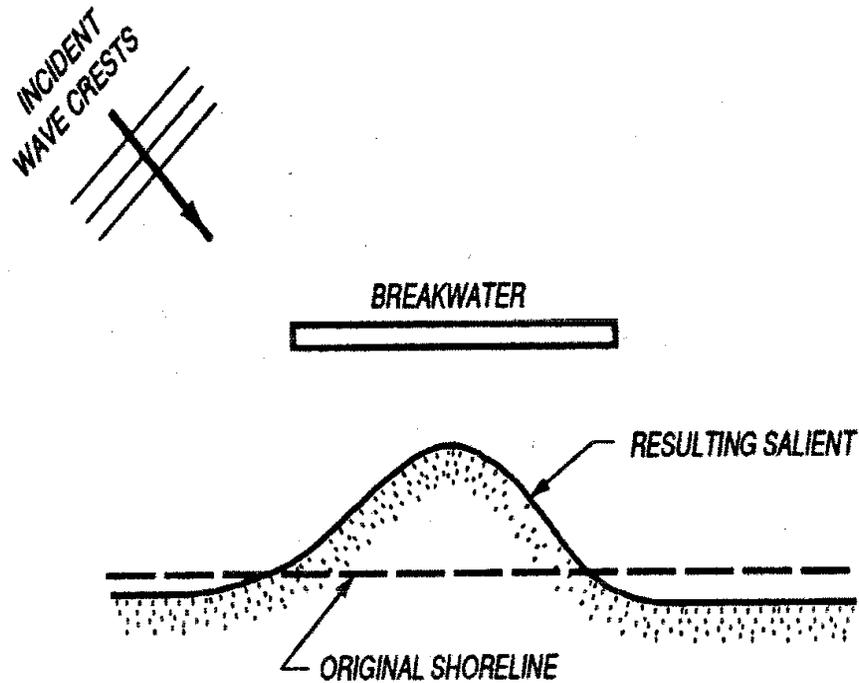


Source: USACE, 2006

Figure 7: Example Groin Placement and Effect on the Shoreline

Breakwaters

Breakwaters are typically constructed parallel to the shoreline and placed a short distance offshore. Breakwaters can either stand alone or be constructed in a series. Nearshore breakwaters reduce the amount of wave energy reaching a protected area. The reduction in wave energy would produce sediment deposition and a shoreline bulge, known as a salient, in the sheltered area behind each breakwater (Figure 8). A reduced amount of longshore sediment transport would occur along the coast behind these breakwaters (Basco, 2006). The breakwaters would be permanent structures because future removal would be impractical and cost prohibitive.



Source: USACE, 2006

Figure 8: Example Breakwater Placement and Effect on the Shoreline

Beach Prisms/Beach Beams

This option involves placing pre-cast concrete triangular beach prisms or triangular open-lattice beach berms along the Wallops Island shoreline. In 1988, NASA and the U.S. Navy installed two proprietary structures designed to serve as sills to retain sand on the shore. These were the “Beach Prism,” a precast concrete triangular prism, and the “Beach Beam,” a concrete triangular-shape open lattice, shown in Photos 4 and 5, respectively.

Description and Comparison of Alternatives

Photo 4: Experimental “Beach Prism” sand retention units moved out of alignment during an April 1988 storm on Wallops Island



Photo 5: “Beach Beam” units partially sunken into seabed during an April 1988 storm on Wallops Island



2.2.7 No Action

CEQ regulations require that an agency “include the alternative of no action” as one of the alternatives it considers (40 CFR 1502.14[d]). The No Action Alternative serves as a baseline against which the impacts of the Proposed Action are compared. Under the No Action Alternative for this PEIS, the SRIPP would not be conducted on Wallops Island, but maintenance and emergency repairs to existing structures would continue. Maintenance activities include repairs to the existing seawall and geotextile tubes. Emergency actions may include hauling in additional rock to add to the existing seawall, hauling and placing sand on the beach or behind existing shoreline protection, installing sheet piling in or near the high tide level, or emergency geotextile tube installation. Under this alternative, the seawall can be expected to continue to deteriorate and would be increasingly vulnerable to massive failure during large storm events as waves break directly on the structure and also undercut the leading edge of the seawall.

Over \$1 billion in NASA, U.S. Navy, and MARS equipment, buildings, and infrastructure would continue to be at increasing risk from storm damage. Maintenance and emergency repairs to structures and the seawall would continue to be required. Shoreline retreat would continue. Operations at facilities may be disrupted during severe storm events from waves overtopping the seawall and flooding. The danger to the MARS launch complex and UAS airstrip on the southern portion of the island would increase due to the rapidly retreating shoreline in that area.

2.3 INITIAL SCREENING OF THE ALTERNATIVES

2.3.1 Screening Criteria

Below are the five criteria used to screen the initial alternatives carried forward as reasonable and feasible:

Disruption to WFF Operations

This factor evaluates the potential disruption to operations at WFF due to implementation of the alternative. Disruption to WFF operations is categorized as follows:

- Low – little to no interruptions in daily activities and/or missions at Wallops Island facilities
- Moderate – minor disruptions during emergency repairs or construction; may cause brief (hours to days) delays or interruptions in daily activities and/or missions at Wallops Island facilities
- High – would cause severe (several days to weeks or longer) interruptions in daily activities and/or missions at Wallops Island facilities; may cause unacceptable delays in missions

Description and Comparison of Alternatives

Storm Damage Reduction

The anticipated level of storm damage reduction is a measure of the protection to critical infrastructure provided by the alternative from storm-generated waves. Categories for anticipated level of storm damage reduction are identified as:

- Low – provides protection from 10-year storm event or smaller
- Moderate – provides protection between 10-year and 50-year storm event
- High – provides protection above the 50-year storm event

Note that the beach-fill-only alternatives are designed to provide storm damage reduction up to a 30-year storm event, and the beach fill with the seawall is designed to provide storm damage reduction up to a 100-year storm event.

Initial Cost

The anticipated level of storm damage reduction drove the alternative designs and their respective costs; the higher the anticipated level of storm damage reduction, typically the greater the cost. Costs of the initial construction of the alternatives developed by the USACE can be categorized as follows:

- Low – less than \$30 million
- Moderate – between \$30 million and \$40 million
- High – greater than \$40 million

Maintenance Costs

This criterion involves the cost driven by the annual maintenance requirements of each alternative. Maintenance could include frequent renourishment of sand or replacement of rock for the sand retention structures or seawall as needed to retain an adequate level of storm damage reduction.

- Low – less than \$500,000
- Moderate – between \$500,000 and \$1,000,000
- High – greater than \$1,000,000

Anticipated Change in Sand Availability for Longshore Transport

This criterion includes an evaluation of the effect of the alternative on longshore sediment transport as well as impacts on the overall sand supply made available to the system.

- Negative – would reduce sand available to longshore sediment transport system
- Neutral – would not alter current longshore sediment transport rates
- Positive – would increase sand available to longshore sediment transport system

2.3.2 Screening Results

Table 1 below shows the results of the screening analysis for the alternatives carried forward.

Table 1: Initial Screening Analysis of the Alternatives

Alternative	Disruption to WFF Operations	Initial Cost	Annual Maintenance Costs	Anticipated Level of Storm Damage Reduction	Anticipated Change in Sand Availability for Longshore Transport
Relocation of At-Risk Infrastructure	High	High	Low	High	Neutral
Seawall Extension	Moderate	Moderate	Low	Low	Negative
Sand Dunes with Various Cores	Moderate	Moderate	Moderate	Low	Positive
Beach Fill	Moderate	Moderate to High	Moderate to High	Moderate to High	Positive
Beach Fill and Seawall Extension	Moderate	Moderate to High	Moderate to High	High	Positive
Beach Fill, Seawall Extension and Sand Retention Structures	Moderate	Moderate to High	Moderate to High	High	Positive
No Action	High	Low	Low	Low	Negative

2.3.3 Alternatives Eliminated After Initial Screening

Based on the results of the screening analysis, the following alternatives were dismissed from further consideration. The following discussion explains why each alternative was dismissed.

2.3.3.1 *Relocating At-Risk Infrastructure*

Figure 6 shows the residences that would be affected if the Wallops Island launch range and the spacecraft fueling facility were moved to Wallops Mainland. While this alternative would reduce the risk to critical infrastructure from storm events, the public would be exposed to greater safety risks, which is absolutely unacceptable to NASA and its partners. In addition, relocating Wallops Island facilities would severely restrict NASA’s ability to conduct its mission.

The LHA typically requires evacuation several hours prior to launch until liftoff. Recent orbital launches have had several attempts where conditions do not permit a launch at that time; rescheduled launches would require hazard area clearance at the next launch window until either the launch is completed or rescheduled again. Requiring large numbers of people to evacuate their homes for an unpredictable amount of time is not only impractical and unacceptably disruptive to WFF neighbors, it would severely restrict WFF’s continued ability to conduct its low cost, fast turnaround operations. Therefore relocation of launch pads and support facilities to a western location on Wallops Mainland was dismissed as not feasible.

Based upon the potential impacts to both WFF and the general public under the hypothetical scenarios of moving Wallops Island facilities inland, Wallops Main Base was dismissed as a possible launch site as it would likely require evacuation of all of the Town of Chincoteague, would completely shut down the Route 175 causeway to Chincoteague Island, and would likely

Description and Comparison of Alternatives

require a complete evacuation of the WFF Main Base, which currently serves in a variety of launch support roles during an active launch countdown. Moving Wallops Island facilities to Wallops Main Base could result in potential impacts that would substantially alter WFF's ability to conduct its pre-launch operations and would place the general public at an unacceptable level of risk. For these reasons, use of Wallops Main Base as a launch site was dismissed as not feasible.

NASA also examined the possibility of acquiring mainland property west of Wallops Island from private landowners for the purpose of relocating Wallops Island facilities. However, this alternative would face the same potential impacts as relocating the infrastructure to Wallops Mainland—creating unacceptable public safety risks and/or severely constraining mission operations. Therefore, privately owned lands west of Wallops Island were dismissed from further consideration.

To determine if suitable easterly sites are available along the Eastern Shores of Maryland and Virginia, NASA investigated the potential for upland sites with the same approximate longitude of Wallops Island within the region. All properties at least as distant from populated areas on the Eastern Shore of Maryland and Virginia include Virginia's 11 other barrier islands, all of which are publicly or privately owned for conservation purposes, and would require substantial infrastructure development while still being susceptible to the same storm damage risks that Wallops Island has faced throughout its history.

For the reasons stated above, NASA determined that alternatives to move at-risk infrastructure are not feasible and these alternatives are not evaluated further in this PEIS.

2.3.3.2 Seawall Extension Only

The existing seawall is being undermined by wave action and has partially fallen into the ocean; this erosion process of the sediment underneath the seawall will continue if sand is not placed in front of the seawall. Because the Seawall Extension Only alternative does not include beach fill, it would not provide adequate long-term storm damage reduction to the shoreline on Wallops Island. Therefore, this alternative was dismissed from further consideration.

2.3.3.3 Sand Dunes with Various Cores Only

The construction of sand dunes with various cores without beach fill would not involve adding sand to the beach and thus would not provide adequate storm damage reduction. Construction of sand dunes without beach in front of them would expose the dunes to wave action and they would be undermined by erosion processes, as evidenced by the existing seawall. Because the Sand Dunes with Various Cores Only alternative does not include beach fill, it would not provide adequate long-term storm damage reduction on Wallops Island. Therefore, this alternative does not meet the purpose and need of the SRIPP to protect critical infrastructure on Wallops Island and was dismissed from further consideration.

2.3.3.4 Types of Sand Retention Structures

The use of beach prisms or beach beams as a type of sand retention structure was dismissed from further consideration because, although these structures would provide some damage reduction during normal storm events, they both tend to be knocked over and sink during larger than normal storm events. After the installation of beach beams and beach prisms at WFF in 1988, the

shore was monitored by Moffatt & Nichol, Inc., who concluded, “The Beach Beams and Beach Prisms have been only marginally successful. Therefore, their continued use to protect critically needed facilities at Wallops Island is not advised” (Moffatt & Nichol, 1989). Because this alternative is likely to fail during even modest storm events, conditions under this alternative would be no different from the existing conditions on the island and critical infrastructure would remain at risk; therefore, this alternative does not meet the purpose and need of the project and was dismissed from further consideration.

2.3.3.5 Beach Fill Only

This alternative would provide additional damage reduction to the shoreline in front of the existing seawall, reducing the potential for damages to the critical infrastructure on Wallops Island. However, the absence of a seawall extension to the south would leave other valuable infrastructure at risk from 100-year storm events. Therefore, the beach fill only alternative without extension of the seawall did not pass the initial screening and was dismissed from further consideration.

2.4 SECONDARY SCREENING OF ALTERNATIVES

The alternatives that passed the initial screening—extension of the seawall combined with beach fill or extension of the seawall combined with beach fill and sand retention structure (either groin or breakwater)—were evaluated by USACE in more detail.

2.4.1 Detailed Options within Alternatives Carried Forward

A variety of detailed options for implementing beach fill, the groin, and the breakwater was evaluated to determine which combination would provide the maximum level of storm damage reduction within available funding (Table 2).

Table 2: Summary of Options for Components Carried Forward

Component	Options
Width of berm ¹ on beach	9 m (30 ft), 21 m (70 ft), 30 m (100 ft)
Length of beach fill	Reduced (3.0 km [1.9 mi]) or Long (6.0 km [3.7 mi])
Location of Breakwater	No Breakwater, South Wallops Island, South Wallops Island with Groin at North End
Location of Groin	No Groin, North Wallops Island with Breakwater at South End, South Wallops Island, or Both North and South Wallops Island
Renourishment Frequency	3-year cycle, 5-year cycle, 7-year cycle
Seawall Extension	Common to all Alternative Combinations

¹Berm refers to the portion of the beach fill that is the minimum amount needed to provide defense from storm damage.

The above options for implementing beach fill and sand retention structures were combined and resulted in 54 different potential alternatives. At this point, the USACE determined that all alternatives should include an approximately 460-m (1,500-ft) extension of the seawall to provide an adequate level of storm damage reduction to the most critical assets on the south end of Wallops Island.

Description and Comparison of Alternatives

An estimate of the initial and renourishment fill requirements was calculated for each of the alternatives. A reduced fill refers to the placement of fill along only 3.0 km (1.9 mi) of the southern portion of project. A long fill refers to the placement of fill along the entire length of the project (6.0 km [3.7 mi]). In addition, a planning-level cost estimate was generated for each of the 54 combinations (Table 3). The alternatives presented in Table 3 were developed before detailed design information was available; therefore, fill volumes presented in the table do not correspond with exact fill volumes presented under the Proposed Action Alternatives evaluated in detail in this PEIS.

2.4.2 Secondary Screening Results

Secondary screening was conducted on the 54 alternatives in Table 3 as described on Figure 9 below. Screening criteria included level of storm damage reduction, initial cost, and maintenance cost. After secondary screening was conducted, the following components were eliminated from further analysis because they did not provide an acceptable level of storm damage reduction: 9-m (30-ft) beach berm (total width of the aboveground beach fill) and reduced beach fill (Alternatives 1-30, 37-39, and 46-48 from Table 3). Additionally, after secondary screening was conducted the following components were eliminated from further analysis because of costs: 30-m (100-ft) beach berm, multiple sand retention structures, and the 3-year and 7-year renourishment cycles (Alternatives 31, 33-36, 40, 42-45, and 49-54 from Table 3). The seawall extension remained a component of each alternative.

Figure 9 below shows the results of the secondary screening analysis for the 54 combinations of alternatives. This screening analysis resulted in the final three alternatives (Alternatives 32, 41, and 50 from Table 3) carried forward for detailed analysis in this PEIS.

Description and Comparison of Alternatives

Table 3: Analysis of the 54 Potential Alternatives

	Alternative	No. of Groins	No. of Breakwaters	Total Initial Fill (yd ³)	Total Initial Fill (m ³)	Total Initial Cost ¹	Total Renourishment Volume Per Cycle (yd ⁵)	Total Renourishment Volume Per Cycle (m ³)	Total Renourishment Cost Per Cycle	Annual Renourishment Cost
1	B030S_HS00_Y3	0	0	1,416,770	1,083,198	\$21,668,000	389,366	297,692	\$4,894,000	\$1,631,000
2	B030S_HS00_Y5	0	0	1,755,807	1,342,411	\$25,059,000	813,163	621,708	\$9,132,000	\$1,826,000
3	B030S_HS00_Y7	0	0	2,094,845	1,601,624	\$28,449,000	1,208,707	924,123	\$13,087,000	\$1,870,000
4	B070S_HS00_Y3	0	0	2,010,601	1,537,215	\$27,606,000	474,126	362,495	\$5,741,000	\$1,914,000
5	B070S_HS00_Y5	0	0	2,377,891	1,818,028	\$31,279,000	897,922	686,511	\$9,979,000	\$1,996,000
6	B070S_HS00_Y7	0	0	2,745,181	2,098,841	\$34,952,000	1,321,719	1,010,527	\$14,217,000	\$2,031,000
7	B100S_HS00_Y3	0	0	2,072,491	1,584,533	\$28,225,000	445,873	340,894	\$5,459,000	\$1,820,000
8	B100S_HS00_Y5	0	0	2,637,553	2,016,554	\$33,876,000	897,922	686,511	\$9,979,000	\$1,996,000
9	B100S_HS00_Y7	0	0	3,174,362	2,426,974	\$39,244,000	1,349,972	1,032,128	\$14,500,000	\$2,071,000
10	B030S_HS11_Y3	2	0	1,218,998	931,991	\$21,190,000	276,354	211,288	\$3,764,000	\$1,255,000
11	B030S_HS11_Y5	2	0	1,445,023	1,104,799	\$23,451,000	558,885	427,298	\$6,589,000	\$1,318,000
12	B030S_HS11_Y7	2	0	1,671,048	1,277,608	\$25,711,000	841,416	643,309	\$9,414,000	\$1,345,000
13	B070S_HS11_Y3	2	0	1,756,323	1,342,805	\$26,563,000	304,607	232,889	\$4,046,000	\$1,349,000
14	B070S_HS11_Y5	2	0	2,038,854	1,558,816	\$29,388,000	615,391	470,500	\$7,154,000	\$1,431,000
15	B070S_HS11_Y7	2	0	2,321,385	1,774,826	\$32,214,000	926,176	708,112	\$10,262,000	\$1,466,000
16	B100S_HS11_Y3	2	0	1,874,719	1,433,326	\$27,747,000	219,848	168,086	\$3,199,000	\$1,066,000
17	B100S_HS11_Y5	2	0	2,270,262	1,735,740	\$31,703,000	643,644	492,101	\$7,437,000	\$1,487,000
18	B100S_HS11_Y7	2	0	2,637,553	2,016,554	\$35,376,000	1,039,188	794,516	\$11,392,000	\$1,627,000
19	B030S_HS12_Y3	1	1	1,190,745	910,390	\$27,158,000	248,101	189,687	\$3,481,000	\$1,160,000
20	B030S_HS12_Y5	1	1	1,388,517	1,061,597	\$29,136,000	445,873	340,894	\$5,459,000	\$1,092,000
21	B030S_HS12_Y7	1	1	1,586,289	1,212,805	\$31,113,000	700,151	535,304	\$8,002,000	\$1,143,000

Description and Comparison of Alternatives

	Alternative	No. of Groins	No. of Breakwaters	Total Initial Fill (yd ³)	Total Initial Fill (m ³)	Total Initial Cost ¹	Total Renourishment Volume Per Cycle (yd ³)	Total Renourishment Volume Per Cycle (m ³)	Total Renourishment Cost Per Cycle	Annual Renourishment Cost
22	B070S_HS12_Y3	1	1	1,699,816	1,299,603	\$32,248,000	248,101	189,687	\$3,481,000	\$1,160,000
23	B070S_HS12_Y5	1	1	1,954,094	1,494,012	\$34,791,000	530,632	405,697	\$6,306,000	\$1,261,000
24	B070S_HS12_Y7	1	1	2,208,372	1,688,422	\$37,334,000	756,657	578,506	\$8,567,000	\$1,224,000
25	B100S_HS12_Y3	1	1	1,846,466	1,411,725	\$33,715,000	191,595	146,485	\$2,916,000	\$972,000
26	B100S_HS12_Y5	1	1	2,213,756	1,692,538	\$37,388,000	587,138	448,899	\$6,872,000	\$1,374,000
27	B100S_HS12_Y7	1	1	2,524,540	1,930,149	\$40,496,000	841,416	643,309	\$9,414,000	\$1,345,000
28	B030L_HS00_Y3	0	0	1,715,675	1,311,728	\$24,657,000	242,684	185,545	\$3,426,000	\$1,142,000
29	B030L_HS00_Y5	0	0	2,064,684	1,578,564	\$28,147,000	514,136	393,085	\$6,141,000	\$1,228,000
30	B030L_HS00_Y7	0	0	2,374,914	1,815,752	\$31,250,000	785,587	600,624	\$8,855,000	\$1,265,000
31	B070L_HS00_Y3	0	0	2,466,265	1,885,595	\$32,162,000	359,021	274,491	\$4,590,000	\$1,530,000
32	<i>B070L_HS00_Y5²</i>	<i>0</i>	<i>0</i>	<i>2,854,053</i>	<i>2,182,080</i>	<i>\$36,040,000</i>	<i>397,799</i>	<i>304,139</i>	<i>\$4,978,000</i>	<i>\$996,000</i>
33	B070L_HS00_Y7	0	0	3,241,841	2,478,565	\$39,918,000	397,799	304,139	\$4,978,000	\$711,000
34	B100L_HS00_Y3	0	0	2,865,001	2,190,450	\$36,150,000	397,799	304,139	\$4,978,000	\$1,659,000
35	B100L_HS00_Y5	0	0	3,252,789	2,486,936	\$40,028,000	630,472	482,030	\$7,304,000	\$1,461,000
36	B100L_HS00_Y7	0	0	3,640,577	2,783,421	\$43,906,000	824,366	630,273	\$9,243,000	\$1,320,000
37	B030L_HS01_Y3	1	0	1,560,560	1,193,134	\$23,856,000	203,906	155,897	\$3,039,000	\$1,013,000
38	B030L_HS01_Y5	1	0	1,793,232	1,371,024	\$26,183,000	397,799	304,139	\$4,978,000	\$996,000
39	B030L_HS01_Y7	1	0	1,987,126	1,519,267	\$28,122,000	552,915	422,734	\$6,529,000	\$933,000
40	B070L_HS01_Y3	1	0	2,311,150	1,767,001	\$31,361,000	281,463	215,194	\$3,814,000	\$1,271,000
41	<i>B070L_HS01_Y5²</i>	<i>1</i>	<i>0</i>	<i>2,582,601</i>	<i>1,974,540</i>	<i>\$34,076,000</i>	<i>320,242</i>	<i>244,843</i>	<i>\$4,202,000</i>	<i>\$840,000</i>
42	B070L_HS01_Y7	1	0	2,815,274	2,152,431	\$36,402,000	320,242	244,843	\$4,202,000	\$600,000
43	B100L_HS01_Y3	1	0	2,671,107	2,042,208	\$34,961,000	320,242	320,242	\$4,202,000	\$1,401,000
44	B100L_HS01_Y5	1	0	2,942,559	2,249,748	\$37,675,000	475,357	363,437	\$5,753,000	\$1,151,000

Description and Comparison of Alternatives

	Alternative	No. of Groins	No. of Breakwaters	Total Initial Fill (yd ³)	Total Initial Fill (m ³)	Total Initial Cost ¹	Total Renourishment Volume Per Cycle (yd ³)	Total Renourishment Volume Per Cycle (m ³)	Total Renourishment Cost Per Cycle	Annual Renourishment Cost
45	B100L_HS01_Y7	1	0	3,175,231	2,427,638	\$40,002,000	591,693	542,382	\$6,916,000	\$988,000
46	B030L_HS02_Y3	0	1	1,521,781	1,163,485	\$29,718,000	203,906	155,897	\$3,039,000	\$1,013,000
47	B030L_HS02_Y5	0	1	1,754,454	1,341,376	\$32,045,000	359,021	274,491	\$4,590,000	\$918,000
48	B030L_HS02_Y7	0	1	1,909,569	1,459,970	\$33,596,000	475,357	363,437	\$5,753,000	\$822,000
49	B070L_HS02_Y3	0	1	2,272,371	1,737,352	\$37,223,000	242,684	185,545	\$3,426,000	\$1,142,000
50	<i>B070L_HS02_Y5²</i>	<i>0</i>	<i>1</i>	<i>2,505,044</i>	<i>1,915,244</i>	<i>\$39,550,000</i>	<i>281,463</i>	<i>215,194</i>	<i>\$3,814,000</i>	<i>\$763,000</i>
51	B070L_HS02_Y7	0	1	2,737,716	2,093,134	\$41,877,000	281,463	215,194	\$3,814,000	\$545,000
52	B100L_HS02_Y3	0	1	2,632,328	2,012,559	\$40,823,000	281,463	215,194	\$3,814,000	\$1,271,000
53	B100L_HS02_Y5	0	1	2,865,001	2,190,450	\$43,150,000	397,799	304,139	\$4,978,000	\$996,000
54	B100L_HS02_Y7	0	1	3,097,674	2,368,342	\$45,477,000	514,136	393,085	\$6,141,000	\$877,000

¹Total initial cost for all alternatives also includes \$6,500,000 for construction of a 460 m (1,500 ft) seawall extension

²Rows where text is shown as bold italics are the alternatives that were carried forward in the SRIPP analysis.

Alternatives Coding Legend:

B	Berm Width
###	30, 70, or 100 feet of dry beach width following construction and period of equilibrium (the final result following natural redistribution of outer end of berm).
S or L	Short or Long project. Both projects start from the southern camera stand at a point referred to as Z 100.
HS##	Hard Structure followed by two digits, the first indicating the type of structure at the North end of the project, the 2nd digit indicating the type of structure at the South end of the project. 0-No Structure 1-Groin 2-Breakwater
Y#	Renourishment Interval followed by a digit indicating the number of years (3, 5, or 7) between renourishment events

This page intentionally left blank.



Figure 9: Secondary Alternative Screening Process Flow

Description and Comparison of Alternatives

2.4.3 Sources Considered for Beach Fill Material

2.4.3.1 Navigation Projects

Chincoteague Inlet

Chincoteague Inlet was considered as a possible sediment source because it is periodically dredged by the USACE Norfolk District under the Federal Navigation Project and is immediately to the north of Wallops Island. The sediment in the inlet contains a significant proportion of fine-grained material (silts and clays) and is not the ideal grain size suited for beach fill (USACE, 2006). Because fine-grained material is more vulnerable to storm waves and thus suspension and transport, sediment dredged from Chincoteague Inlet would require a higher overfill ratio to accommodate the higher rate of loss of the fine-grained material compared to sand.

The USACE Norfolk District has been dredging Chincoteague Inlet since the mid-1990s, placing the material in the offshore disposal site that is approximately 1,220 m (4,000 ft) offshore of Wallops Island (Figure 10). The disposal site covers an area approximately 305 m (1,000 ft) by 915 m (3,000 ft). The volume of sediment dredged from Chincoteague Inlet varies annually—in March 2006, 53,520 m³ (70,000 yd³) was removed; in July 2007, 25,360 m³ (33,170 yd³) was removed; in March 2008, 48,810 m³ (63,841 yd³) was removed, and in December 2008, 29,830 m³ (39,018 yd³) was removed.

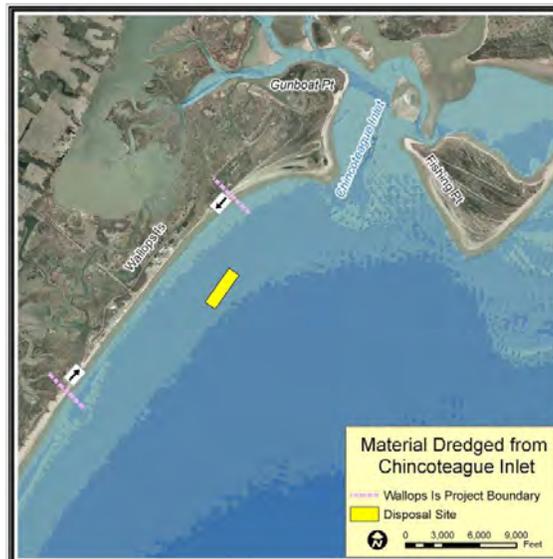


Figure 10: Offshore Disposal Site for Chincoteague Inlet Dredged Material

In 2002, the USACE partnered with NASA to place dredged material from the inlet channel along the Wallops Island shoreline to observe the behavior of the material once placed along the shoreline and determine if this placement scenario could be a viable long-term solution. Comparison of the after-placement survey and the monitoring survey generally showed that the material had moved away from the seawall face and joined nearshore bars and generally diffused throughout the area. The cost per yard for the dredging and sand placement operations was \$22.60—this is a very high cost compared to typical dredging and sediment disposal costs for Chincoteague Inlet which ranged from approximately \$5 to \$9 for the USACE projects between

1995 and 2006 (USACE, 2010a). Because the mobilization and demobilization costs to dredge the relatively small amounts of sediment (compared to the amounts required for the SRIPP) and place them on the beach result in a high cost of the dredged material per yard, the process has not been repeated during more recent inlet dredging events and this area was removed from consideration as a borrow site.

In addition to an inadequate grain size, the nearshore environment off of the northern portion of Wallops Island, immediately south of and including Chincoteague Inlet contains known historic World War II target ranges from the shoreline up to 8 km (5 mi) offshore. These historic ranges contain munitions and explosives of concern (MEC) that are buried in the sea bottom.

Magnetometer surveys could be used to delineate the extent of the MEC and allow dredging in the area to occur but this would result in additional costs to the dredge program and the safety risks associated with these areas would be high. Because of the hazard potential, the areas with potential for MEC were removed from consideration for beach nourishment borrow sites.

Virginia Inside Passage

The Virginia Inside Passage, a waterway along the coast of Virginia between the mainland and the barrier islands, was considered as a possible sediment source because it is periodically dredged by the USACE and is adjacent to the west side of Wallops Island. The sediment in the Virginia Inside Passage contains a significant proportion of fine-grained material (silts and clays) and is not suitable for beach fill (Stamper, USACE, personal comm.). In addition, in order to obtain volumes required for SRIPP fill, the Virginia Inside Passage channels would have to be dredged deeper than the current dredge depths of 2.5 m (8 ft). The USACE noted that dredging these channels any deeper is a problem due to their proximity to the marsh islands and nearby oyster grounds. The deeper the channel is dredged, the farther out the side slopes would extend into marsh areas, causing slumping of the marsh into the dredge cut (Stamper, USACE, personal comm.). Therefore, this area was removed from consideration as a potential borrow site.

2.4.3.2 Nearshore Borrow Sites East of Wallops Island

The USACE collected sediment samples from the nearshore environment east of Wallops Island (out to 5.5 km [3.5 mi] from the shoreline) during a hydrographic survey in November 2006 (Figure 11) (USACE, 2010a). During the survey, 25 transects were spaced 300 m (1,000 ft) apart from the shoreline out to a water depth of approximately 9 m (30 ft). Grab samples of the sediment surface were collected at 1.5-m (5-ft) depth intervals. The USACE conducted grain size analyses on the samples to determine if the sediments in the sampling area contained suitable material for beach fill.

The results of the sampling showed a median grain size of 0.20 mm, which is finer than sand that would be ideally suited for beach fill. Although using finer-grain size is an option and would slow shoreline erosion, critical infrastructure would remain at risk, especially during storm events because the finer-grained beach would be susceptible to severe erosion during small to moderate storm events. To compensate for the additional loss due to erosion renourishment would be much more frequent (potentially every 1 to 2 years) or would require additional overfill. While the transport costs from the closer, nearshore environment are lower than that of borrow sites further offshore, the larger required volumes and more frequent renourishment requirements would be cost prohibitive. Therefore, this area was removed from consideration as a borrow site.

Description and Comparison of Alternatives

2.4.3.3 Offshore Borrow Sites

Because the nearshore seafloor east of Wallops Island contains sediment that is finer than would be ideally suited for beach fill, the USACE conducted additional sampling to identify potential borrow sites farther offshore.

May 2007 USACE Sampling

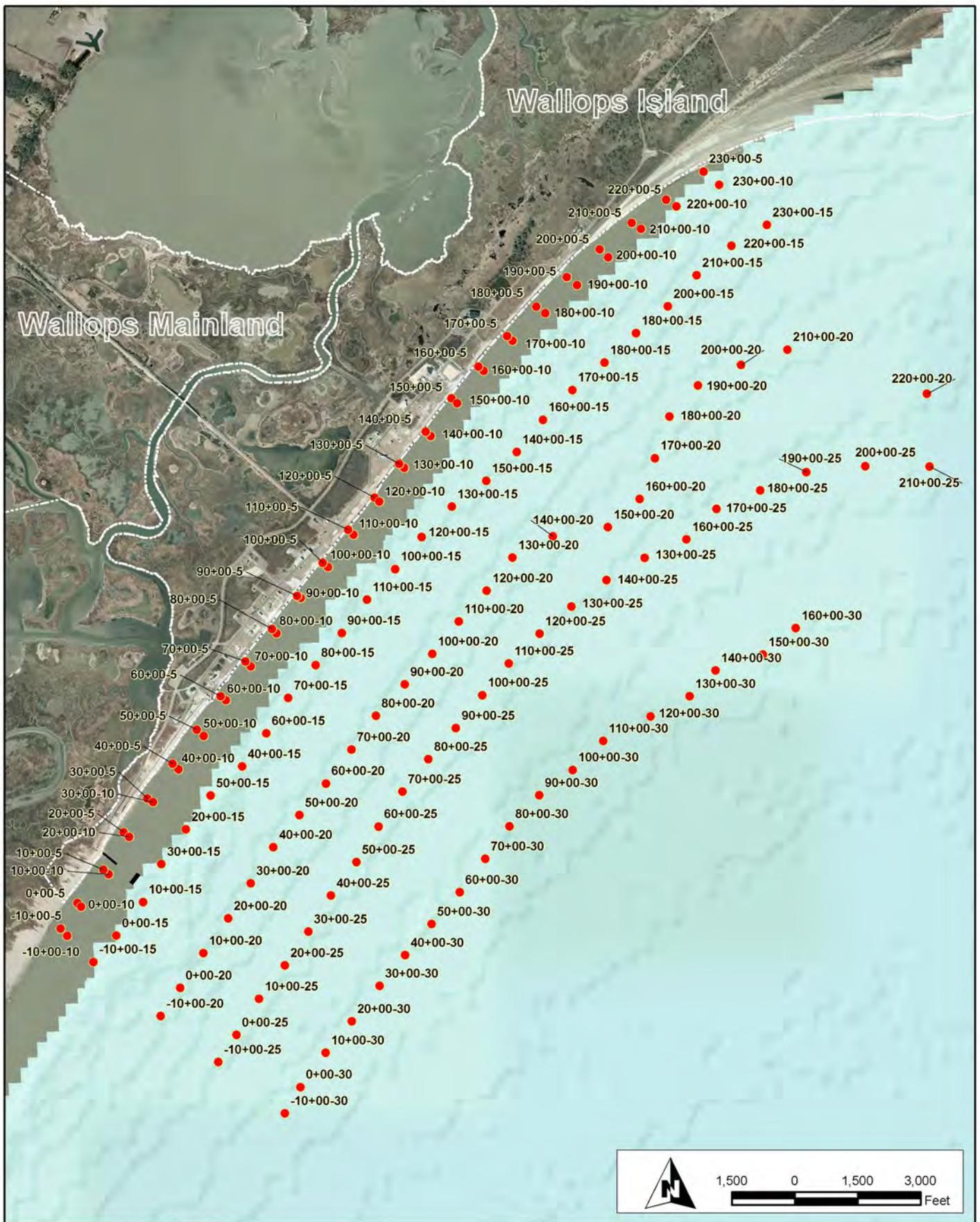
In May 2007, the USACE conducted sediment sampling offshore of Wallops Island to identify any areas that might contain suitable beach quality materials (Figure 12). The sampling initially concentrated on areas directly offshore and the attached finger shoals that are located southeast of Wallops Island. The samples taken immediately offshore of Wallops Island were found to be marginally unsuitable to unsuitable for beach fill (USACE, 2010a). There was substantial scatter in the median grain size of these sediments, but most had a median grain size of less than 0.20 mm. This May 2007 survey also investigated Porpoise Banks, located southeast of Wallops Island. Six borings drilled in this area indicated that it lacks suitable borrow material.

From the May 2007 sampling, the USACE identified three potential shoals within the geographical range where transportation costs to Wallops Island would not be prohibitive that contained adequate volume and suitable grain size: Blackfish Bank Shoal, Unnamed Shoal A, and Unnamed Shoal B (Figure 12).

December 2007 USACE Sampling

In December 2007, the USACE concentrated additional vibracore sampling on the three potential shoals to be used as SRIPP borrow sites. Analysis of the samples indicated that Blackfish Bank Shoal contains approximately 19 million m³ (25 million yd³) of beach quality material, Unnamed Shoal A contains at least 52 million m³ (68 million yd³), and Unnamed Shoal B contains at least 100 million m³ (132 million yd³) of suitable material. These volumes are substantially in excess of the estimated 7.6 million m³ (10 million yd³) of fill material needed over the lifetime of the project.

A grain size analysis was conducted on the sediments in the samples. The samples were typically divided into three sections (upper, mid, and lower), with mean grain size calculated for each layer as well as the composite of all three layers. Table 4 below lists the grain sizes of Blackfish Bank Shoal and Unnamed Shoals A and B in millimeters from the December 2007 vibracore samples. Because dredging could extend to a depth of approximately 1.8 m (6 ft), the results of vibracore sample analysis to approximately 1.8 m (6 ft) are provided (grain size for all depths of the project cores is provided in Appendix A). These data indicate that the Blackfish Bank composite mean sediment diameter is 0.35 mm; the range of mean grain size values for the top two layers (which are shown in Table 4) is from 0.14 mm to 0.31 mm.



● Sediment Sample Location
(USACE, November 2006)

Title: Nearshore Sediment Sample Locations



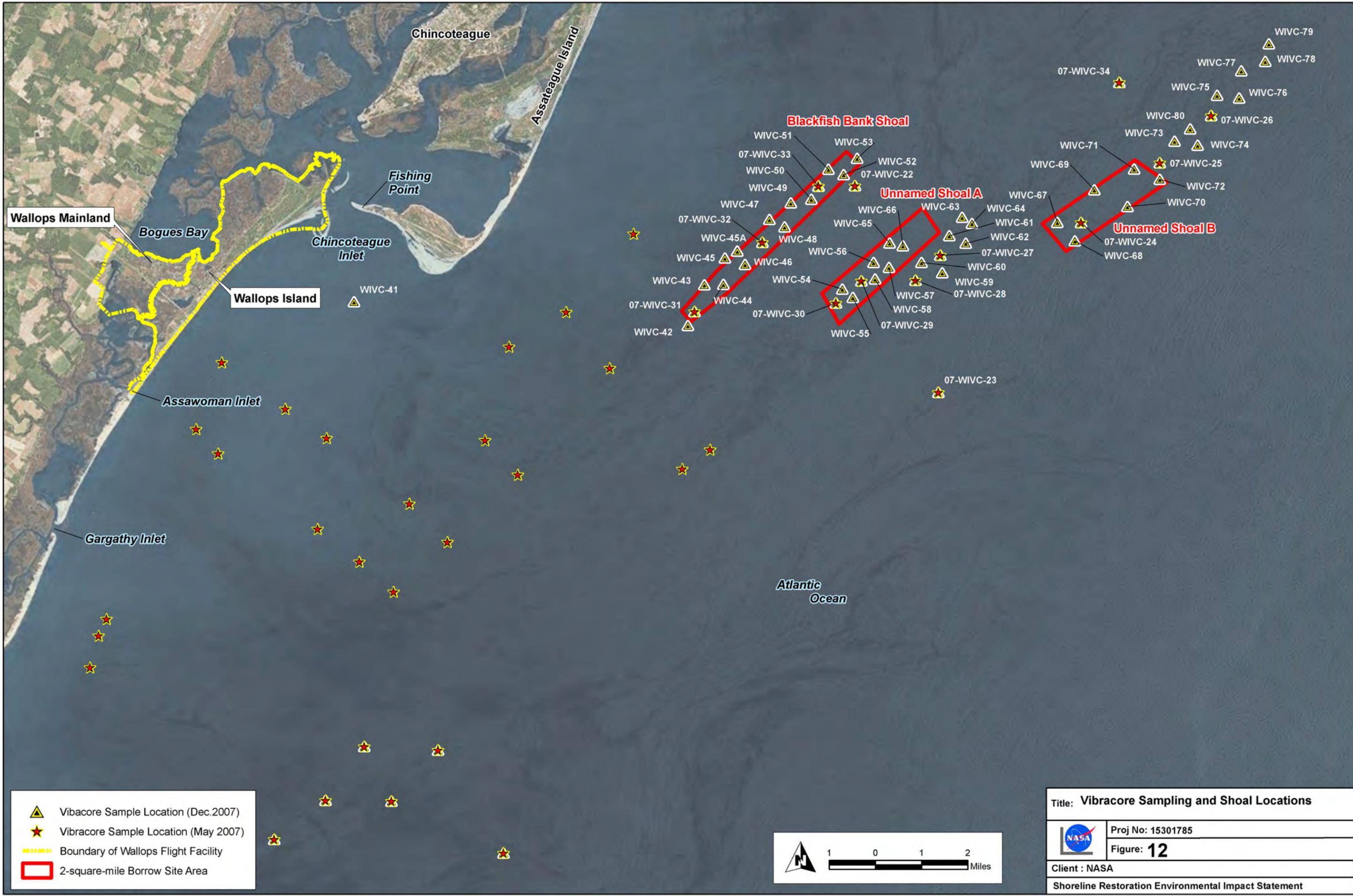
URS Proj No: 15301785

Figure: 11

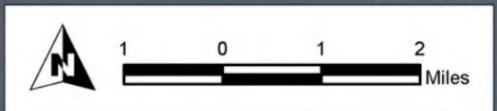
Client : NASA

Shoreline Restoration Environmental Impact Statement

This page intentionally left blank.



-  Vibrocore Sample Location (Dec.2007)
-  Vibrocore Sample Location (May 2007)
-  Boundary of Wallops Flight Facility
-  2-square-mile Borrow Site Area



Title: Vibrocore Sampling and Shoal Locations	
	Proj No: 15301785
Figure: 12	
Client : NASA	
Shoreline Restoration Environmental Impact Statement	

This page intentionally left blank.

Description and Comparison of Alternatives

The sediment on Unnamed Shoals A and B is generally well-sorted, medium sand with a median composite grain size of 0.29 mm (USACE, 2010a). It is anticipated that the dredging would occur within the top two sample layers, the depth of which varies between the samples and is shown in Table 4. The mean grain size in the top layer of Unnamed Shoal A is 0.42 mm, while the top layer of Unnamed Shoal B has a mean grain size of 0.34 mm. The range of mean grain sizes within the top two layers of Unnamed Shoal A is between 0.24 mm and 0.78 mm and on Unnamed Shoal B is between 0.17 mm and 0.47 mm. The sampling results indicate that the top layer of sand is generally coarser than lower layers, though there were samples where the top layer was finer than the bottom layer.

Table 4: Grain Size in Samples Taken from Blackfish Bank, Unnamed Shoal A, and Unnamed Shoal B

Vibracore Sample Number ¹	Sample Depth m (ft)	Mean Grain Size (mm)
Blackfish Bank		
WIVC-59	0–1 (0–3.2)	0.22
	1–1.4 (3.2–4.6)	0.20
WIVC-60	0–0.2 (0–0.8)	0.31
	0.2–1.4 (0.8–4.5)	0.14
WIVC-61	0–1.5 (0–5)	0.22
	1.5–2.9 (5–9.5)	0.22
WIVC-62	0–0.7 (0–2.3)	0.17
	0.7–3 (2.3–10)	0.17
WIVC-63	0–1.5 (0–5)	0.20
	1.5–2.2 (5–7.3)	0.19
WIVC-64	0–1.8 (0–6)	0.21
	1.8–3.5 (6–11.6)	0.18
Unnamed Shoal A		
07-WIVC-30	0–1.2 (0–4.1)	0.60
	1.2–2.9 (4.1–9.5)	0.49
WIVC-54	0–1.5 (0–5)	0.69
	1.5–3.5 (5–11.4)	0.78
WIVC-55	0–1.7 (0–5.6)	0.37
	1.7–2.7 (5.6–9)	0.45
07-WIVC-29	0–1.1 (0–3.7)	0.38
	1.1–2.2 (3.7–7.2)	0.38
WIVC-58	0–1.2 (0–4)	0.30
	1.2–2.4 (4–8)	0.28
WIVC-56	0–1.9 (0–6.1)	0.35
	1.9–3 (6.1–10)	0.25

Description and Comparison of Alternatives

Vibracore Sample Number ¹	Sample Depth m (ft)	Mean Grain Size (mm)
WIVC-57	0–1.2 (0–4)	0.24
	1.2–2.4 (4–8)	0.24
WIVC-65	0–0.6 (0–2)	0.40
	0.6–1.5 (2–5)	0.34
WIVC-66	0–0.5 (0–1.8)	0.47
	0.5–2.6 (1.8–5)	0.24
Unnamed Shoal B		
WIVC-67	0–1.5 (0–5)	0.32
	1.5–3 (5–10)	0.47
WIVC-68	0–1.5 (0–5)	0.37
	1.5–2.8 (5–9.3)	0.43
WIVC-69	0–1.5 (0–5)	0.43
	1.5–3 (5–10)	0.27
WIVC-70	0–1.5 (0–5)	0.27
	1.5–2.8 (5–9.2)	0.29
WIVC-71	0–0.4 (0–1.3)	0.31
	0.4–1.5 (1.3–5)	0.17
WIVC-72	0–0.8 (0–2.6)	0.35
	0.8–1.5 (2.6–5)	0.25

¹See Figure 12 for map of vibracore sampling locations. Grain size data for all depths of the sample cores are provided in Appendix A.

Source: *Alpine Ocean Seismic Survey, Inc., 2008*

Blackfish Bank Shoal

Blackfish Bank Shoal is located approximately 8 km (5 mi) east of Assateague Island and approximately 11 km (7 mi) northeast of the Wallops Island shoreline. The USACE determined that Blackfish Bank Shoal would provide suitable grain size and adequate quantities of sediment for the SRIPP.

This shoal is a popular commercial and recreational fishing location, partly due to an artificial reef on the southern portion of the shoal that was developed through the efforts of the Town of Chincoteague and the Chincoteague Island Charterboat Association. The artificial reef, which is regulated by the Virginia Marine Resources Commission (VMRC) Artificial Reef Program and constructed primarily of subway cars, covers approximately 1.75 square kilometers (km²) (0.7 square miles [mi²]) and provides habitat for fish and invertebrates.

In the spring of 2009, NASA conducted a survey of commercial and recreational fishermen to determine the level of use of Blackfish Bank Shoal, Unnamed Shoal A, and the Wallops Island shoreline. At the time of the survey, Unnamed Shoal B had not been selected as a potential borrow site and therefore was not included in the survey. The survey was designed to assess

commercial and recreational fishermen's perceptions of potential impacts on the fishing industry from dredging activities that may occur at either shoal. The majority of respondents were concerned that project activities would destroy the artificial reef at Blackfish Bank, thereby removing important fishing grounds.

Comments received during the PEIS scoping period in May 2009 also indicated public concern regarding the potential dredging of Blackfish Bank Shoal and the resulting changes to the wave energy on Assateague Island. Some comments focused on the removal of the crest of the Blackfish Bank Shoal that could result in increased wave energy on Assateague Island and increased beach erosion. Other comments stated that Blackfish Bank should be left intact to minimize the potential impacts of dredging on Assateague Island National Seashore marine life.

To determine the potential effects of dredging Blackfish Bank Shoal, Unnamed Shoal A, and Unnamed Shoal B on Assateague Island's shoreline, the USACE used a model based on site-specific wave characteristics and longshore sediment transport methodology. The USACE modeling methodology and results for dredging Unnamed Shoals A and B are explained in more detail in Section 4.2.2.1 of this PEIS and in Appendix A. Results of the USACE modeling showed that changes in longshore sediment transport as a result of dredging Blackfish Bank Shoal could be distinguished from naturally occurring sediment transport, and therefore the dredging may result in shoreline changes to the Assateague Island shoreline that would be attributable to the SRIPP. The model results showed a few locations along the Assateague shoreline that could exhibit shoreline changes in response to dredging Blackfish Bank Shoal; however, the primary area that would be impacted would be the Tom's Cove Isthmus area because it is naturally vulnerable to shoreline change.

Because of the potentially adverse impacts on the Assateague Island shoreline and the public concern regarding negative impacts on commercial and recreational fishing communities, Blackfish Bank Shoal was removed from consideration as a borrow site option.

Unnamed Shoal A

The southwest end of Unnamed Shoal A is located approximately 11 km (7 mi) east of Assateague Island and approximately 18 km (11 mi) northeast of Wallops Island. The total predicted volume of Unnamed Shoal A is approximately 52 million m³ (68 million yd³). This shoal covers an area of approximately 700 ha (1,800 ac).

This shoal is carried forward for detailed analysis because sediment analyses and a review of bathymetric data conducted by the USACE indicate that this borrow site would provide adequate volumes and appropriately sized sediment for nourishment of the beach throughout the SRIPP's 50-year design life. The USACE modeling methodology and results for dredging Unnamed Shoal A are explained in more detail in Section 4.2.2.1 of this PEIS and in Appendix A.

Unnamed Shoal B

Unnamed Shoal B is located approximately 16 km (10 mi) east of Assateague Island. The southwest end of Unnamed Shoal B is located approximately 19 km (12 mi) east of Assateague Island and approximately 21 km (13 mi) northeast of Wallops Island. The total predicted volume of Unnamed Shoal B is approximately 100 million m³ (132 million yd³). This shoal covers an area of approximately 1,600 ha (3,900 ac).

Description and Comparison of Alternatives

This shoal is carried forward for detailed analysis because sediment sampling analyses and a review of bathymetric data conducted by the USACE indicate that this borrow site would provide adequate volumes and appropriately sized sediment for nourishment of the beach throughout the SRIPP's 50-year design life. The USACE modeling methodology and results for dredging Unnamed Shoal B are explained in more detail in Section 4.2.2.1 of this PEIS and in Appendix A.

2.4.3.4 Upland Sand Sources

North Wallops Island Beach Borrow Site – Renourishment Only

One option for renourishment is to remove sand from a portion of the existing beach on the northern end of Wallops Island (Figure 13). In addition to the existing sand on the beach, sediment that is expected to accumulate at the north end of Wallops Island after the initial beach fill would extend the existing beach seaward. This future accumulation area could also be used as fill material for renourishment.

The exact limits of the borrow area are undefined at this time as they will undoubtedly vary between SRIPP initial and renourishment events in response to: the volumes and patterns of accretion, the varying suitability of the sediment, Chincoteague Inlet dynamics, changes in vegetative cover, and biological factors. However, approximate limits of the potential borrow site area, shown on Figure 13, were identified based on a vegetation mapping survey conducted in October 2009 (see Section 3.2.1.1 Vegetation for more detail on the survey).

On October 6, 2009, the USACE performed sediment sampling of the beach at the northern end of Wallops Island (USACE, 2009a). Sixteen samples were collected to a depth of 1.8 m (6 ft). Grain size analysis was conducted on the surface layer of all samples, and then at either a depth of 0.6 m (2 ft) or 1.2 m (4 ft) for alternating numbered samples (Table 5). Figure 13 shows the sample locations. The sediments generally consisted of tan to gray, poorly graded fine to medium sand with trace shell fragments and silt (USACE, 2009a). The median grain sizes of all samples were between 0.18 and 0.27 mm.



Legend

- Sediment Sample Location (Oct. 2009)
- WFF Boundary
- - Existing Unpaved Road
- Existing Road
- Potential Borrow Site Area

Note: Extent of the potential borrow site area is shown for existing conditions and follows the existing shoreline. Future borrow site area may extend into nearshore waters due to sediment accumulation

Title: North Wallops Island Borrow Site	
	URS Proj No: 15301785
Figure: 13	
Client : NASA	
Shoreline Restoration Environmental Impact Statement	



This page intentionally left blank.

Table 5: Grain Size in Samples Collected from North Wallops Island

Sample Number	Depth¹ m (ft)	Median Grain Size (mm)
NB-01	0	0.22
	0.6 (2)	0.21
NB-02	0	0.19
	1.2 (4)	0.21
NB-03	0	0.20
	0.6 (2)	0.20
NB-04	0	0.19
	1.2 (4)	0.19
NB-05	0	0.19
	0.6 (2)	0.19
NB-06	0	0.19
	1.2 (4)	0.19
NB-07	0	0.20
	0.6 (2)	0.19
NB-08	0	0.21
	1.2 (4)	0.20
NB-09	0	0.18
	0.6 (2)	0.19
NB-10	0	0.19
	1.2 (4)	0.22
NB-11	0	0.19
	0.6 (2)	0.19
NB-12	0	0.19
	1.2 (4)	0.22
NB-13	0	0.19
	0.6 (2)	0.19
NB-14	0	0.27
	1.2 (4)	0.23
NB-15	0	0.19
	0.6 (2)	0.20
NB-16	0	0.21
	1.2 (4)	0.23

¹Grain size analysis was done at the surface and 0.6 m [2 ft]) for odd numbered samples, and at the surface and 1.2 m [4 ft]) for even numbered samples; these data presented in this table represent the complete data set

Source: USACE, 2009b

Description and Comparison of Alternatives

USACE modeling has shown that on average, approximately 30,600 m³ (40,000 yd³) of sediment per year accumulates at the northern end of Wallops Island by longshore transport from the south. Once the beach fill is placed, that volume is expected to increase to 76,500 to 115,000 m³ (100,000 to 150,000 yd³) per year under all three of the SRIPP Proposed Action Alternatives (USACE, 2010a). A portion of the renourishment volume under each alternative could come from this beach source. Although the area currently does not contain sediment of an optimal grain size for use as beach fill material, the northern end of Wallops Island would offer potential renourishment material without the mobilization and operational costs associated with offshore dredging. Sediment transported alongshore to the north from a previous fill cycle would be of the proper grain size and could be effectively recycled, or “backpassed” by excavating it and placing it in eroding areas in the southern project area.

Based on current vegetation and wildlife habitat constraints (such as avoiding areas of most dense vegetation and highest Piping Plover and sea turtle nesting activity), the total potential area for sand removal is approximately 60 ha (150 ac) (Figure 13). Excavation depth is expected to be limited to about 1 m (3.5 ft) below the ground surface due to tidal fluctuations and the high permeability of the soil (USACE, 2009b). Based on target depth of sediment removal, the area to be excavated would vary. For example, excavating to a depth of 1 m (3.5 ft) would require a 23 ha (57 ac) area to provide a renourishment volume of 230,000 m³ (300,000 yd³).

2.4.3.5 Summary of Preferred Borrow Sites

Several borrow sites were dismissed because they did not meet the criteria for a useable source of sand. Based on the evaluation described above, the following three borrow sites are considered potential sand sources for the beach fill under the Proposed Action Alternatives: Unnamed Shoal A, Unnamed Shoal B, and the north Wallops Island beach (renourishment only).

The minimum, maximum, and mean grain sizes for each of these three potential borrow sites are shown in Table 6. The data in Table 6 is based on the vibracore sampling by the USACE in 2007 (Alpine Ocean Seismic Survey, 2008) and subsurface sampling of the beach on the northern end of Wallops Island in October 2009 (USACE, 2009a) described above.

Table 6: Summary of Borrow Site Options Carried Forward for Analysis

Borrow Site Option	Source	Minimum Grain Size (mm)	Maximum Grain Size (mm)	Mean Composite Grain Size (mm)	Approximate Travel Distance ¹ from Pump-Out Station (km [mi])
Unnamed Shoal A	Offshore	0.24	0.78	0.42	22 (14)
Unnamed Shoal B	Offshore	0.27	0.43	0.34	31 (19)
North Wallops Island	Upland (beach)	0.11	0.30	0.20	0.8 (0.5)

¹One-way distance that the dredge vessel would travel from the shoal to the pump-out station (not a straight line from the shoal to Wallops Island)

Sources: *Alpine Ocean Seismic Survey, 2008 and USACE, 2009b*

2.5 PROPOSED ACTION ALTERNATIVES

The combinations of options that would provide the maximum level of storm damage reduction while remaining within the limits of available funding were evaluated in detail as the three Proposed Action Alternatives discussed below. Each Proposed Action Alternative described in this section includes an initial phase of beach fill with a corresponding estimate of renourishment beach fill that would be required over the 50-year duration of the SRIPP. Each of these three alternatives would require a Cooperating Agency action, which for USACE would be the issuance of permits under the CWA and RHA, and for BOEMRE would be the execution of a non-competitive lease/MOA with NASA and USACE for use of OCS sand resources for the beach fill material.

2.5.1 Project Elements Common to All Alternatives

A number of design and construction elements would be applicable to all three alternatives and are described in this section. Differences among the alternatives (e.g., initial and renourishment fill volumes, type of sand retention structure, etc.) are discussed in detail in each individual alternative's respective section.

2.5.1.1 *Adaptive Management Framework*

As there is an inherent level of uncertainty in designing, constructing, and maintaining a long-term project subject to the effects of the open ocean environment, NASA may identify the need to modify its storm damage reduction measures in the future. As such, all Proposed Action Alternatives include the adaptive management strategy described in Section 1.4 of this PEIS. At this time, the Preferred Alternative is expected to accomplish the SRIPP purpose and need while minimizing adverse impacts on the environment compared to the other two feasible alternatives. However, should the monitoring program show that the Preferred Alternative by itself is not adequately meeting NASA's goals for the SRIPP, the other Proposed Action Alternatives (or elements from them) could be reevaluated in the future.

NASA's knowledge of the physical processes in the project area has increased through the preparation of this PEIS and results of future monitoring will add to this understanding. As described in further detail in Section 5.2 of this PEIS, NASA will rely on the analysis of data from its ongoing monitoring program to guide its decision-making process. In doing so, a variety of project components could be optimized. These components might include adjusting renourishment frequencies and volumes, developing ways to address erosional "hot spots" without dredge mobilization, and the possible addition of a sand retention structure either north or south of the beach fill.

Should NASA identify any such additional elements that are not specifically considered in this PEIS, supplemental NEPA documentation would be prepared to determine environmental impacts, engage stakeholders, and consider relevant costs and benefits. Appropriate permits and approvals would be obtained prior to implementation.

2.5.1.2 *Seawall Extension*

All three Proposed Action Alternatives include a southerly seawall extension that would serve a critical role as a second line of defense against storms where water levels (and breaking waves) were no longer halted by the beach.

Description and Comparison of Alternatives

The seawall extension would be constructed on the beach parallel to the shoreline in the approximate location of existing geotextile tubes (Figure 14), and would be implemented in the first year of the SRIPP prior to the placement of the initial beach fill. The new seawall would be constructed landward of the shoreline and would extend a minimum of 435 m (1,430 ft) up to a maximum of 1,400 m (4,600 ft) south of the existing seawall. To provide storm damage reduction to the most critical infrastructure on south Wallops Island (launch pad 0-B), the seawall would be initially extended approximately 435 m (1,430 ft) and would include a 61-m (200-ft) flankwall that tapers southwest past pad 0-B (Figure 15). The southern end of the 1,400-m (4,600-ft) extension would be at camera stand Z-100, which is located approximately 460 m (1,500 feet) north of the Wallops Island-Assawoman Island property boundary. The seawall would be extended south to its full length in future years as funding allows.

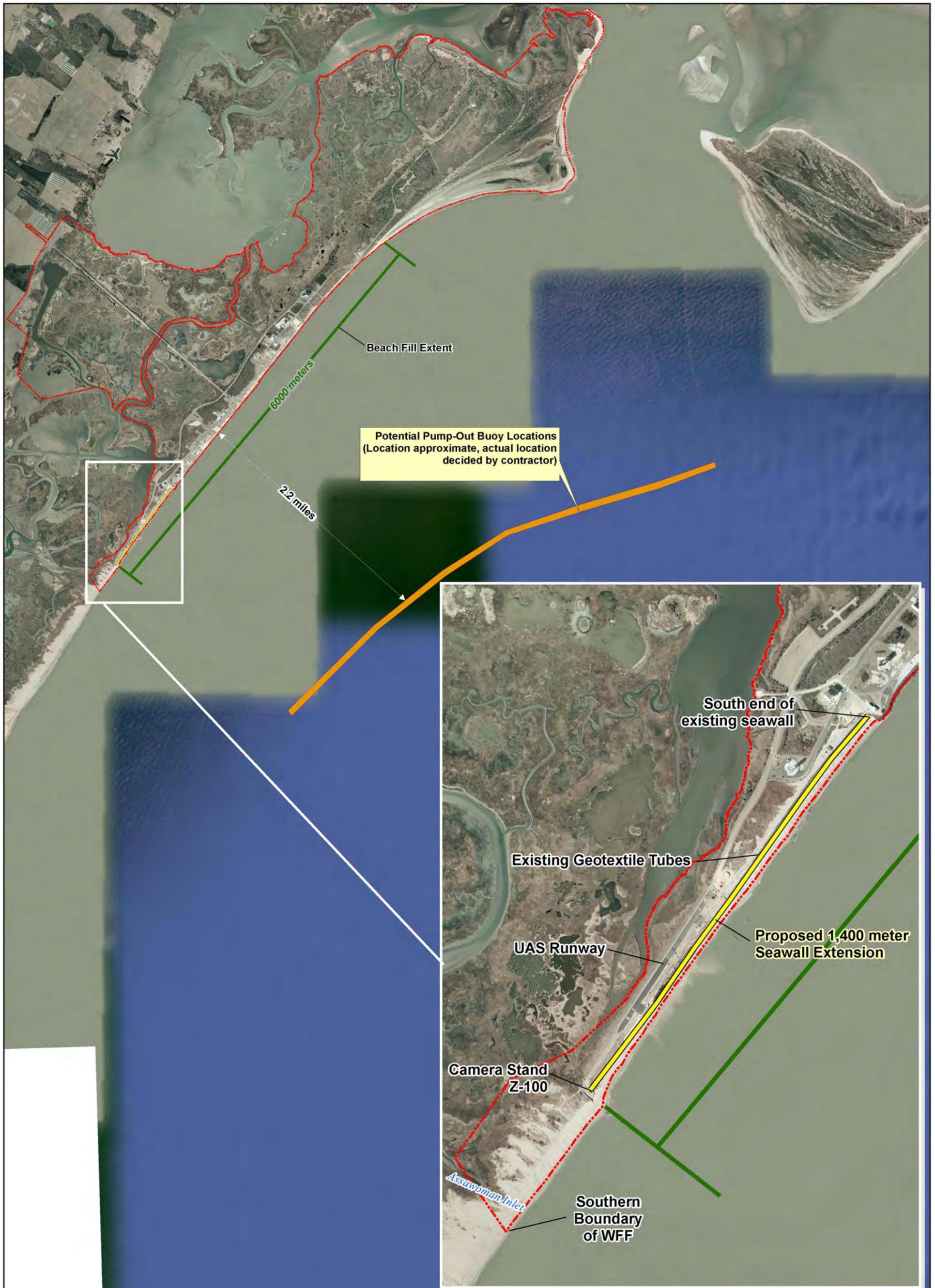
The seawall would consist of 4.5- to 6.4-mt (5- to 7-ton) rocks and would be placed on the beach (some rock slightly below the beach surface, the majority of the rock sitting on top of the beach surface). The top of the seawall would be approximately 5 m (14 ft) above the normal high tide water level, depending on the extent of existing shoreline retreat (see cross section on Figure 15). Due to the size of the rocks needed for seawall construction, it is anticipated that they would be transported to the WFF area by rail, offloaded, and trucked over the road to the desired destination on Wallops Island for placement.

2.5.1.3 Beach Fill

Beach Fill Design

Beach fill is a necessary component of all three Proposed Action Alternatives as the new beach would provide a surface to dissipate wave energy, counteract sea-level rise effects, and contribute additional sediment to the nearshore system. The beach fill would start approximately 460 m (1,500 ft) north of the Wallops Island-Assawoman Island property boundary (near camera stand Z-100 shown on Figure 14) and extend north for 6.0 km (3.7 mi).

The initial fill would be placed so that there would be a 1.8-m-high (6-ft-high) berm extending a minimum of 21 m (70 ft) seaward of the existing seawall. The remainder of the fill would slope underwater for an additional distance seaward; the amount of that distance would vary along the length of the beach fill, but would extend for a maximum of about 52 m (170 ft), so that the total distance of the fill profile from the seawall would be up to approximately 73 m (240 ft). The beach fill profile would also include a 4.3-m-high (14-ft-high) dune at the seawall (shown in yellow on Figure 16). The front sloping face of the dune would rest against the seawall. Sections of sand fence approximately 3 m (10 ft) long would be installed at approximate 45 degree angles to the shoreline along the entire length of the seaward side of the new dune (Figure 15). The sections of sand fence would be spaced approximately 2 m (7 ft) apart to allow wildlife passage from the dune to the ocean.



Title: **Seawall Extension and Beach Fill Overview**

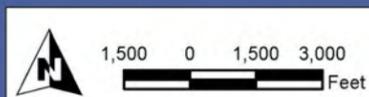


URS Proj No:15301785

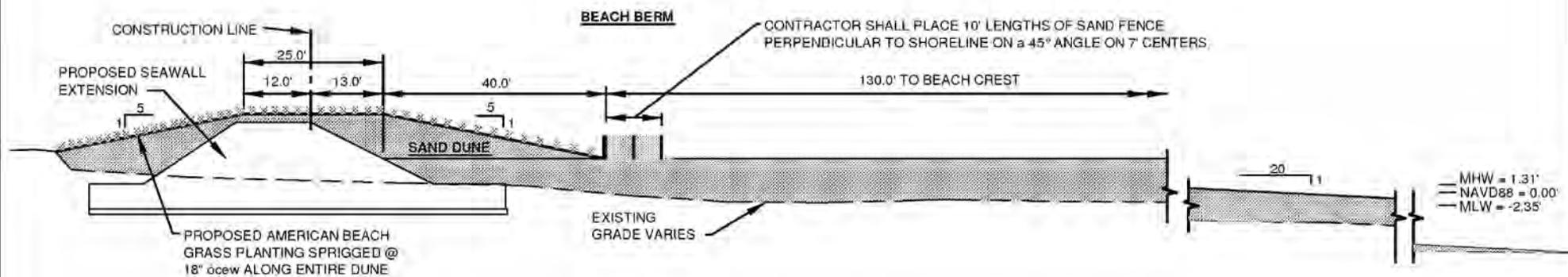
Figure: **14**

Client : NASA

Shoreline Restoration Environmental Impact Statement



This page intentionally left blank.



TYPICAL REVETMENT EXTENSION AREA BEACH FILL SECTION

Scale: 1" = 30'



Title: Profile of Typical Revetment Extension Area Beach Fill Section



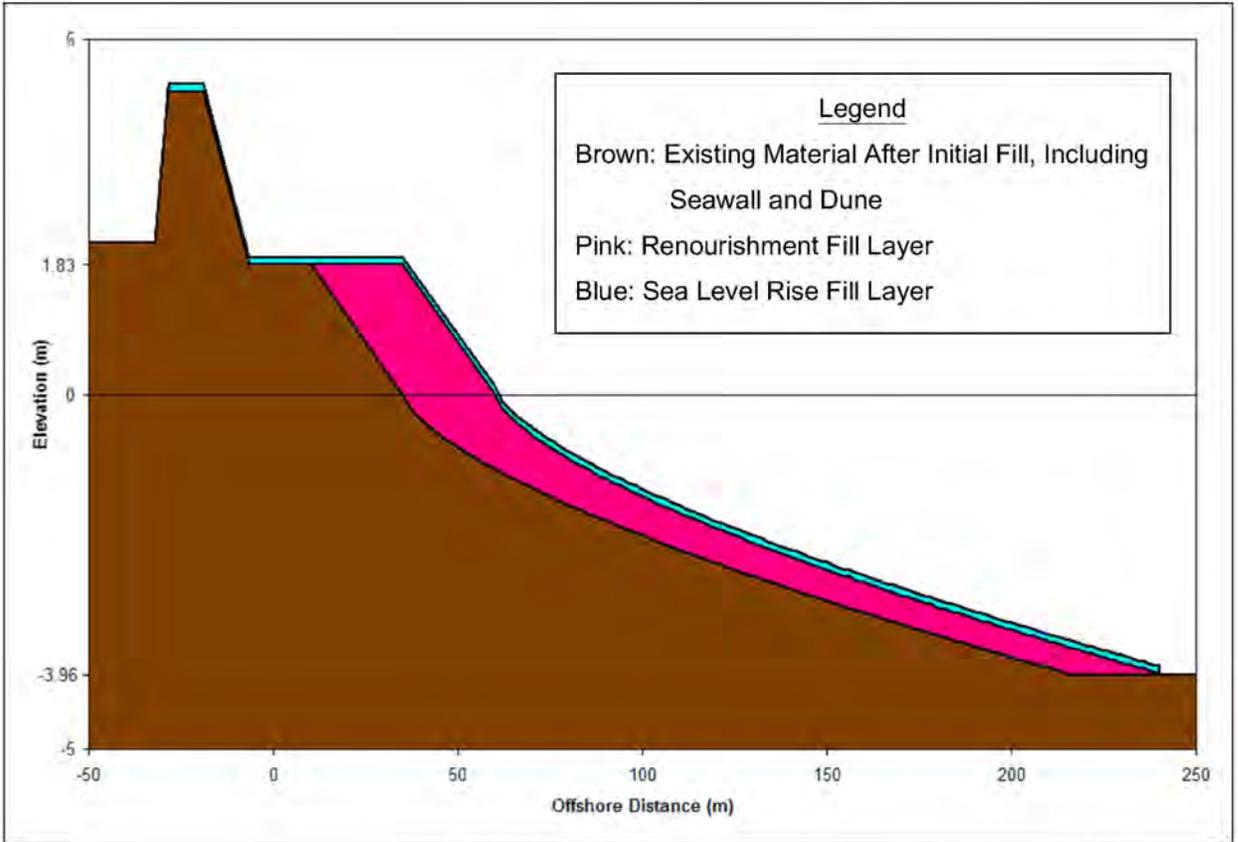
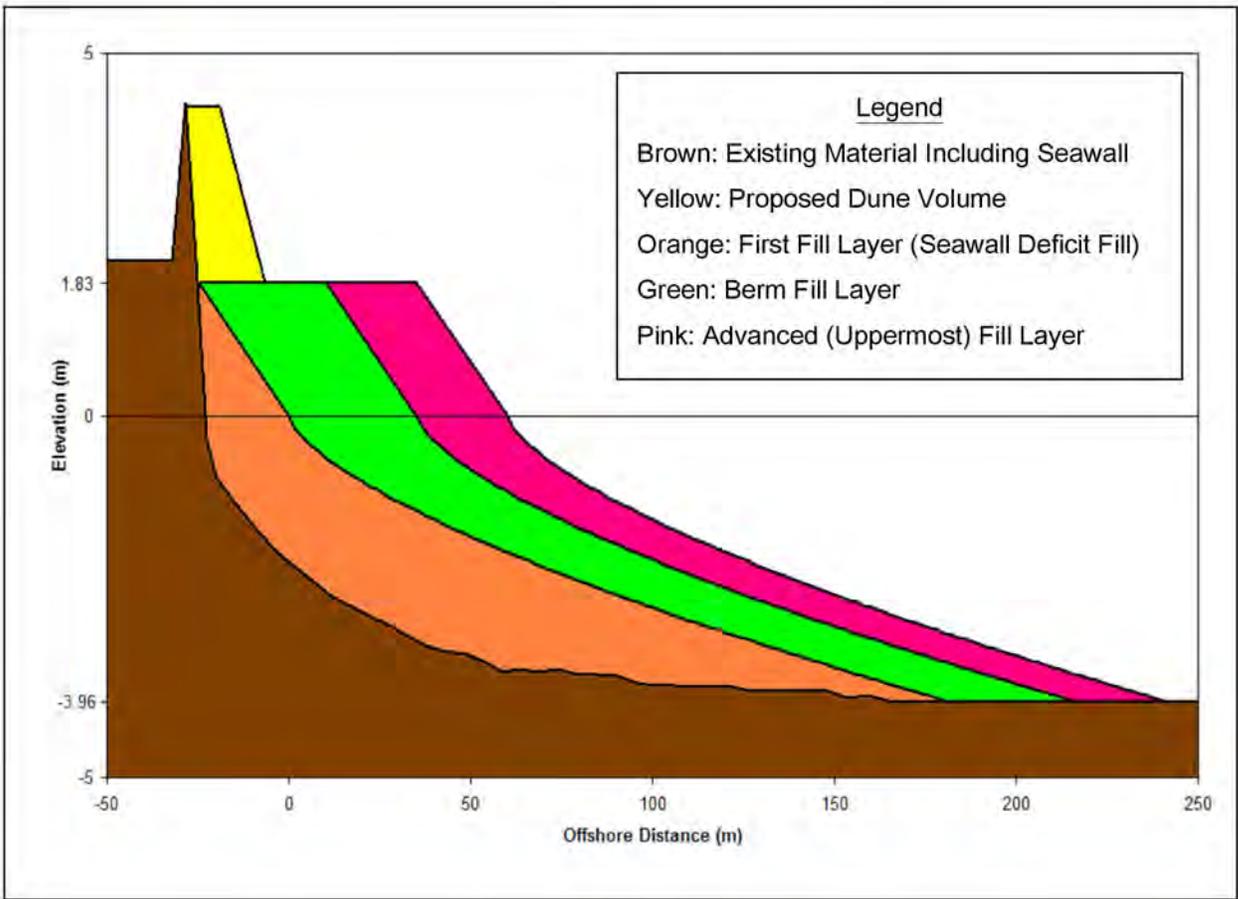
URS Proj No: 15301785

Figure: 15

Client : NASA

Shoreline Restoration Environmental Impact Statement

This page intentionally left blank.



Title: Fill Material Conceptual Diagrams	
	URS Proj No: 15301785
	Figure: 16
Client : NASA	
Shoreline Restoration Environmental Impact Statement	

This page intentionally left blank.

The beach fill would be composed of two primary components: the anticipated minimum amount (minimum target fill) needed to provide defense from storm damage, plus an additional sacrificial amount (the advanced fill) that is expected to be removed by longshore transport between renourishment events. This approach strives to ensure that the minimum amount of fill remaining at the project site, just before renourishment, would still provide adequate storm damage reduction (USACE, 2002; Gravens, et al., 2006). The volumes needed for the minimum target fill were based upon SBEACH (Storm-Induced BEACH CHange) modeling, and the amount of advanced fill was determined by GENESIS modeling, both conducted by the USACE (Appendix A). A larger volume of advanced fill material would be placed at the updrift end of the project, with little or no advanced fill placed at the downdrift end of the project area.

Figure 16 shows a conceptual representation of the components of the initial and renourishment fill profiles. The initial fill includes a seawall deficit volume, a berm volume, a dune volume, an overfill volume, and an advanced nourishment volume (Figure 16). The renourishment fill includes the advanced fill volume and a sea-level rise volume. The sea-level rise fill volume was accounted for by including an additional amount of material at each renourishment event that would raise the entire beach profile by an amount equal to the projected amount of sea-level rise, as estimated by King et al. (USACE, 2010a) in the USACE analysis and design.

The placement of sand on the shoreline for the initial beach fill would occur within the first 3 years of the SRIPP (USACE, 2010a). No beach fill work is planned for Year 1. In Year 2, placement activities would likely move south to north and would be initiated to restore the underwater area in front of the seawall to its equilibrium condition (USACE, 2010a). The remainder of the initial fill volume would be placed in Year 3 (USACE, 2010a). The existing seawall has halted the shoreline retreat along its length; however, this has come at the cost of sediment being removed below the waterline in front of the seawall, steepening the underwater profile from the seawall seaward and leaving a sediment deficit especially in the middle portions of the existing wall. The “equilibrium condition” is the natural state of the underwater beach profile. Through modeling, the USACE determined that the volume of sand placed on the Wallops Island shoreline in Year 2 of would restore this profile close to its natural, or equilibrium, condition.

Effects of Grain Size on Beach Fill Design

A sediment grain diameter of 0.29 mm was chosen to represent the fill material for modeling each Proposed Action Alternative. This value is considered conservative because most of the offshore borrow site samples have median grain sizes larger than this, particularly at Unnamed Shoal A, the preferred borrow site. However, there are relatively few sample cores available to characterize this sediment. As such, it should be noted that an overestimate of grain size would have a substantial effect on the underwater volume of fill material needed for the initial placement. To illustrate this, King et al. (USACE, 2010a) calculated such volumes. If the actual grain size of sand placed on the beach was 0.28 mm, an additional volume of over 45,900 m³ (60,000 yd³) would be needed; encountering finer sediments of 0.25 mm (which is much less likely than encountering grain sizes in the 0.28 – 0.29 mm range) would require approximately 221,700 m³ (290,000 yd³) of additional material. The statistical likelihood of the true median grain diameter of the material on the two potential shoals being less than 0.29 mm decreases rapidly with smaller grain size.

Description and Comparison of Alternatives

There would be fewer impacts to the above water portion of the profile compared to the underwater portion. Impacts would be mostly limited to the portion of the profile between mean sea level (MSL) and the berm crest (the foreshore slope). This portion of the beach profile is exposed to wave action during the higher times of the tide cycle and can be expected to reach an equilibrium slope based upon grain size in a manner similar to the underwater portion of the profile (steeper slopes for larger grain sizes). The native beach material at Wallops Island is about 0.20 mm, and the foreshore slope is naturally adjusted for that grain size. The beach fill design modeling was based on the measured slopes from the beach on Wallops Island. The grain size of the fill material is expected to be larger than 0.20 mm, and thus following nourishment the foreshore slope would likely be steeper than at present. A steeper foreshore slope would require less fill material between the berm crest and the depth of closure than is called for in the present design, and therefore the present beach fill design is considered conservative.

Additionally, any of several other reasons (including, but not limited to: model limitations, estimate of the depth of closure, or an unusually stormy wave climate in the years following placement) could lead to an underestimation of the volume of material needed for the initial fill. To help compensate for this potential, an additional amount of material (95,600 m³ [125,000 yd³], the overflow volume) is specifically included in the total initial fill volume. However, if the total initial fill volume used is less than the volume needed, the most likely result would be that the first renourishment event would need to occur sooner than the expected 5-year time frame. Otherwise, the design level of storm damage protection provided by the SRIPP in the time period preceding renourishment would be compromised. On the other hand, if the total initial fill volume used is in excess of that required, the first renourishment event could be appropriately postponed.

Sources of Beach Fill Material

Unnamed Shoal A only would be used to obtain initial fill volumes under all three alternatives. For renourishment fill volumes, up to one-half of the fill volume could be excavated from the north Wallops Island borrow site, and the remaining half—or the entire renourishment volume—would be dredged from either Unnamed Shoal A or Unnamed Shoal B.

Subsequent beach renourishment cycles would vary throughout the 50-year life of the Proposed Action. Storm frequency and severity would dictate the magnitude and rate of recurrence of beach renourishment. The timing and volume of material placed during renourishment events would be based upon an analysis of the monitoring data. For the purpose of this PEIS, the renourishment cycle is expected to be every 5 years.

2.5.2 Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

In the initial nourishment, NASA would place an estimated 2,446,000 m³ (3,199,000 yd³) of fill (minimum and advanced target fill combined) along the shoreline. The renourishment cycle is anticipated to involve approximately 616,000 m³ (806,000 yd³) of sand every 5 years. The initial fill plus the total fill volume over nine renourishment events would result in approximately 7,992,000 m³ (10,453,000 yd³) of sand being placed on the shoreline.

The absence of sand retention structures would result in a larger amount of sand being available for erosion and longshore transport.

2.5.3 Alternative Two: Full Beach Fill, Groin, Seawall Extension

Beach fill would be placed along the same length of the shoreline as described under Alternative One, but because less initial nourishment and renourishment fill would be required, the beach profile would not extend as far into the ocean (Figure 17).

Construction of a groin (described below) would result in more sand being retained along the Wallops Island shoreline, so less fill would be required for both the initial nourishment and renourishment volumes compared to Alternative One. The initial fill volume would be an estimated 2,229,000 m³ (2,916,000 yd³), and each renourishment fill volume would be approximately 552,000 m³ (722,000 yd³). The initial fill plus the total fill volume over nine renourishment events would result in approximately 7,198,000 m³ (9,414,000 yd³) of sand being placed on the shoreline.

In addition, a groin would be constructed at the south end of the Wallops Island shoreline (Figure 17). Groin construction would occur in the third year of the SRIPP, after seawall construction in Year 1 and the first phase of beach fill in Year 2. Construction would involve the placement of rocks in a linear structure perpendicular to the shoreline at approximately 445 m (1,460 ft) north of the Wallops Island-Assawoman Island border (Figure 17). The rocks would be similar in size to those used for the seawall.

The groin would be constructed of 4.5 to 6.4 mt (5 to 7 tons) of rocks placed perpendicular to the shore. The structure would be approximately 130 m (430 ft) long and 15 m (50 ft) wide, and would take approximately 1 month to build. Approximately two-thirds of the groin (80 m [265 ft]) would be installed on the beach once the fill has been placed, and the remaining one-third, approximately 50 m (165 ft), would extend beyond the beach into the ocean. As with the rocks needed for the seawall extension, the rocks for constructing the groin would be transported to the WFF area by rail, offloaded, and trucked to the handling or placement site on Wallops Island.

2.5.4 Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

Beach fill would be placed along the same length of the shoreline as described under Alternatives One and Two, but because the least volume of initial nourishment and renourishment fill would be required, the beach profile would not extend as far into the ocean as Alternatives One and Two (Figure 17).

Construction of the breakwater (described below) would result in the most sand being retained along the Wallops Island beach, so the least amount of fill would be required for both the initial nourishment and renourishment volumes compared to Alternatives One and Two. The initial fill volume would be 2,170,000 m³ (2,839,000 yd³), and each renourishment fill volume would be 537,000 m³ (703,000 yd³). The initial fill plus the total fill volume over nine renourishment events would result in approximately 7,008,000 m³ (9,166,000 yd³) of sand being placed on the shoreline.

In addition, a nearshore breakwater structure would be constructed at the south end of the Wallops Island shoreline in the third year of the SRIPP, after seawall construction in Year 1 and the first phase of beach fill in Year 2 (Figure 17). A single breakwater would be constructed approximately 230 m (750 ft) offshore in order to avoid tombolo formation. A tombolo forms as sand deposited in the sheltered area behind the breakwater connects the breakwater to the beach. A tombolo would block longshore sediment transport and cause erosion on the downdrift side of

Description and Comparison of Alternatives

the feature. Eventually, sand transport may resume along the seaward face of the breakwater, but the water may be too deep for large amounts of transport to occur.

The breakwater would be constructed of 4.5 to 6.4 mt (5 to 7 tons) of rocks placed parallel to the shore and would measure approximately 90 m (300 ft) long and 35 m (110 ft) wide (Figure 17). Similar to the seawall extension and groin, the rocks for constructing the breakwater would be transported to the WFF area by rail, offloaded, and then trucked to the handling or placement site on Wallops Island. Construction, estimated to last approximately 1 month, would take place in the water using a barge and heavy lifting equipment.

2.5.5 Summary of Dredge and Fill Volumes for Each of the Alternatives

Table 7 below shows the estimated volumes of sand that would be placed on the Wallops Island beach during the project lifecycle for each alternative considered.

Table 7: Fill Volumes for the Alternatives

Volume Type	Alternative One m ³ (yd ³)	Alternative Two m ³ (yd ³)	Alternative Three m ³ (yd ³)
Initial Fill	2,446,000 (3,199,000)	2,229,000 (2,916,000)	2,170,000 (2,839,000)
Renourishment	616,000 (806,000)	552,000 (722,000)	537,000 (703,000)
Number of Renourishment Events	9	9	9
Project Lifetime	7,992,000 (10,453,000)	7,198,000 (9,414,000)	7,008,000 (9,166,000)

Source: USACE, 2010a

Because of overflow from the hopper dredge at the offshore borrow sites during dredging, pump-out, and placement, a larger volume of material would need to be dredged to meet the targeted fill volume. Based on information from other shoreline restoration projects, sediment losses during dredging and placement operations may be up to 25 percent (Wikel, personal comm.). Using a conservative 25-percent loss factor for the SRIPP, estimated dredge volumes for the offshore borrow sites in order to meet the targeted fill volumes are shown in Table 8.

Table 8: Dredge Volumes for Alternatives

Dredge Event	Alternative One m ³ (yd ³)	Alternative Two m ³ (yd ³)	Alternative Three m ³ (yd ³)
Initial Fill	3,057,500 (3,998,750)	2,786,250 (3,645,000)	2,712,500 (3,548,750)
Renourishment	770,000 (1,007,500)	690,000 (915,000)	671,250 (878,750)
Project Lifetime	9,990,000 (13,066,250)	8,997,500 (11,767,500)	8,760,000 (11,457,500)



This page intentionally left blank.

2.5.6 Delineation of Shoal Study Areas

NASA delineated a study area on each of the two offshore shoals A and B based upon early planning estimates of the area needed to obtain the necessary borrow volumes. The borrow areas were sized based on a comparison with the USACE Atlantic Coast of Maryland Project for the Short-Term Restoration of Assateague (USACE, 2008). For this exercise, assuming an approximate 1.8-m (6-ft) dredging depth, the amount of shoal area required to obtain the necessary beach fill material for Alternative One would be approximately 5.2 km² (2 mi²), or 520 ha (1,280 ac). Because this area would likely be the largest dredge or borrow area on each of the proposed shoals, it was established as the study area for resources such as benthic (bottom) habitats and submerged cultural resources. If the need arose to consider dredging outside of this study area, additional studies would be conducted and supplemental NEPA analyses prepared as appropriate.

2.5.7 Dredging and Sand Placement Operation

2.5.7.1 *Offshore Dredging Method*

Trailer suction hopper dredges are the most likely dredges to be used for the SRIPP. These dredges are self-propelled, seagoing vessels and are equipped with propulsion machinery, a sediment container (i.e., hopper), dredge pumps, and other specialized equipment required to perform the essential function of excavating sediments from the sea floor. Hopper dredges have enough horsepower for required free-running speed and dredging against strong currents, and have excellent maneuverability.

The hopper dredge fills its hoppers by employing large pumps to create suction in pipes that are lowered into the water to remove sediment from the shoal bottom (the process very closely resembles that of a typical vacuum cleaner, Photo 6). The hopper dredges likely to be used typically remove material from the bottom of the sea floor in layers up to 0.3 m (1 ft) in depth (Williams, personal comm.).

Centrifugal pumps within the hull, sometimes mounted on the drag arm, create a region of low pressure or centrifugal force around the drag heads. This low pressure forces water and sediment up the drag arm and into the hopper. The closer the drag head is to the sediment, the more efficient the dredging.

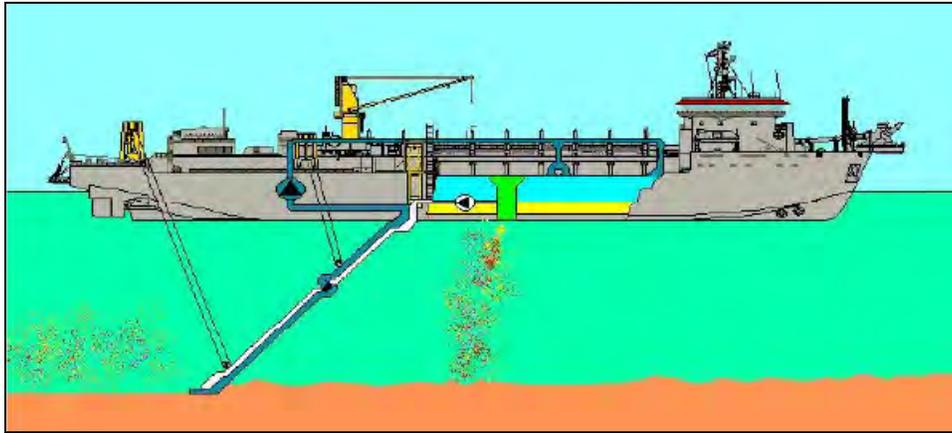
Once the dredge hopper is filled, the dredge would transport the material to a pump-out buoy or station that would be placed at a water depth of approximately 9 m (30 ft), which would be approximately 3 km (2 mi) offshore of the placement area (Figure 14). The pathway from Unnamed Shoals A and B to the pump-out buoy is not a straight line, but a dogleg shape with a turning point, for the purpose of avoiding Chincoteague Shoal and Blackfish Bank. The distance from the turning point to the pump-out buoy is approximately 5 km (8 mi). The one-way distance from Unnamed Shoal A to the theoretical pump-out buoy is approximately 22 km (14 mi), and the corresponding transit distance from Unnamed Shoal B to the theoretical pump-out buoy is approximately 31 km (19 mi). Booster pumps may be needed to aid the offloading of sand from the pump-out buoy to the shoreline.

Based on previous offshore dredging operations along the east coast, it is assumed that dredgers with a hopper capacity of approximately 3,000 m³ (4,000 yd³) would be used; however, because this volume is a slurry and not all sand, the actual volume of sand that each dredge would

Description and Comparison of Alternatives

transport during each trip would be approximately 2,300 m³ (3,000 yd³). The dredges would operate for 12- to 24-hour stretches.

Photo 6: Schematic of a self-propelled trailer suction hopper dredge



Source: MMS 2004-076

2.5.7.2 Offshore Dredging Plan

During the planning process for the SRIPP, NASA and USACE evaluated two BOEMRE-sponsored studies that served as the basis for the SRIPP dredging plan. The studies are: *Analysis of Potential Biological and Physical Impacts of Dredging on Offshore Ridge and Shoal Feature* (CSA International, Inc. et al., 2009), and *Investigation of Dredging Guidelines to Maintain and Protect the Integrity of Offshore Ridge and Shoal Regimes* (Dibajnia and Nairn, *in press*). The two studies focused on shoals north of the SRIPP project area; however, the authors of the papers stated that their recommendations are generally applicable to shoals off the coast of Delaware, Maryland, and Virginia.

The primary recommendations NASA considered in developing the dredging plan are listed below.

From CSA International, Inc. et al., (2009):

- Extract sand from a depocenter, or leading or downdrift margin of a shoal, to avoid interrupting natural shoal migration and potentially reduce the time required for site refilling.
- Avoid dredging in erosional areas that source downdrift depocenters, which also may be slow to refill after dredging.
- Employ shallow dredging over large areas rather than excavating small but deep pits.
- Dredge in a striped pattern to leave sediment sources adjacent to and interspersed throughout target areas, leading to a more uniformly distributed infilling process.
- Excavate material from shoal crests and higher areas of the leading edge rather than lower areas on the shoals because of greater sediment mobility, which potentially results in more rapid sediment reworking and site infilling.

From Dibajnia and Nairn, *in press*:

- Dredge only those shoals located in less than 30 m depth as they have the potential to re-grow after dredging. Shoals with a Base Depth of greater than 30 m should not be dredged if it is determined to be important to maintain the pre-dredge shoal height from an ecological perspective.
- Avoid dredging shoals with Relative Shoal Height (defined as Height/Base Depth) of less than 0.5 if shoal recovery to its pre-dredge height is desired from an ecological perspective. Shoals with Relative Shoal Height of less than 0.5 are not likely to recover after dredging.
- Target shoals that are approaching their maximum Relative Shoal Height (defined as [Base Depth-5]/Base Depth) because a fully grown shoal (in height) can potentially re-grow and rebuild itself to the same height upon being dredged.
- Avoid dredging sand from the entire length of the shoal. Longitudinal dredging (i.e., dredging all along the longer axis) is not preferred because it affects wave focusing processes and the shoal does not recover to the same pre-dredge height.
- Dredge from shoal flanks below the -10-m contour over the southwest half of the shoal because it is expected to have little effect on shoal integrity and little change is anticipated for the dredged area. This dredging option is practical if it can provide sand suitable for nourishment.

Initial Fill

To identify accretional areas per the above recommendations, NASA performed a GIS analysis on the change in shoal topography between 1934 and 1978/1982 using NOAA National Ocean Service Office of Coast Survey data. Based on this analysis, accretional areas were found to be generally on the seaward or east flank of the shoals. The southern portion of the landward sides of Shoals A and B were found to be eroding over the long term.

To further refine dredging plans, NASA and USACE then delineated the limits of three sub-areas for consideration within the (5.2 km²) (2 mi²) study blocks on Shoals A and B (Figure 18). The preferred areas for dredging (labeled as A-1 and B-1 on each respective shoal) were identified first. The width of these preferred areas was established by overlaying the vibrocore sample data (to identify suitable [coarsest] fill material) on the abovementioned shoal topographic change maps (to avoid erosional areas). The sub-area length was then established by estimating the distance needed for an oceangoing dredge to fill its hopper in “up and back” cycles, thus maximizing efficiency; this distance was calculated to be approximately 3.2 km (2 mi), less than the entire longitudinal length of either shoal. Once the preferred areas were delineated, the remaining sub-areas (A/B 2 and 3) within the larger study area were established. Sub-area A-1 was chosen over B-1 as the preferred initial dredge site due to its proximity to the Wallops Island Beach (and resulting lower estimated project cost).

Consistent with the recommendations of the BOEMRE studies, dredging would occur in areas that are accreting to the extent practicable, with erosional areas avoided to the extent practicable. Additionally, the dredge depth needed to obtain the required fill volume would not be excessive at approximately 2 m (6.6 ft). However, due to the inherent inaccuracies in open ocean hopper

Description and Comparison of Alternatives

dredging as a result of variable sea conditions (the variation is estimated to be about 0.6 m [2 ft]), actual dredged depths could likely be closer to 3 m (9.8 ft) in some areas.

At this point, NASA is not considering dredging in a striped pattern due to its expected adverse effects on dredging efficiency, which would lead to much higher project costs. There is also no plan to avoid shoal crests as recent studies have indicated that there is potential for recovery of shoal crest height provided the dredging cut depth is not excessive (CSA International Inc. et al., 2009; Dibajnia and Nairn, *in press*). In addition, the crests have lower benthic abundance and diversity than the flanks and adjacent troughs (e.g., Cutter and Diaz, 2000; Diaz et al., 2006; Slacum et al., *in press*). Per Dibajnia and Nairn (*in press*) recommendations, NASA would not dredge along the entire length of the shoal.

In summary, for the initial fill, sub-area A-1 on Shoal A would be targeted first. Portions of sub-area A-2 would only be dredged (to a similar depth) in an off-nominal condition, such as the discovery of a previously unidentified underwater obstruction or if fill material is substantially finer than what was shown by the exploratory vibracores. Sub-area A-3 would not be dredged for initial fill.

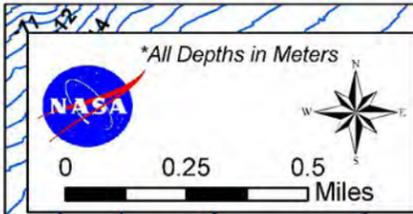
Renourishment Fill

NASA would follow the same general dredging guidelines for planning renourishment fill cycles as for initial fill and would consider use of either Shoal A or Shoal B for offshore borrow material. However, due to potential changes in the recommended dredging methodology and based on shoal conditions as determined by monitoring and new studies, dredging plan details would be developed prior to renourishment cycles. If conditions warrant, and with appropriate agency consultations, NASA may modify its approach in the future.

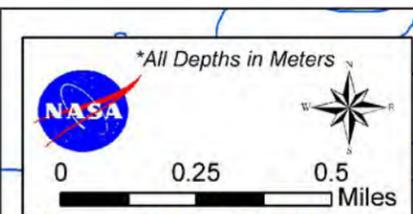
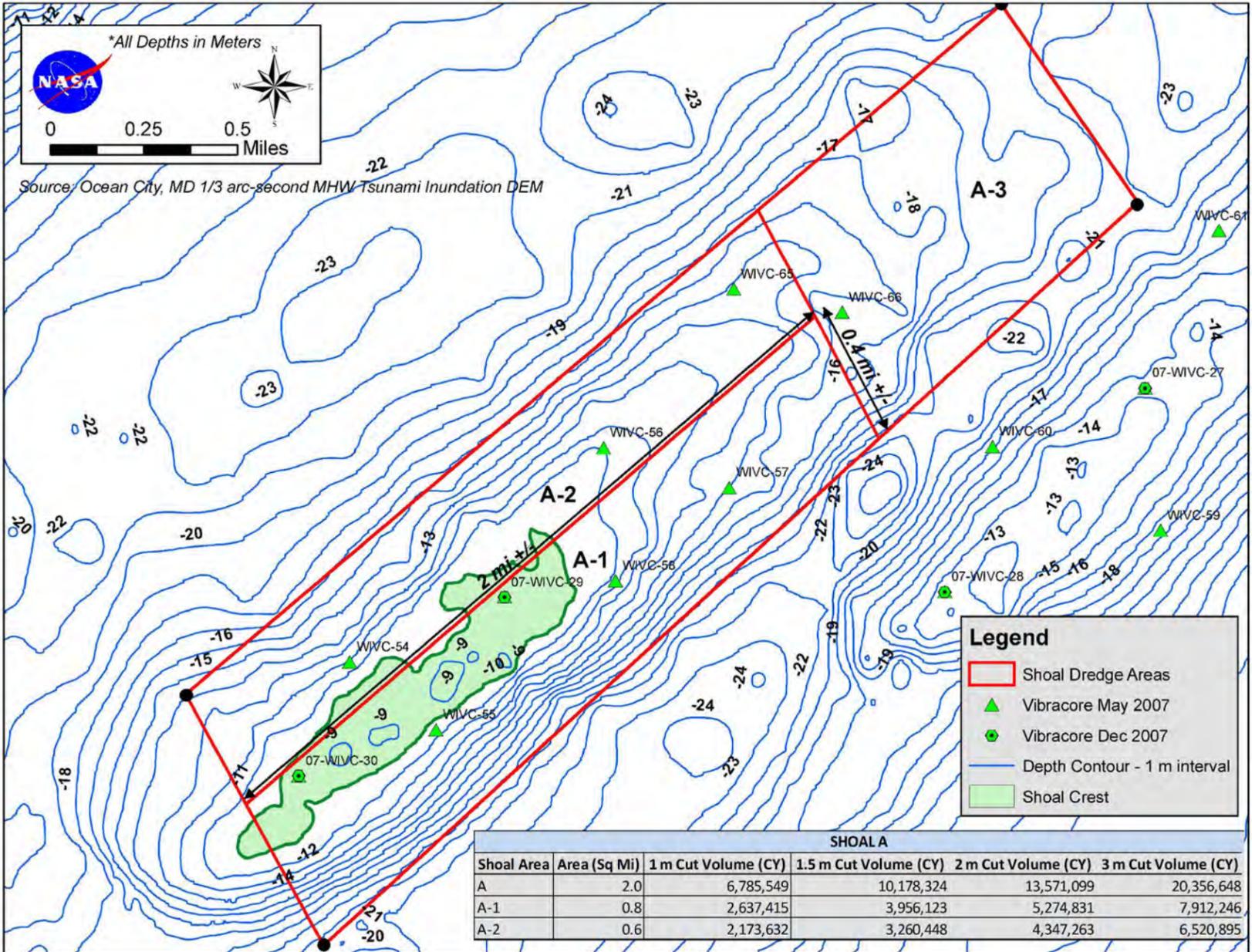
Additional details of the SRIPP dredging plan (including an assessment of shoal geometry such as Relative Shoal Height and Base Depth) are described in NASA's Essential Fish Habitat (EFH) consultation with the National Marine Fisheries Service (NMFS) (see Appendix J).

2.5.7.3 Sand Placement from Offshore Dredging

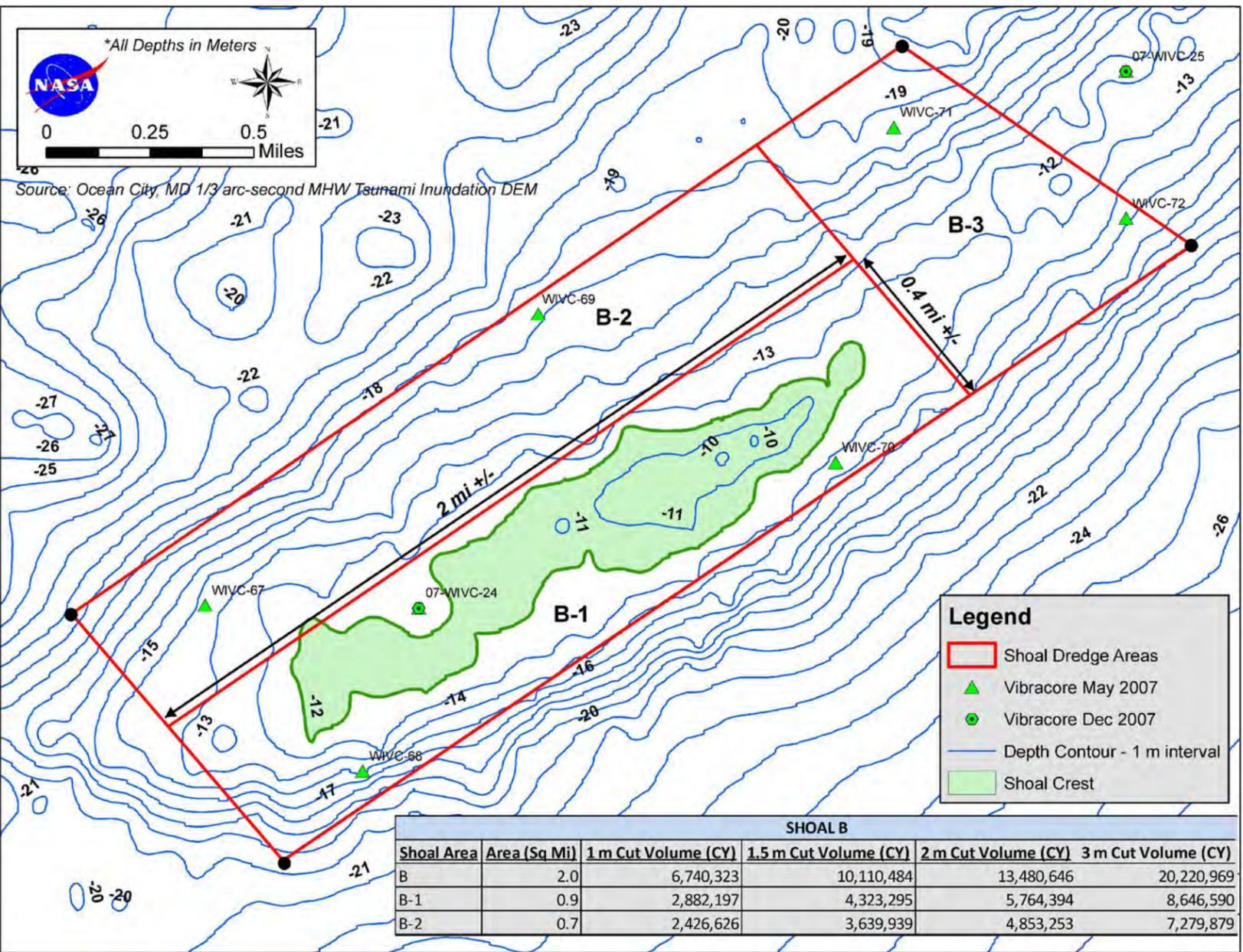
Once the dredge arrives at the pump-out buoy (approximately 3 km [2 mi] offshore), it would connect to the discharge pipeline on the buoy. The dredge would then mix the dredged sand with water to form a slurry, and pump the slurry from its discharge manifold through a submerged or floating pipeline. Discharge at the beach would occur at a fixed point in tandem with contouring of the deposited sand by bulldozers. Booster pumps may be needed to aid in offloading the sand from the pump-out buoy to the shoreline.



Source: Ocean City, MD 1/3 arc-second MHW Tsunami Inundation DEM



Source: Ocean City, MD 1/3 arc-second MHW Tsunami Inundation DEM



This page intentionally left blank.

2.5.7.4 North Wallops Island Borrow Site

A pan excavator would likely be used to remove sand from the north Wallops Island borrow site (Photo 7). Because it runs on several rubber tires with a low tire pressure, it can work in areas of the beach where typical equipment may be bogged down in unstable sand. The pan excavator would stockpile the sand, which would be loaded onto dump trucks that would transport the fill material up and down the beach. Bulldozers would then be used to spread the fill material once it is placed on the beach. All heavy equipment would access the beach from existing roads and established access points. No new temporary or permanent roads would be constructed to access the beach or to transport the fill material to renourishment areas.

Photo 7: Example of a pan excavator



2.6 SUMMARY AND COMPARISON OF ALTERNATIVES

This section summarizes and compares the potential environmental impacts, presented in detail in Chapter 4, of the Proposed Action Alternatives and No Action Alternative.

The four alternatives carried forward for analysis in this PEIS are:

- Alternative One (Preferred Alternative) – Beach Fill, Seawall Extension
- Alternative Two – Beach Fill, Groin, Seawall Extension
- Alternative Three – Beach Fill, Breakwater, Seawall Extension
- No Action Alternative

For initial fill volumes under all three Proposed Action Alternatives, only Unnamed Shoal A would be used because it is closer than Unnamed Shoal B and requires less transit time and fuel. Dredging at Unnamed Shoal A and B would result in similar environmental impacts. For renourishment fill, a portion of the fill volume could be excavated from the north Wallops Island borrow site, or the entire fill volume could be dredged from either Unnamed Shoal A or Unnamed Shoal B.

2.6.1 Implementation Schedule

WFF does not expect to receive sufficient funding to implement all of the initial components (seawall extension and initial phase of the beach fill) in a single year. Instead, the initial components would be staged and completed over a 3-year time span. The order in which

Description and Comparison of Alternatives

construction would occur has been carefully considered. The first year of construction would consist of the approximately 400-m (1,315-ft) seawall extension. Years 2 and 3 would be dedicated to dredging and placement of beach fill. If the expected funding in Year 2 or Year 3 is postponed or cancelled, the completed portions of the project would be viable projects themselves and would not have negative shoreline consequences either to Wallops Island or to its neighbors (USACE, 2010a). However, each individual project element (seawall and beach fill) would only partially fulfill the purpose and need of the SRIPP and therefore would not intentionally be constructed by itself as a long-term solution. In Year 2, funding is expected to be available to place approximately 917,000 m³ (1.2 million yd³) of fill material. Year 3 funding would allow for placement of the remaining beach fill, expected to be approximately 1,530,000 m³ (2 million yd³) of sand.

Using the total volumes listed in Table 7 and Table 8, the initial beach fill would require approximately 1,000 to 1,100 dredge trips from the offshore borrow sites to the Wallops Island shoreline and each renourishment fill would require approximately 240 to 270 dredge trips. Two dredges would be in use at the same time and would accomplish about three round trips per day. Assuming 10-percent downtime for the dredges due to weather, equipment failure, etc., the 917,000 m³ (1.2 million yd³) volume of fill placed in Year 2 would result in approximately 410 dredge trips and would take approximately 81 days, or about 3 months. The remaining volume to be placed under Alternative One, approximately 1,530,000 m³ (2 million yd³) would result in approximately 690 dredge trips and would take approximately 135 days, or about 4.5 months. Renourishment activities (assuming all fill is taken from one of the proposed offshore shoals) would take approximately 50 days, or about 2 months each cycle.

The implementation schedule in Table 9 would apply to all of the Proposed Action Alternatives.

Table 9: Implementation Schedule

Project Year	Activity	Time Required for Implementation
Year 1	Construction of the seawall extension	7 months
	Initiation of a monitoring program	Ongoing
Year 2	Partial initial beach fill and dredging	3 months
	Continuation of the monitoring program	Ongoing
Year 3	Completion of initial beach fill dredging	4.5 months
	Construction of the groin, breakwater, or neither, depending upon the alternative chosen	1 month (same for both groin and breakwater)
	Continuation of the monitoring program	Ongoing
Year 8	First renourishment fill	2 months

2.6.2 Consideration of Costs and Benefits

The planning process for USACE Civil Works projects requires that a cost-benefit analysis be performed to ensure that the benefits of a proposed project outweigh the costs, thereby providing a justification for implementation. As the SRIPP is not a USACE project but would rather be funded through NASA appropriations, conducting a cost-benefit analysis using a standard

Description and Comparison of Alternatives

USACE methodology is not required prior to project implementation and was therefore not performed. However, in planning the SRIPP, NASA worked closely with USACE to consider the costs of each alternative and whether the benefit realized (storm damage reduction) would outweigh the monetary expenses.

Following the initial and secondary screening of alternatives described in Sections 2.3 and 2.4, USACE prepared lifecycle cost estimates for each alternative analyzed in detail in this PEIS. Of the three Proposed Action Alternatives considered in detail in this PEIS, several iterations of those alternatives were evaluated, with the difference being the sand source (Shoal A, Shoal B, north Wallops Island, or a combination) for initial construction and future renourishment cycles. Based on the sand source, project lifecycle costs ranged from \$87 million to approximately \$100 million in 2010 U.S. dollars.

Regarding the benefits of storm damage reduction, NASA first assessed the values of the Federal and State infrastructure located on Wallops Island. The current replacement value of the Wallops Island infrastructure is just over \$1 billion, with an additional \$100 million expected within the next several fiscal years. Although the reduction in direct damage to infrastructure is a primary goal of the SRIPP, its true benefit is the continued use of the island to support the aerospace programs that are at the core of WFF's mission.

Attempting to estimate the value of the benefits to WFF programs and projects throughout the 50-year term of the SRIPP would be highly speculative given the fact that the facility, as a research range, is subject to short-lived, intensive projects that come and go. As such, NASA found it more appropriate to consider the shorter-term (i.e., approximately 5 to 10 years) benefits of programs and projects that are established and more certain.

Since its founding as a U.S. government aerospace test range, WFF has supported a regular manifest of suborbital rocket missions. These missions, typically flown on sounding rockets, currently take place at a frequency of approximately 30 per year. The value of each sounding rocket mission is \$3 million, totaling approximately \$90 million annually. This money primarily stays at NASA and in the local economy. The value of each Expendable Launch Vehicle mission, 2-8 of which may reasonably occur annually within the next 5 to ten years, is \$200 million, with about \$3 million of that being provided locally for range support excluding tourism (\$6-24 million annually). Up to 20 UAS missions could occur per week, each with a value of \$100,000, with about \$20,000 of that going directly to WFF for a week of flight (approximately \$1 million annually). In total, these missions and activities at Wallops Island add up to between approximately \$97-115 million annually, and do not include revenues generated by local businesses for lodging, meals, and other tourism-based activities, which would increase the positive economic impact.

Additionally, the recent decision of Orbital Sciences Corporation to base its operations at WFF for the Commercial Orbital Transportation System and Commercial Resupply Services contracts to supply the International Space Station represent an up to \$1.9 billion economic impact over at least 5 years that would span globally, with its core operations being at the launch facilities on Wallops Island.

After reviewing the abovementioned values of both the infrastructure and programs supported by Wallops Island, NASA concluded that even the short-term benefits of implementing the SRIPP substantially outweighed the lifecycle monetary costs.

Description and Comparison of Alternatives

2.6.3 Comparison of Costs of Dredging from Shoal A versus Shoal B

There would be a cost reduction in dredging sand from Unnamed Shoal A versus Unnamed Shoal B due to the shorter transit distance required for the dredge. As described in Section 2.5.7.1 (Offshore Dredging), the one-way distance from Unnamed Shoal A to the theoretical pump-out buoy location is approximately 9 km (5 mi) less than it is for Unnamed Shoal B. The reduced distance would translate into lower fuel consumption and costs for dredging sand from Unnamed Shoal A. Table 10 below shows a cost reduction of approximately \$3.3 million for the initial beach fill and \$840,000 for each renourishment event under the Preferred Alternative if Shoal A is used instead of Shoal B.

Table 10: Approximate Cost Reduction by Dredging Sand from Shoal A versus Shoal B

	Initial Beach Fill	Single Renourishment Event
Alternative One (Preferred)	\$3,300,000	\$840,000
Alternative Two	\$3,000,000	\$750,000
Alternative Three	\$3,000,000	\$730,000

2.6.4 Comparison of Impacts

Table 11 provides a comparison of the potential impacts shown by resource for each alternative.

Table 11: Summary of Impacts from the Proposed Action Alternatives

Resource	Alternative One: Full Beach Fill, Seawall Extension	Alternative Two: Full Beach Fill, Groin, Seawall Extension	Alternative Three: Full Beach Fill, Breakwater, Seawall Extension	No Action
Geology and Geomorphology – Shoreline	<p>Placement of beach fill (initial and renourishment) would create and maintain a beach approximately 21 m (70 ft) wide on Wallops Island. The addition of sediment to the longshore transport system would result in a reduction in the rate of erosion at the southern end of Wallops Island and northern end of Assawoman Island. Over the lifetime of the SRIPP, the seawall extension and beach fill would have long-term direct beneficial impacts on the Wallops Island shoreline by mitigating the current rate of shoreline retreat. Continued beach nourishment would add to this benefit.</p> <p>Long-term adverse impacts on geology would occur because placement of beach fill would prevent overwash, thereby causing some island narrowing.</p> <p>North Wallops Island sand removal would result in minor adverse impacts on sediments and would lower topography within the excavated areas.</p>	<p>Placement of beach fill (initial and renourishment) would create and maintain a beach approximately 21 m (70 ft) wide on Wallops Island. The addition of sediment to the longshore transport system would result in a reduction in the rate of erosion at the southern end of Wallops Island and northern end of Assawoman Island. Over the lifetime of the SRIPP, the seawall extension and beach fill would have long-term direct beneficial impacts on the Wallops Island shoreline by mitigating the current rate of shoreline retreat. Continued beach nourishment would add to this benefit.</p> <p>Long-term adverse impacts on geology would occur because placement of beach fill would prevent overwash, thereby causing some island narrowing.</p> <p>Construction of a groin would help to retain sand on the Wallops Island shoreline so that erosion and sediment transport from Wallops Island would be reduced and the beach created by the SRIPP would stay in place longer than under Alternative One.</p> <p>North Wallops Island sand removal would result in minor adverse impacts on sediments and would lower topography within the excavated areas.</p>	<p>Placement of beach fill (initial and renourishment) would create and maintain a beach berm approximately 21 m (70 ft) wide on Wallops Island. The addition of sediment to the longshore transport system would result in a reduction in the rate of erosion at the southern end of Wallops Island and northern end of Assawoman Island. Over the lifetime of the SRIPP, the seawall extension and beach fill would have long-term direct beneficial impacts on the Wallops Island shoreline by mitigating the current rate of shoreline retreat. Continued beach nourishment would add to this benefit.</p> <p>Long-term adverse impacts on geology would occur because placement of beach fill would prevent overwash, thereby causing some island narrowing.</p> <p>Construction of a breakwater would help to retain sand on the Wallops Island shoreline so that erosion and sediment transport from Wallops Island would be reduced and the beach created by the SRIPP would stay in place longer than under Alternative One.</p> <p>North Wallops Island sand removal would result in minor adverse impacts on sediments and would lower topography within the excavated areas.</p>	<p>Adverse impacts would result on land use, geology, and sediments from continued loss of the shoreline. Climate change, including sea-level rise and storm intensity and/or frequency, is anticipated to increase the vulnerability of Wallops Island shoreline to storms by contributing to shoreline erosion. Negligible adverse impacts on sediments would result during emergency operations over the 50-year lifetime of the SRIPP.</p>
Geology, Geomorphology and Bathymetry – Offshore Shoals and Nearshore Environment	<p>Dredging would remove a total of approximately 3,057,500 m³ (3,998,750 yd³) of sand from Unnamed Shoal A for the initial beach fill. Each of the nine anticipated renourishment cycles would require 770,000 m³ (1,007,500 yd³) or a total of</p>	<p>Dredging would remove a total of approximately 2,786,250 m³ (3,645,000 yd³) of sand from Unnamed Shoal A for the initial beach fill. Each of the nine anticipated renourishment cycles would require 690,000 m³ (915,500 yd³) or a total of approximately</p>	<p>Dredging would remove a total of approximately 2,712,500 m³ (3,548,750 yd³) of sand from Unnamed Shoal A for the initial beach fill. Each of the nine anticipated renourishment cycles would require 671,250 m³ (878,750 yd³) or a total of approximately</p>	<p>No impacts.</p>

Description and Comparison of Alternatives

Resource	Alternative One: Full Beach Fill, Seawall Extension	Alternative Two: Full Beach Fill, Groin, Seawall Extension	Alternative Three: Full Beach Fill, Breakwater, Seawall Extension	No Action
	<p>approximately 9,990,000 m³ (13,066,250 yd³) of sand over the lifetime of the SRIPP. The renourishment material may be dredged from Unnamed Shoal A, Unnamed Shoal B, and/or the northern end of Wallops Island. Dredging would result in changes to the volume, shape, and elevation of the sediments on either shoal. Removal of shoal sediments would result in long-term adverse impacts on site-specific and regional geology.</p> <p>The newly created beach profile would extend underwater for a maximum of 52 m (170 ft), resulting in a new bathymetric profile within the subaqueous lands immediately east of Wallops Island.</p>	<p>8,997,500 m³ (11,767,500 yd³) of sand over the lifetime of the SRIPP. The renourishment material may be dredged from Unnamed Shoal A, Unnamed Shoal B, and/or the northern end of Wallops Island. Dredging would result in changes to the volume, shape, and elevation of the sediments on either shoal. Removal of shoal sediments would result in long-term adverse impacts on site-specific and regional geology.</p> <p>The newly created beach profile would extend underwater for a maximum of 52 m (170 ft), resulting in a new bathymetric profile within the subaqueous lands immediately east of Wallops Island.</p>	<p>8,760,000 m³ (11,457,500 yd³) of sand over the lifetime of the SRIPP. The renourishment material may be dredged from Unnamed Shoal A, Unnamed Shoal B, and/or the northern end of Wallops Island. Dredging would result in changes to the volume, shape, and elevation of the sediments on either shoal. Removal of shoal sediments would result in long-term adverse impacts on site-specific and regional geology.</p> <p>The newly created beach profile would extend underwater for a maximum of 52 m (170 ft), resulting in a new bathymetric profile within the subaqueous lands immediately east of Wallops Island.</p>	
Shoreline Change	<p>Placement of beach fill (initial and renourishment) would create a beach berm approximately 21 m (70 ft) wide on Wallops Island, resulting in long-term beneficial direct impacts. The addition of sediment to the longshore transport system would offset some ongoing erosion that is occurring at the northern end of Assawoman Island. Dredging of the offshore shoals would result in minimal change to local wave conditions and no impact to the Assateague Island shoreline. Sediment would continue to accrete along the northern end of Wallops Island.</p>	<p>Placement of beach fill (initial and renourishment) would create a beach berm approximately 21 m (70 ft) wide on Wallops Island, resulting in long-term beneficial direct impacts. The groin would be specifically designed to let some sand pass through the structure; according to USACE modeling, the combination of the groin with beach fill would result in accretion of sand on the north end of Assawoman Island. The greatest amount of erosion and accretion would occur immediately adjacent to the groin and would exponentially decrease with distance from the groin. Renourishing the beach would reduce the potential for downdrift erosion by providing continual sand on the Wallops Island shoreline, some of which would be available to the longshore sediment transport system.</p> <p>Dredging of the offshore shoals would result in minimal change to local wave conditions</p>	<p>Placement of beach fill (initial and renourishment) would create a beach berm approximately 21 m (70 ft) wide on Wallops Island, resulting in long-term beneficial direct impacts.</p> <p>The breakwater would be specifically designed to let some sand pass through the structure; according to USACE modeling, the combination of the breakwater and beach fill would result in accretion of sand on the north end of Assawoman Island. Renourishing the beach would reduce the potential for downdrift erosion by providing continual sand on the Wallops Island shoreline, some of which would be available to the longshore sediment transport system.</p> <p>Dredging of the offshore shoals would result in minimal change to local wave conditions and no impact to the Assateague Island shoreline. Sediment would continue to accrete along the northern end of Wallops Island.</p>	<p>The shoreline along the southern portion of Wallops Island would continue to erode at a rate of approximately 3 m (10 ft) per year. The shoreline along the seawall would be held at its current location until erosional forces and undermining of the seawall would cause it to fail. The current seawall shows 13 areas of concern where the seawall has shown a vertical drop of at least 2 m (6 ft). Sediment would continue to accrete along the northern end of Wallops Island.</p>

Description and Comparison of Alternatives

Resource	Alternative One: Full Beach Fill, Seawall Extension	Alternative Two: Full Beach Fill, Groin, Seawall Extension	Alternative Three: Full Beach Fill, Breakwater, Seawall Extension	No Action
		and no impact to the Assateague Island shoreline. Sediment would continue to accrete along the northern end of Wallops Island.		
Water Resources	Elevated turbidity would result in marine waters at the offshore shoals from dredging and in the nearshore environment from sand placement.	Elevated turbidity would result in marine waters at the offshore shoals from dredging and in the nearshore environment from sand placement.	Elevated turbidity would result in marine waters at the offshore shoals from dredging and in the nearshore environment from sand placement.	No impacts.
Air Quality	Emissions from construction and dredging activities are not anticipated to cause long-term adverse impacts on air quality or climate change.	Emissions from construction and dredging activities are not anticipated to cause long-term adverse impacts on air quality or climate change.	Emissions from construction and dredging activities are not anticipated to cause long-term adverse impacts on air quality or climate change.	Emissions from construction and dredging activities are not anticipated to cause long-term adverse impacts on air quality or climate change.
Noise	Temporary, localized minor impacts are anticipated during construction, dredging, and fill. Temporary, localized impacts would result on marine mammals associated with increased noise from vessel activities (dredging).	Temporary, localized minor impacts are anticipated during construction, dredging, and fill. Temporary, localized impacts would result on marine mammals associated with increased noise from vessel activities (dredging).	Temporary, localized minor impacts are anticipated during construction, dredging, and fill. Temporary, localized impacts would result on marine mammals associated with increased noise from vessel activities (dredging).	Temporary, localized impacts are anticipated during construction and/or maintenance activities.
Hazardous Materials	Restoring the shoreline and increasing the distance between breaking waves and hazardous materials critical storage areas and accumulation points would have a beneficial impact.	Restoring the shoreline and increasing the distance between breaking waves and hazardous materials critical storage areas and accumulation points would have a beneficial impact.	Restoring the shoreline and increasing the distance between breaking waves and hazardous materials critical storage areas and accumulation points would have a beneficial impact.	Potential adverse impacts are anticipated from shoreline retreat and distance of hazardous materials critical storage areas and accumulation points from breaking waves.
MEC	MEC are not anticipated to be encountered in the area of seawall construction or beach fill. Shoreline erosion would increase to the south of the seawall extension in the first 1 to 2 years of the SRIPP; MEC may migrate to the ocean if further beach erosion occurs in this area. The beach fill (starting in Year 2) would reduce the potential of MEC migration into the ocean. There is a potential that MEC would be encountered during excavation of	MEC are not anticipated to be encountered in the area of seawall construction or beach fill. Shoreline erosion would increase to the south of the seawall extension in the first 1 to 2 years of the SRIPP; MEC may migrate to the ocean if further beach erosion occurs in this area. The beach fill (starting in Year 2) would reduce the potential of MEC migration into the ocean. There is a potential that MEC would be encountered during	MEC are not anticipated to be encountered in the area of seawall construction or beach fill. Shoreline erosion would increase to the south of the seawall extension in the first 1 to 2 years of the SRIPP; MEC may migrate to the ocean if further beach erosion occurs in this area. The beach fill (starting in Year 2) would reduce the potential of MEC migration into the ocean. There is a potential that MEC would be encountered during excavation of the north	NASA would continue to follow the WFF MEC Avoidance Plan, conduct surveys, and remove MEC as necessary; therefore, no adverse impacts are anticipated.

Description and Comparison of Alternatives

Resource	Alternative One: Full Beach Fill, Seawall Extension	Alternative Two: Full Beach Fill, Groin, Seawall Extension	Alternative Three: Full Beach Fill, Breakwater, Seawall Extension	No Action
	the north Wallops Island borrow site. NASA would implement an MEC Avoidance Plan, conduct surveys, and remove MEC as necessary.	excavation of the north Wallops Island borrow site. NASA would implement an MEC Avoidance Plan, conduct surveys, and remove MEC as necessary.	Wallops Island borrow site. NASA would implement an MEC Avoidance Plan, conduct surveys, and remove MEC as necessary.	
Biological Resources – Birds	Temporary noise disturbances from the construction machinery used for seawall extension, movement of beach sand, excavation of the north Wallops Island borrow site, and the dredges are expected to adversely affect birds. Adverse effects may also occur from disturbance of beach habitat during the placement of sand on Wallops Island shoreline (initial fill and renourishment cycles) and excavation at north Wallops Island for renourishment. Dredging may disrupt feeding at offshore shoals and cause changes to shoal morphology that could impact foraging, but the impacts are not anticipated to be significant within a regional context given the hundreds of shoals and potential forage areas available to the birds within the mid-Atlantic region. The newly created beach could create suitable shorebird nesting habitat.	Temporary noise disturbances from the construction machinery used for seawall extension and groin, movement of beach sand, excavation of the north Wallops Island borrow site, and the dredges are expected to adversely affect birds. Adverse effects may also occur from disturbance of beach habitat during the placement of sand on Wallops Island shoreline (initial fill and renourishment cycles) and excavation at north Wallops Island for renourishment. Dredging may disrupt feeding at offshore shoals and cause changes to shoal morphology that could impact foraging, but the impacts are not anticipated to be significant within a regional context given the hundreds of shoals and potential forage areas available to the birds within the mid-Atlantic region. The newly created beach could create suitable shorebird nesting habitat.	Temporary noise disturbances from the construction machinery used for seawall extension and breakwater, movement of beach sand, excavation of the north Wallops Island borrow site, and the dredges are expected to adversely affect birds. Adverse effects may also occur from disturbance of beach habitat during the placement of sand on Wallops Island shoreline (initial fill and renourishment cycles) and excavation at north Wallops Island for renourishment. Dredging may disrupt feeding at offshore shoals and cause changes to shoal morphology that could impact foraging, but the impacts are not anticipated to be significant within a regional context given the hundreds of shoals and potential forage areas available to the birds within the mid-Atlantic region. The newly created beach could create suitable shorebird nesting habitat.	Maintenance and emergency repair activities could disrupt birds. Substantial changes to the Wallops Island shoreline would continue to occur and would adversely affect shorebirds, seabirds, and migratory birds by decreasing the amount of beach habitat.
Biological Resources – Benthic Resources	Direct adverse impacts are anticipated on bottom communities within dredging area. Benthic communities and habitat would be removed during dredging. Assuming the entire proposed borrow area of Shoal A would be dredged (uniform dredge depth of approximately 0.6 m [2 ft]) for the initial beach fill, approximately 518 ha (1,280 ac) of benthic habitat would be removed. During each of nine renourishment cycles, approximately 140 ha (347 ac) of benthic habitat on Shoal A or Shoal B would be	Direct adverse impacts are anticipated on bottom communities within dredging area. Benthic communities and habitat would be removed during dredging. Assuming the entire proposed borrow area of Shoal A would be dredged (uniform dredge depth of approximately 0.6 m [2 ft]) for the initial beach fill, approximately 518 ha (1,280 ac) of benthic habitat would be removed. During each of nine renourishment cycles, approximately 116 ha (287 ac) of benthic habitat on Shoal A or Shoal B would be	Direct adverse impacts are anticipated on bottom communities within dredging area. Benthic communities and habitat would be removed during dredging. Assuming the entire proposed borrow area of Shoal A would be dredged (uniform dredge depth of approximately 0.6 m [2 ft]) for the initial beach fill, approximately 518 ha (1,280 ac) of benthic habitat would be removed. During each of nine renourishment cycles, approximately 116 ha (287 ac) of benthic habitat on Shoal A or Shoal B would be adversely impacted with a uniform	No impacts.

Description and Comparison of Alternatives

Resource	Alternative One: Full Beach Fill, Seawall Extension	Alternative Two: Full Beach Fill, Groin, Seawall Extension	Alternative Three: Full Beach Fill, Breakwater, Seawall Extension	No Action
	<p>adversely impacted with a uniform dredging depth of approximately 0.6 m (2 ft).</p> <p>Placement of the initial fill would bury existing intertidal benthic community along an approximate 4,300-m (14,000-ft) length of the seawall. The mean tidal range is approximately 1.1 m (3.6 ft); therefore, approximately 0.5 ha (1.2 ac) of hard-bottom, intertidal habitat would be permanently buried. In addition, approximately 91 ha (225 ac) of subtidal benthic community along the existing seawall would be buried during the initial fill placement. A new beach would be formed in front the seawall and a beach benthic community would become established.</p>	<p>adversely impacted with a uniform dredging depth of approximately 0.6 m (2 ft).</p> <p>Placement of the initial fill would bury existing intertidal benthic community along an approximate 4,300-m (14,000-ft) length of the seawall. The mean tidal range is approximately 1.1 m (3.6 ft); therefore, approximately 0.5 hectare (1.2 ac) of hard-bottom, intertidal habitat would be permanently buried. Approximately 91 ha (225 ac) of subtidal benthic community along the existing seawall would also be buried during the initial fill placement. A new beach would be formed in front the seawall and a beach benthic community would become established.</p> <p>In addition, the construction of the groin would bury 0.08 ha (0.19 ac) of sandy, subtidal benthic habitat and replace it with hard substrate.</p>	<p>dredging depth of approximately 0.6 m (2 ft).</p> <p>Placement of the initial fill would bury existing intertidal benthic community along an approximate 4,300-m (14,000-ft) length of the seawall. The mean tidal range is approximately 1.1 m (3.6 ft); therefore, approximately 0.5 hectare (1.2 ac) of hard-bottom, intertidal habitat would be permanently buried. Approximately 91 ha (225 ac) of subtidal benthic community along the existing seawall would also be buried during the initial fill placement. A new beach would be formed in front the seawall and a beach benthic community would become established.</p> <p>In addition, the construction of the groin would bury 0.08 ha (0.19 ac) of sandy, subtidal benthic habitat and replace it with hard substrate.</p>	
Biological Resources – Fisheries	<p>Direct site-specific adverse effects would result on EFH within: (1) the dredged area due to removal of benthic habitat and changes in shoal bathymetry, and (2) the fill placement area due to burial of existing benthic habitat. However, the impacts would not be significant within a regional context. There would also be minor direct impacts to fisheries outside the dredging and fill footprints due to turbidity as a result of the dredging and fill placement operations.</p>	<p>Direct site-specific adverse effects would result on EFH within: (1) the dredged area due to removal of benthic habitat and changes in shoal bathymetry, and (2) the fill placement area due to burial of existing benthic habitat. However, the impacts would not be significant within a regional context. There would also be minor direct impacts to fisheries outside the dredging and fill footprints due to turbidity as a result of the dredging and fill placement operations.</p> <p>The groin would provide hard bottom habitat within the nearshore area. The introduction of hard substrate would provide diverse habitat and prey to the nearshore fish assemblage.</p>	<p>Direct site-specific adverse effects would result on EFH within: (1) the dredged area due to removal of benthic habitat and changes in shoal bathymetry, and (2) the fill placement area due to burial of existing benthic habitat. However, the impacts would not be significant within a regional context. There would also be minor direct impacts to fisheries outside the dredging and fill footprints due to turbidity as a result of the dredging and fill placement operations.</p> <p>The breakwater would provide hard bottom habitat within the nearshore area. The introduction of hard substrate would function similar to an artificial reef and provide diverse habitat and prey to the nearshore fish assemblage.</p>	No impacts.

Description and Comparison of Alternatives

Resource	Alternative One: Full Beach Fill, Seawall Extension	Alternative Two: Full Beach Fill, Groin, Seawall Extension	Alternative Three: Full Beach Fill, Breakwater, Seawall Extension	No Action
Biological Resources – Marine Mammals	Potential temporary, localized adverse impacts would be associated with (1) physical disturbance to habitats during dredging and fill, (2) vessel strike, and (3) increased noise from vessel activities (dredging).	Potential temporary, localized adverse impacts would be associated with (1) physical disturbance to habitats during dredging and fill, (2) vessel strike, and (3) increased noise from vessel activities (dredging).	Potential temporary, localized adverse impacts would be associated with (1) physical disturbance to habitats during dredging and fill, (2) vessel strike, and (3) increased noise from vessel activities (dredging).	No impacts.
Biological Resources – Threatened & Endangered Species	The SRIPP may affect, but not likely to adversely affect vegetation, whales, sea turtles (except for loggerhead), and the Red Knot. May affect, and likely to adversely affect loggerhead sea turtle and Piping Plover. No adverse effect to other bird species is anticipated.	The SRIPP may affect, but not likely to adversely affect vegetation, whales, sea turtles (except for loggerhead), and the Red Knot. May affect, and likely to adversely affect, loggerhead sea turtle and Piping Plover. No adverse effect to other bird species is anticipated.	The SRIPP may affect, but not likely to adversely affect vegetation, whales, sea turtles (except for loggerhead), and the Red Knot. May affect and likely to adversely affect loggerhead sea turtle and Piping Plover. No adverse effect to other bird species is anticipated.	No impacts.
Socioeconomics	Beneficial impacts would result from reducing damages to infrastructure, reducing losses of work days and jobs, and from temporary construction-related job creation. Temporary minor adverse effects would result on surf clams and fisheries at dredge site from smothering and elevated turbidity. Temporary impacts would result on commercial and recreational fishing resources during the placement of beach fill material on Wallops Island due to elevated turbidity levels in the nearshore environment and disruption of the benthos, which would cause fish to avoid the disturbed areas. No long-term adverse impacts on commercial and recreational fisheries are anticipated. No disproportionate impacts to minority and low-income persons are anticipated.	Beneficial impacts would result from reducing damages to infrastructure, reducing losses of work days and jobs, and from temporary construction-related job creation. Temporary minor adverse effects would result on surf clams and fisheries at dredge site from smothering and elevated turbidity. Temporary impacts would result on commercial and recreational fishing resources during the placement of beach fill material on Wallops Island due to elevated turbidity levels in the nearshore environment and disruption of the benthos, which would cause fish to avoid the disturbed areas. No long-term adverse impacts on commercial and recreational fisheries are anticipated. No disproportionate impacts to minority and low-income persons are anticipated.	Beneficial impacts would result from reducing damages to infrastructure, reducing losses of work days and jobs, and from temporary construction-related job creation. Temporary minor adverse effects would result on surf clams and fisheries at dredge site from smothering and elevated turbidity. Temporary impacts would result on commercial and recreational fishing resources during the placement of beach fill material on Wallops Island due to elevated turbidity levels in the nearshore environment and disruption of the benthos, which would cause fish to avoid the disturbed areas. No long-term adverse impacts on commercial and recreational fisheries are anticipated. No disproportionate impacts to minority and low-income persons are anticipated.	Potential adverse impacts would result from interruption of WFF activities or loss of infrastructure. No disproportionate impacts to minority and low-income persons are anticipated.
Cultural Resources	No archaeological (below-ground or underwater) resources or above-ground historic properties are in the project area; therefore, no cultural resources would be affected.	No archaeological (below-ground or underwater) resources or above-ground historic properties are in the project area; therefore, no cultural resources would be affected.	No archaeological (below-ground or underwater) resources or above-ground historic properties are in the project area; therefore, no cultural resources would be affected.	No archaeological (below-ground) or above-ground historic properties would be affected.

Description and Comparison of Alternatives

Resource	Alternative One: Full Beach Fill, Seawall Extension	Alternative Two: Full Beach Fill, Groin, Seawall Extension	Alternative Three: Full Beach Fill, Breakwater, Seawall Extension	No Action
Transportation	A temporary increase in upland and maritime traffic is anticipated with no adverse impacts.	Temporary increase in upland and maritime traffic is anticipated with no adverse impacts.	Temporary increase in upland and maritime traffic is anticipated with no adverse impacts.	An increase in upland traffic for emergency/repair measures is anticipated.
Cumulative Impacts	Dredging operations would contribute incrementally to the overall removal of sand resources from shoals located on the inner continental shelf in the Mid-Atlantic region offshore of Maryland and Virginia. The SRIPP would contribute incrementally to the overall beneficial impacts of shoreline restoration efforts within the region by adding sand to the nearshore sediment transport system. The incremental contribution to cumulative water resource impacts would be negligible. The cumulative reduction in benthic invertebrate fauna would indirectly affect fish that forage on these benthic species; however, nearby shoals would provide alternate foraging grounds for marine species and mitigate adverse cumulative impacts. Negligible cumulative impacts are anticipated on air quality and marine mammals. Adverse and beneficial impacts are anticipated on birds and sea turtles; NASA would implement mitigation measures required by U.S. Fish and Wildlife Service (USFWS) and NMFS through SRIPP Section 7 consultation. Beneficial socioeconomic impacts are anticipated.	Dredging operations would contribute incrementally to the overall removal of sand resources from shoals located on the inner continental shelf in the Mid-Atlantic region offshore of Maryland and Virginia. The SRIPP would contribute incrementally to the overall beneficial impacts of shoreline restoration efforts within the region by adding sand to the nearshore sediment transport system. The incremental contribution to cumulative water resource impacts would be negligible. The cumulative reduction in benthic invertebrate fauna would indirectly affect fish that forage on these benthic species; however, nearby shoals would provide alternate foraging grounds for marine species and mitigate adverse cumulative impacts. Negligible cumulative impacts are anticipated on air quality and marine mammals. Adverse and beneficial impacts are anticipated on birds and sea turtles; NASA would implement mitigation measures required by USFWS and NMFS through SRIPP Section 7 consultation. Beneficial socioeconomic impacts are anticipated.	Dredging operations would contribute incrementally to the overall removal of sand resources from shoals located on the inner continental shelf in the Mid-Atlantic region offshore of Maryland and Virginia. The SRIPP would contribute incrementally to the overall beneficial impacts of shoreline restoration efforts within the region by adding sand to the nearshore sediment transport system. The incremental contribution to cumulative water resource impacts would be negligible. The cumulative reduction in benthic invertebrate fauna would indirectly affect fish that forage on these benthic species; however, nearby shoals would provide alternate foraging grounds for marine species and mitigate adverse cumulative impacts. Negligible cumulative impacts are anticipated on air quality and marine mammals. Adverse and beneficial impacts are anticipated on birds and sea turtles; NASA would implement mitigation measures required by USFWS and NMFS through SRIPP Section 7 consultation. Beneficial socioeconomic impacts are anticipated.	Potential adverse impacts are anticipated on socioeconomics from interruption of WWF activities or loss of infrastructure.

This page intentionally left blank.

2.7 SUMMARY OF MITIGATION MEASURES FOR PROPOSED ACTION ALTERNATIVES

For activities associated with the Proposed Action that are anticipated to have potential environmental impacts, NASA would be expected to utilize site-specific mitigation measures to avoid or minimize the impacts. Table 12 below provides an overview of the mitigation measures that would be utilized under each Proposed Action Alternative; mitigation measures are presented in detail in Chapter 5 of this PEIS.

Table 12: Summary of Mitigation Measures for the Proposed Action Alternatives

Mitigation Measures
<p>Seawall Extension</p> <ul style="list-style-type: none"> • Best Management Practices (BMPs) would be implemented for erosion, sediment control, and vehicle and equipment fueling spill prevention. • During construction operations in beach nesting bird or sea turtle nesting season, biological resource surveys would be conducted within the project area by a qualified biologist. Any nests identified within the project work area would be avoided. • USFWS reasonable and prudent measures and terms and conditions would be followed to avoid and minimize effects on Piping Plovers and sea turtles. <p>Offshore Dredging Operations</p> <ul style="list-style-type: none"> • The dredge contractor would be required to implement a marine pollution control plan to minimize any direct impacts to water quality from construction activity. • Dredging would be conducted in a manner generally consistent with the recommendations of recent BOEMRE sponsored studies, which include: <ul style="list-style-type: none"> ○ Dredging in areas that are accreting to the extent practicable; ○ Avoiding dredging in erosional areas to the extent practicable; ○ Dredging at a depth needed to obtain the required fill volume that would not be excessive (approximately 2 m [6.6 ft]); and ○ Not dredging along the entire length of the shoal. • USACE dredging guidelines would be followed, including use of dredge dragheads with rigid deflectors to reduce the risk of entrainment of sea turtles. • NMFS reasonable and prudent measures and terms and conditions would be followed to avoid and minimize incidental takes of sea turtles. <p>Sand Placement Activities</p> <ul style="list-style-type: none"> • If nourishment occurs during shore bird or sea turtle nesting season, a qualified biologist would closely monitor the beach during sand placement activities to ensure that impacts to any beach nesting birds or sea turtle species and their nests would be avoided or minimized. If any sea turtle or nests are detected within the planned work area, the nest would be avoided until NASA consulted with USFWS. • NASA would plant the newly created beach with native vegetation.

Description and Comparison of Alternatives

Mitigation Measures

- NASA would install sand fencing perpendicular to the beach with regular gaps to allow wildlife passage between the beach berm and dune area.
- USFWS reasonable and prudent measures and terms and conditions would be followed to avoid and minimize effects on Piping Plovers and sea turtles.

North Wallops Island Sand Removal

- BMPs would be implemented for erosion, sediment control, and vehicle and equipment fueling spill prevention.
- Prior to starting work, a qualified biologist would survey an area 660 feet around the proposed work area to determine the presence of bald eagle nests. If nests are discovered, NASA would consult with USFWS to minimize effects to the species.
- To avoid impacts to nesting Piping Plovers and sea turtles, excavation of sand for future renourishment would be conducted outside of plover and sea turtle nesting season (March 15 through November 30 or the last date of potential sea turtle hatchling emergence based on when the last eggs were laid).

CHAPTER THREE: AFFECTED ENVIRONMENT

Chapter 3 presents information regarding existing resources at Wallops Island that may be affected by the project alternatives. This chapter contains discussions on resources under the three main categories of Physical Environment, Biological Environment, and Social and Economic Environment. Several of the affected environment sections are based on information provided in the WFF Environmental Resources Document (NASA, 2008a).

3.1 PHYSICAL ENVIRONMENT

Wallops Island is approximately 11 km (7 mi) long and 800 m (2,650 ft) wide. It is bordered by Chincoteague Inlet to the north, Assawoman Island to the south, the Atlantic Ocean to the east, and marshland to the west. The mainland area to the west is comprised mainly of rural farmland. South of Wallops Island is the former Assawoman Inlet (now closed) and Assawoman Island, a 576-ha (1,424-ac) island managed as part of the Chincoteague National Wildlife Refuge (CNWR) by the USFWS. A string of undeveloped barrier islands extends down the coast to the mouth of Chesapeake Bay. The Eastern Shore of Virginia's Atlantic coast shoreline on the Delmarva Peninsula is one of the longest stretches of undeveloped shoreline on the east coast of the United States.

Much of the Wallops Island beach has nearly or completely eroded and is armored with a rock seawall along 4.6 km (2.86 mi) of the shoreline. On the southern portion of the island, near the MARS launch complex, shoreline retreat has averaged about 3.7 m (12 ft) per year from 1857 to the present (USACE, 2010a). Farther south, adjacent to Assawoman Inlet, shoreline retreat exceeded 5 m (16.4 ft) per year during that same time period. The northern end of Wallops Island has been accreting, both as a result of sediment bypassing of Chincoteague Inlet and northward net sediment transport on the northern end of Wallops Island (USACE, 2010a).

The SRIPP project area lies within the Northeast Continental Shelf, which is divided into four major subregions, Gulf of Maine (GOM), Georges Bank (GB), Southern New England (SNE), and the Mid-Atlantic Bight (MAB), that reflect different underlying oceanographic conditions, ecosystems, and fishery management boundaries (Figure 19). There is also variation in sea surface temperature, bathymetry, and biology (e.g., chlorophyll and zooplankton biomass) within each of these subregions. The SRIPP study area lies within the central portion of the MAB.



Source: NOAA NEFSC, 2007

Figure 19: Northeast Continental Shelf Subregions

3.1.1 Meteorology

WFF is located in the climatic region known as the humid continental warm summer climate zone. The climate is tempered by the proximity of the Atlantic Ocean to the east and the Chesapeake Bay to the west. Also affecting the climate is a cold water current, known as the Labrador Current, which originates in the polar latitudes and moves southward along the Delmarva coastline. The current creates a wedge between the warm Gulf Stream offshore and the Atlantic coast.

Four distinct seasons are discernible in the region. The climate is dominated in winter by polar continental air masses and in summer by tropical maritime air masses. Clashes between these two air masses create frontal systems, resulting in thunderstorms, high winds, and precipitation. Summer is hot and humid with precipitation occurring primarily from thunderstorm activity. Autumn is characterized by slightly decreasing temperatures and strong frontal systems with rain and sustained winds.

The storms causing the most significant coastal erosion and other damage along the Mid-Atlantic shorelines are nor'easters, or extratropical storms (Dolan et al., 1988 and references contained therein). On the east coast of North America, nor'easters most often originate from the vicinity of Cape Hatteras, NC (Davis et al., 1993) between December and April, with the peak in February. Unlike a hurricane, the greatest damage from nor'easters comes not from wind, but from strong waves lasting up to several days, which is most damaging along long areas of coastal zones. Unlike a hurricane, which affects a smaller geographic area more intensely, nor'easters can sometimes be difficult to classify and predict due to their diffuse nature. Over the past 50 years, these storms have become less frequent but more intense (Environmental Protection Agency [EPA], 2009a). Zhang et al. (2000) conducted an analysis of hourly tide gauge records from 10 tide gauges along the East Coast; their analysis did not show any discernible long-term

trend in storm activity during the twentieth century. This suggests a lack of response of storminess to minor global warming documented along the U.S. Atlantic coast during the last 100 years (Zhang et al., 2000). However, increased global climate change is predicted in the next century (IPCC, 2007), which is likely to cause changes in seawater temperatures and in turn affect the number and intensity of hurricanes.

Hurricanes and tropical storms occur less frequently than nor'easters and usually occur between June and November. Like nor'easters, hurricanes originate from unstable atmospheric conditions, but they are comprised of a cooler air mass with a warmer temperature at their core. Hurricanes form over warm ocean waters. As opposed to a nor'easter, hurricane impacts can extend well inland from the coastal zone, but typically only affect smaller stretches of the coast (Davis et al., 1993). According to a study by Komar and Allan (2008) that investigated 30 years of wave data, the waves off the east coast of the United States have gradually increased in height, especially those generated by hurricanes. Examination of the wave data indicated a net increase in the occurrence of waves higher than 3 m (9 ft). This is believed to be associated with the rise in frequency and intensification of hurricanes. The steady increase in the capacity of hurricanes to generate higher waves is attributed to gradual climate changes.

The Maryland and Virginia shores have been hit by a number of major storms this century, including 39 nor'easters between 1954 and 2003 and 41 hurricanes and tropical storms between 1856 and 2003 (USACE, 2010a). Specific damaging storms on record include hurricanes in 1902 and 1933, the Ash Wednesday 1962 Nor'easter, the Halloween 1991 Nor'easter, the January 4, 1992 Nor'easter, the December 1992 Nor'easter, and the November 12, 2009 Nor'easter.

3.1.2 Climate Change

There is consensus among leading scientific organizations (The Intergovernmental Panel on Climate Change [IPCC, 2007], The National Academy of Sciences, The American Meteorological Society, the American Geophysical Union, and the American Association for the Advancement of Science, among others [Oreskes, 2004]) that the chemical composition of the Earth's atmosphere is changing. Changes to the atmosphere are occurring both naturally and due to a number of human activities, such as fossil fuel combustion, deforestation, and other land use changes, resulting in the accumulation of trace greenhouse gases (GHGs) in the atmosphere.

By absorbing the radiative energy from the Sun and Earth, GHGs trap heat in the atmosphere, and their accumulation in the atmosphere may be contributing to an increase in the Earth's average surface temperature, which in turn is expected to affect weather patterns and the severity of storms/droughts, increase average sea levels, and increase intrusion of seawater into estuaries. Other effects are changes in precipitation rates, an increase in ozone (O₃) levels due in part to changes in atmospheric photochemistry, and decreased water availability and quality (Jones & Stokes, 2007).

GHGs include water vapor, carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), O₃, and several hydro and chlorofluorocarbons. Water vapor occurs naturally and accounts for the largest percentage of GHGs, while CO₂ is the second-most abundant GHG. Some GHGs are directly emitted from human processes (CO₂, chlorofluorocarbons, and water vapor), while other gases (e.g., nitrogen oxides [NO_x] and volatile organic compounds [VOCs]) emitted from these processes contribute indirectly by forming tropospheric (ground-level) O₃ and other reactive species. Those compounds then react photochemically with GHGs and control the amount of radiation penetrating through the troposphere. As GHGs continue to increase, the average

Affected Environment

temperature of the Earth's surface increases, leading to changes in weather events and precipitation rates, an increase in O₃ levels due in part to changes in atmospheric photochemistry, and decreased water availability and quality.

According to the IPCC (2009), climate change predictions are now estimated to occur within the upper range of values predicted in the 2007 report.

3.1.2.1 *Sea-Level Rise*

Global sea-level rise refers to the average increase in the level of the world's oceans. Sea-level rise is occurring on a world-wide basis and is projected to continue to occur at an increasing rate (EPA, 2009a). As the global climate warms and glaciers retreat, water stored as continental ice is released, adding to the mass of water in the oceans and causing a corresponding rise in sea-level (EPA, 2009a). Relative MSL considers both global sea-level rise and how local historical changes and unique circumstances, like rate of subsidence, affect the sea-level rise within a particular area.

By the Bruun rule (Bruun, 1962), small changes in sea level can be expected to have dramatic effects on shoreline position, with increasing sea levels causing shoreline retreat. The shoreline at Wallops Island would experience the effects of future sea-level rise, as coasts and barrier islands are particularly vulnerable to the sea-level rise and intensified storm and wave events attributed to climate change (Nicholls et al., 2007). Beaches and barrier islands may adjust naturally by growing vertically, moving inland, or expanding laterally, although at a certain point the coastline would be fundamentally altered (EPA, 2009a).

Although the scientific consensus is that the Earth's climate is changing (NASA, 2010b; Oreskes, 2004; EPA, 2009a), there is still great uncertainty in calculating the precise contributing factors which result in sea-level rise, and new data are constantly emerging. Over the last century, relative sea-level rise rates along the Atlantic coast of the United States have ranged between 1.8 mm/year (0.07 in/year) (Maine) to as much as 4.4 mm/year (0.17 in/year) (Zervas, 2001). The lowest rates (1.8 mm/year [0.07 in/year]) are nearly equivalent to the average global rate for the twentieth century of 1.7 ± 0.5 mm/year (0.07 ± 0.02 in/year) (Bindoff et al., 2007) and occur along coastal New England and from Georgia to southern Florida. The highest rates have been observed in the Mid-Atlantic region between northern New Jersey and northeastern North Carolina (Zervas, 2004). Data collected from long-term tidal gauges in Hampton Roads, VA indicate that between 1930 and 1960 the average relative sea-level rise for this location was 4.2 mm (0.17 in) per year (NOAA, 2004). Subsidence of the land surface due to a range of factors contributes to the high rates of relative sea-level rise observed in the mid-Atlantic region.

A report by the EPA (2009a) assesses the effect three potential rates of increase in the relative sea level might have on the physical and social environments from the coast of New York to North Carolina. The first scenario assumes that sea-level rise will continue at the current rate of 2.4 to 4.4 mm (0.09 to 0.17 in) annually throughout the twenty-first century, the second scenario assumes an increase of 5 to 6 mm annually, and the third assumes an increase of 10 to 11 mm (0.39 to 0.43 in) annually. According to the report, if sea-level rise continues at the third scenario rate or higher, it is "very likely that future sea-level rise will contribute to significant changes resulting in the segmentation, disintegration, and/or more rapid landward migration" of the Wallops, Assawoman, Metompkin, and Cedar barrier islands (EPA, 2009a). However, there remains uncertainty in the precise outcome of the three scenarios because they depend upon the

elevation of each individual coastal area in question, and currently available data are not considered accurate enough for scientists to predict quantitatively the precise effects of sea-level rise in the Mid-Atlantic (EPA, 2009a). In addition, the IPCC has concluded that based on new satellite data, the melting of continental ice sheets may contribute more to global sea-level rise than previously reported (IPCC, 2007).

With the anticipated acceleration in the rate of global sea-level rise (e.g., IPCC, 2001 and IPCC, 2007), local rates of relative sea-level rise will also accelerate. Recently, the Fourth Assessment Report of the IPCC has predicted that sea levels will rise by 10 to 59 cm (3.9 to 23.2 in) over the next century, which is a somewhat smaller rise and range than the estimated 11 to 88 cm (4.3 to 34.6 in) reported in the Third Assessment Report (IPCC, 2001). Several recent criticisms of the IPCC's Fourth Assessment Report estimates of future sea-level changes (Rahmstorf, 2007; Rahmstorf et al., 2007; Hansen et al., 2007) argue that these estimates are conservative and do not incorporate adequately the potential contributions of land-based ice melt from Greenland and western Antarctica to the global sea level. The IPCC assessment concludes that the science regarding future acceleration in ice melt and its contribution to sea-level rise is not yet sufficient to include in its sea-level projections.

3.1.3 Bathymetry

Bathymetry is the measurement of depth at various places in a body of water. The nearshore environment east of Wallops Island slopes gently from the shoreline to approximately 12m (40 ft) at the limit of state jurisdictional waters (5.5 km [3 nm] offshore).

The nearshore seafloor east of Assateague Island is characterized by a discontinuous sheet of fine to medium sand containing a complex of linear shoals and troughs. The shoals in this area are approximately 1 to 10 m (3.3 to 33 ft) in height, approximately 2 to 4 km (1.2 to 2.5 mi) apart, and up to tens of km in length (Swift and Field, 1981; McBride and Moslow, 1991). The long axes of the shoals are oriented generally northeast to southwest directly into the predominant or prevailing storm wave approach direction, which is from the northeast in the MAB during nor'easters (Hayes and Nairn, 2004). The region of the continental shelf between Delaware and Chesapeake Bays (including the SRIPP Unnamed Shoals A and B, Blackfish Bank, and Chincoteague Shoals) contains at least 180 shoals similar of similar orientation and morphology (Dibajnia and Nairn, *in press*).

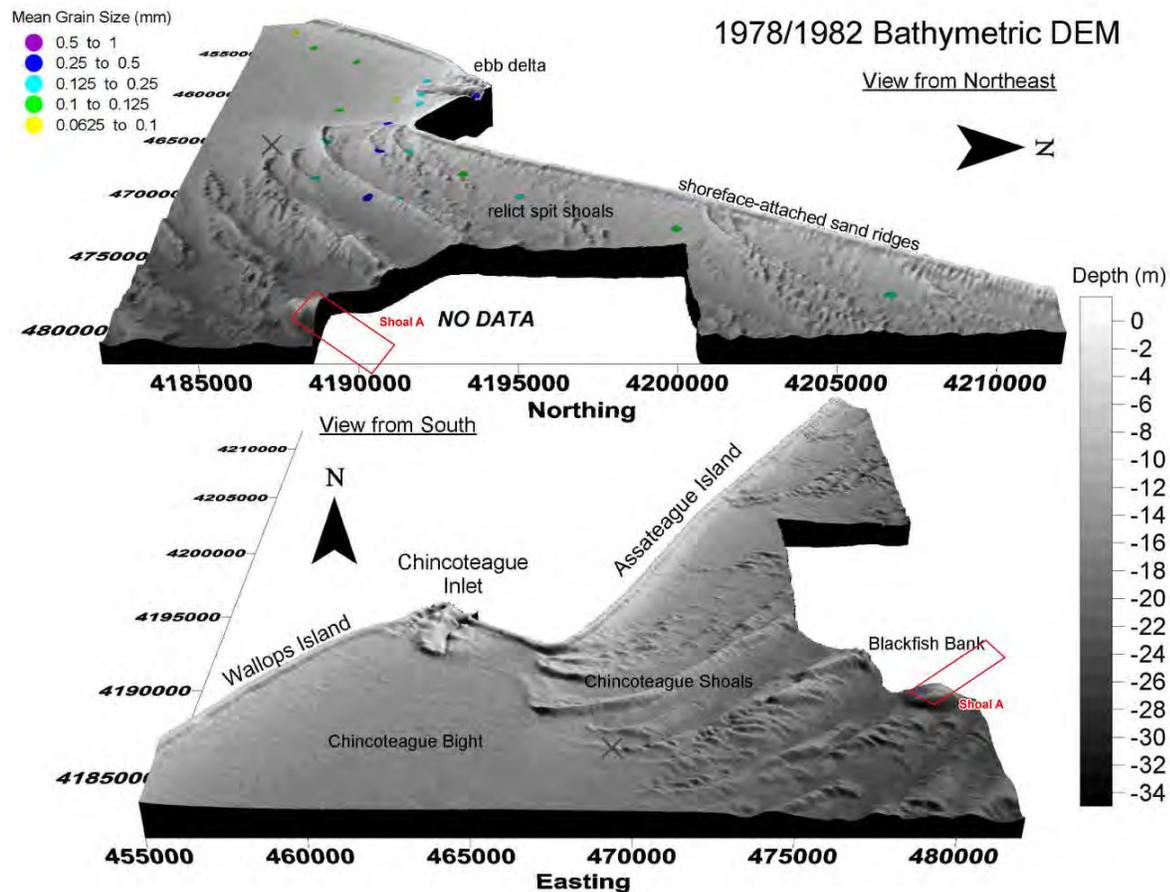
Offshore of Fishing Point, a series of sand ridges and shoals referred to as Chincoteague Shoals (Figure 20) are located in depths of approximately 2 to 5 m (7 to 16 ft). Bathymetry in the shoal complex area east of Assateague Island ranges from an average of about 1 m (3 ft) near the shoreline to about 25 m (85 ft) deep about 21 km (13 mi) offshore in the vicinity of Unnamed Shoal B (Figure 21).

The depth of the first sand ridge east of Chincoteague Shoals—Blackfish Bank—ranges from 9 to 4 m (30 to 13 ft). Moving eastward, depth drops to about 21 m (70 ft) between Blackfish Bank and Unnamed Shoal A. The crest of Unnamed Shoal A is located in depths of 12 to 7.5 m (40 ft to 25 ft). Between Unnamed Shoals A and B, the depth ranges from 23 to 12 m (75 to 40 ft). The crest of Unnamed Shoal B is located in depths between 15 m (50 ft) to 9 m (29 ft). Figures 22 and 23 show a profile view of the bathymetry between Assateague Island and Shoals A and B, respectively.

Affected Environment

The sand ridge complex east of Assateague Island disappears relatively abruptly to the south in a featureless basin (Chincoteague Bight) that exists southeast of Fishing Point and east of Wallops Island (Figure 20). The Chincoteague Bight is characterized by a slow and steady increase in depth seaward from the shoreline.

Bathymetric data (uncorrected for tides) were obtained within the 5.2-km² (2-mi²) survey areas for both Unnamed Shoal A and B during the cultural resources survey conducted in 2009 for the SRIPP (see Section 3.3.7.2). The bathymetry was recorded using an Odom Hydrotrac® digital echo sounder along 80 survey transects spaced at 15.2-m (50-ft) intervals along Unnamed Shoal A, which yielded 348.9 linear survey km (216.8 linear survey mi). Unnamed Shoal B was divided into 84 transect lines spaced at 15.2-m (50-ft) intervals, which yielded 318.3 linear survey km (197.8 linear survey mi). Figure 24 shows the plan view of the bathymetry of Unnamed Shoal A and Unnamed Shoal B. Figure 25 shows the three-dimensional bathymetry of the proposed dredge areas.

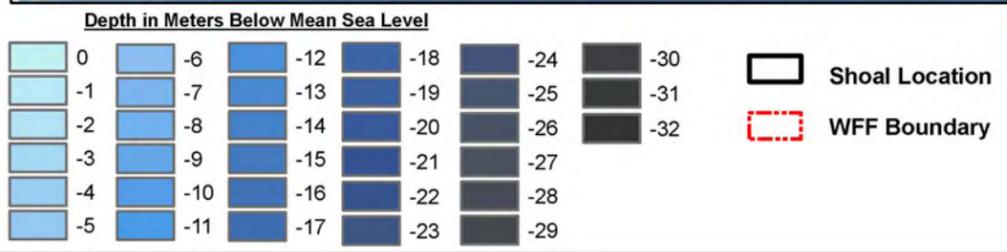


Source: Wikel, 2008. Bathymetric Digital Elevation Model was created from 1978 and 1982 hydrographic surveys from the NOAA – National Geophysical Data Center.

Figure 20: Bathymetry of Chincoteague Shoals and Chincoteague Bight



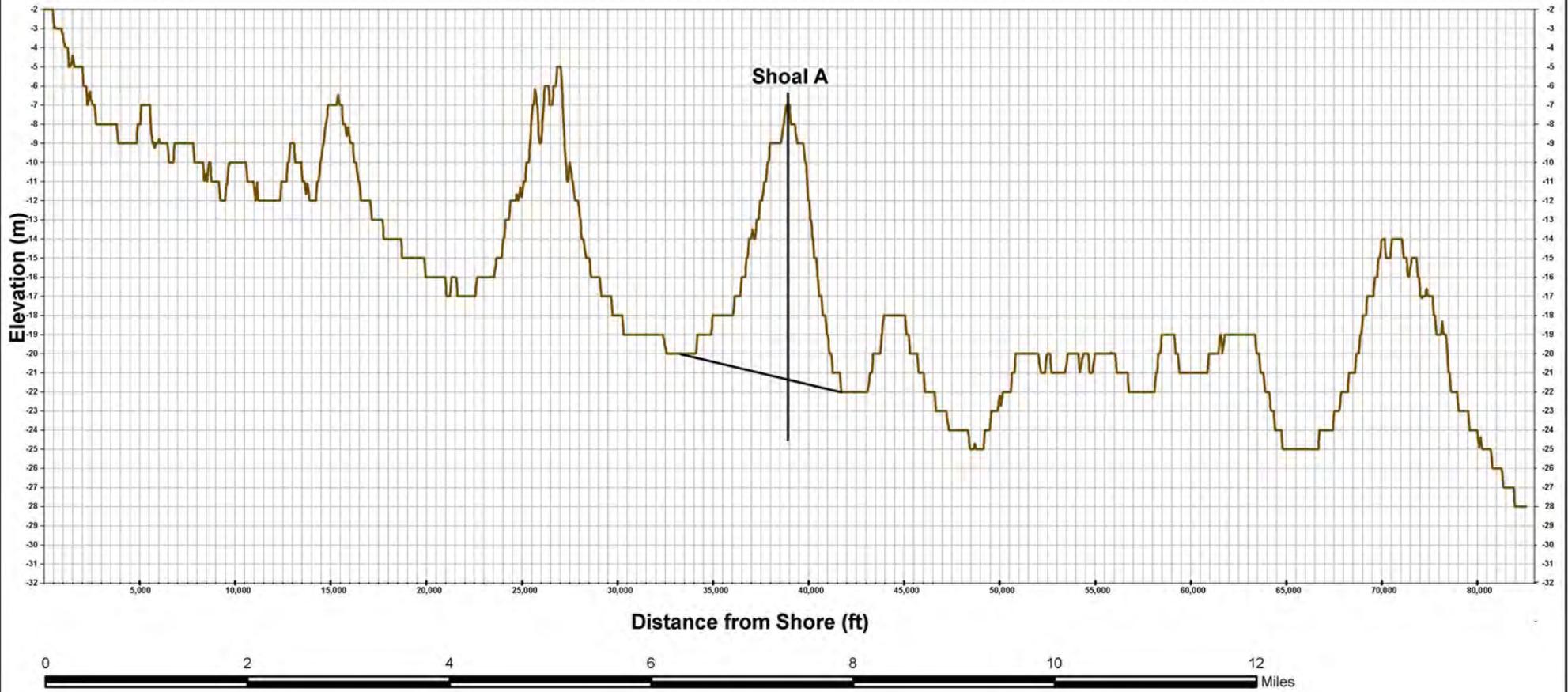
Bathymetric Data: National Geophysical Data Center, "Coastal Relief Model". <http://www.ngdc.noaa.gov/mgg/fliers/01mgg05.html>



Title: Offshore Bathymetry	
	URS Proj No: 15301785
	Figure: 21
Client : NASA	
Shoreline Restoration Environmental Impact Statement	

This page intentionally left blank.

Profile 1



 Bathymetric Surface Along Transect

Vertical Exaggeration = 1000x

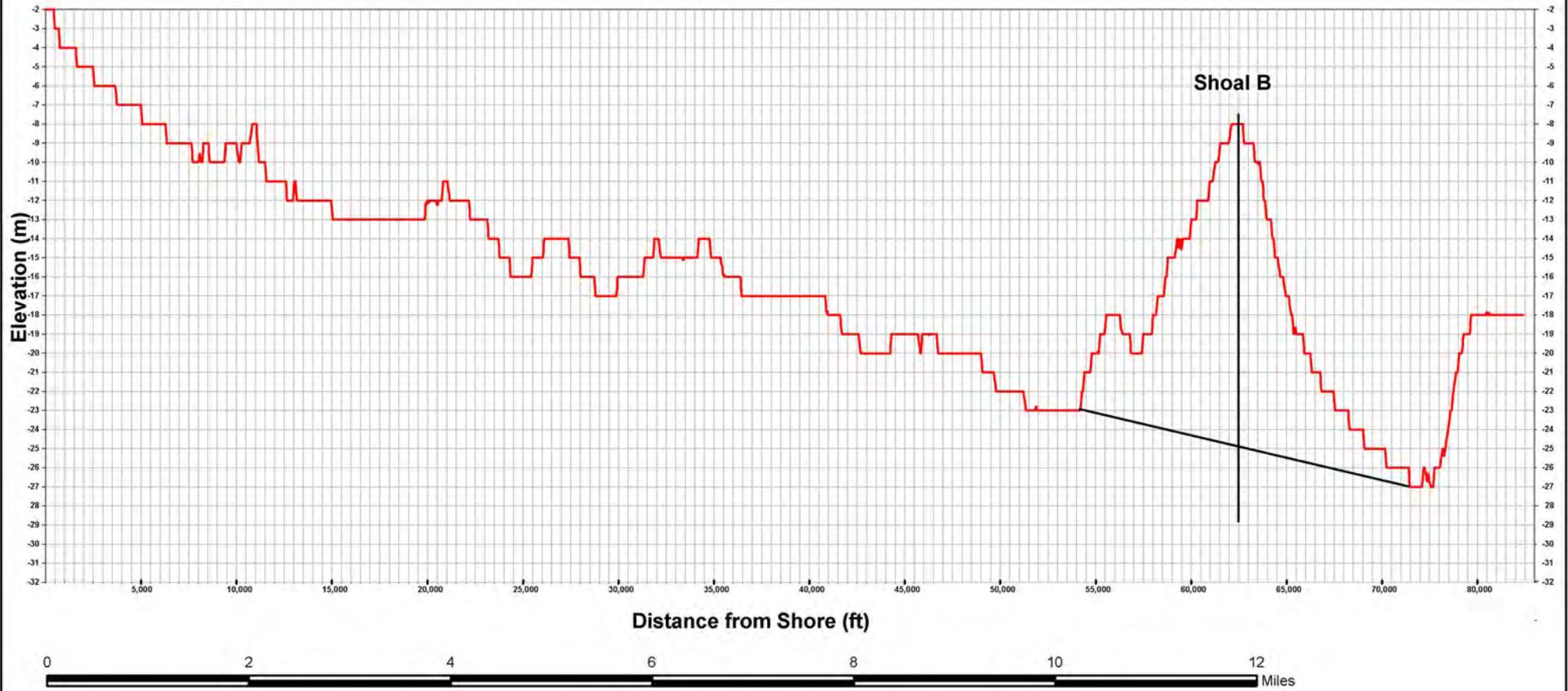
-  Shoal Location
-  WFF Boundary



Title: Profile 1	
	URS Proj No: 15301785
Figure: 22	
Client : NASA	
Shoreline Restoration Environmental Impact Statement	

This page intentionally left blank.

Profile 2



Bathymetric Surface Along Transect

Vertical Exaggeration = 1000x

- Shoal Location
- WFF Boundary



Title: Profile 2



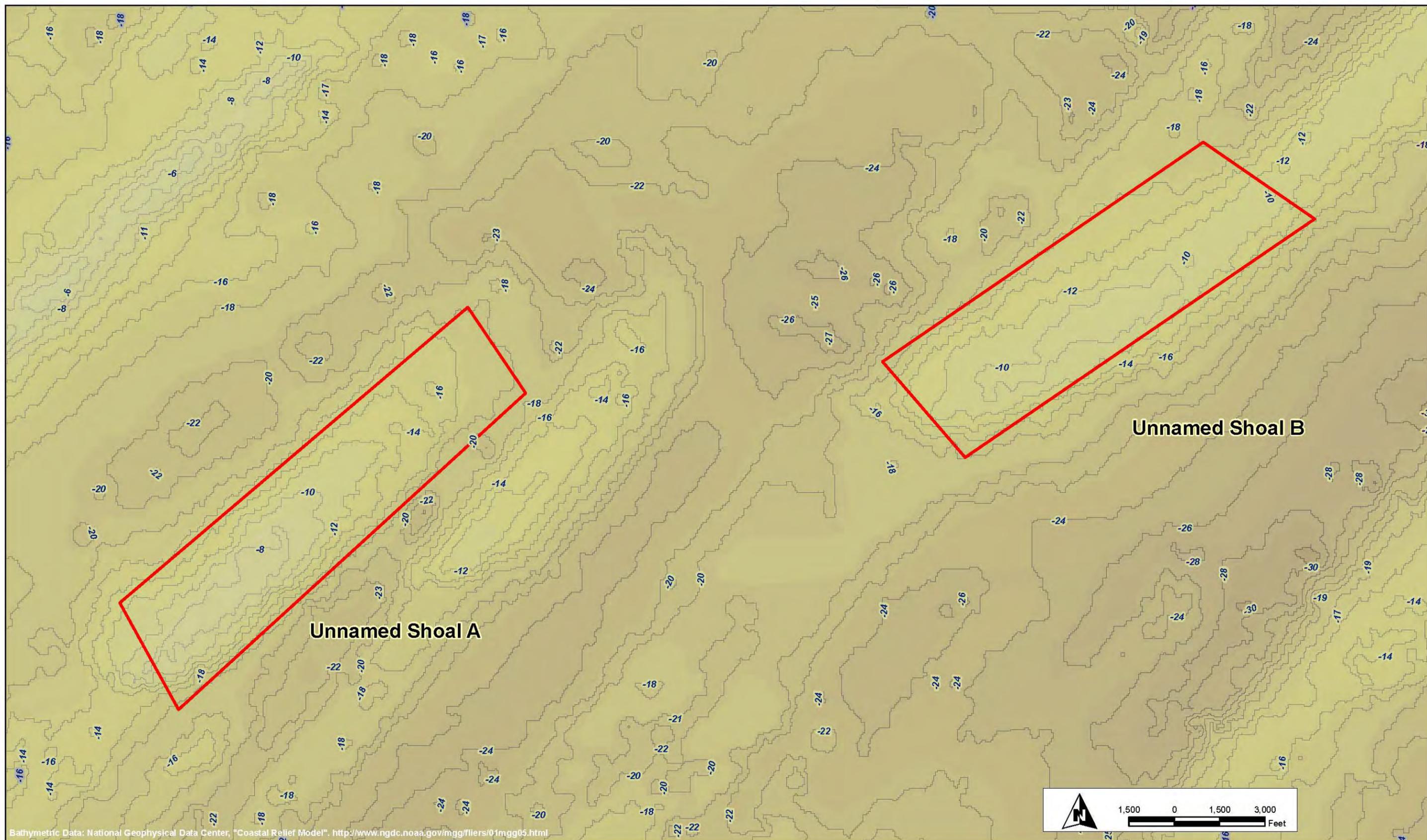
URS Proj No: 15301785

Figure: 23

Client : NASA

Shoreline Restoration Environmental Impact Statement

This page intentionally left blank.



Bathymetric Contours (meters below mean sea level)

-2	-14	-26	-38
-4	-16	-28	-40
-6	-18	-30	-42
-8	-20	-32	-44
-10	-22	-34	
-12	-24	-36	

 Location of 2-square-mile SRIPP Borrow Area

Title: Plan View Bathymetry of Shoals A and B

 URS Proj No: 15301785

Figure: **24**

Client : NASA

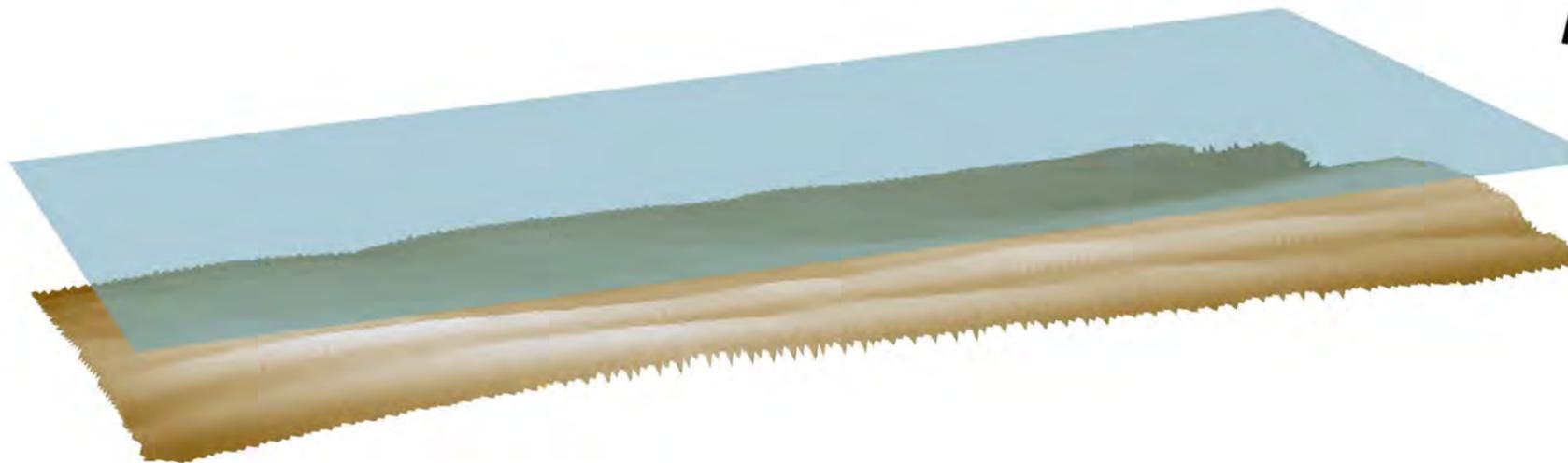
Shoreline Restoration Environmental Impact Statement

This page intentionally left blank.

Oblique View of Shoal A

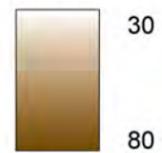


Oblique View of Shoal B



Bathymetric Data: National Geophysical Data Center, "Coastal Relief Model". 11/16/1998, <http://www.ngdc.noaa.gov/mgg/fliers/01mgg05.html>

Depth in Feet Below
Mean Sea Level



Vertical Exaggeration = 20x

Title: Oblique View of Shoal Bathymetry	
	URS Proj No: 15301785
	Figure: 25
Client : NASA	
Shoreline Restoration Environmental Impact Statement	

This page intentionally left blank.

3.1.4 Geology and Geomorphology

This section describes the geology and geomorphological elements of the project area, including an overview of the Virginia Barrier Island system, Wallops Island, shoreline changes, and the offshore sand shoals. In addition, a summary is provided at the end of the section.

3.1.4.1 *Virginia Barrier Island System*

Wallops Island is part of the Virginia barrier island system that fronts the Atlantic Ocean. Barrier islands are dynamic systems formed by the interaction of wave, wind, and tidal energies that erode, transport, and deposit sediments (Leatherman, 1982). By absorbing the impact of high-energy marine processes, barrier islands reduce erosion of the mainland coast and provide shelter for sensitive coastal habitats.

Leatherman (1982) and Kochel et al. (1985) classified the 12 Virginia barrier islands into three groups based on shoreline migration rates: (1) a northern parallel beach retreat group; (2) a middle rotational instability group; and (3) a southern non-parallel beach retreat group. Wallops Island is situated in the northern parallel beach retreat group. Wallops Island also possesses a morphology and features that are indicative of mixed-energy conditions (i.e., sedimentary processes driven by the interplay of waves and tides [Hayes, 1979; Oertel and Kraft, 1994; Wikel, 2008]). While the entire Virginia barrier island chain is subject to mixed-energy conditions (average deep water wave heights = 0.86 m; tidal range = 1.24 m), the morphologic variability expressed by each group of islands (Dolan et al., 1979; Leatherman, 1982) and individual islands within those groups (Byrnes, 1988; Harris, 1992; Richardson and McBride, 2007) suggest that multiple processes operating over a variety of spatial and temporal scales have influenced and continue to influence both short- and long-term dynamics along Wallops Island. For example, the shoreline migration rates and morphology along Wallops Island have changed considerably over its distant and recent geologic past, in part because of its location at the intersection of the northern end of this mixed-energy barrier island chain and the southern end of the wave-dominated, Assateague Island and recurved spit system.

Wallops Island and the three narrow barrier islands to the south—Assawoman, Metompkin, and Cedar—are unusual in that they are concave due to rapid erosion compared to the other barrier islands along the Virginia shore. Leatherman (1982) concludes that the combination of diminishing sediment supply, differential subsidence, and uniform wave attack has promoted the steady retreat of Assateague Island. Several factors help to shape these barrier islands, however, at Wallops Island long-term effects such as differential subsidence are not as great of a consideration as wave driven processes. The inlets between the islands approximately follow the courses of paleochannels formed during the late Wisconsin sea-level regression (Halsey, 1979).

3.1.4.2 *Wallops Island*

The relatively flat topography of Wallops Island is typical of barrier islands. Topography refers to the three-dimensional relief of the Earth's surface, including both human-made and natural features, and is often expressed in elevation relative to sea level and shown as contour lines on a map. The unarmored shoreline segments at the north and south ends of Wallops Island consist of low sloping sandy beaches. The sandy portion of Wallops Island has an elevation of about 2.1 m (6.9 ft) amsl. The highest elevation on Wallops Island is approximately 4.6 m (15 ft) amsl. Most of the island is below 3.0 m (10 ft) amsl (NASA, 2005).

Affected Environment

As is typical of barrier islands in the region, Wallops Island exhibits environmental zones related to changes in topography across the island profile. Generally, dunes are found at the highest elevations, and beaches and marshes are found at the lowest. On Wallops Island, previous structures, such as groins, weirs, beach beams, and beach prisms have modified the natural sediment transport processes, thereby changing the island's structure. The seawall that was constructed to protect critical infrastructure on the island has fixed the shoreline position, thereby resulting in complete loss of the beach seaward of the wall and preventing long-term natural maintenance of the gently sloping nearshore and beach systems that would have existed under natural conditions. In addition, without a beach to provide a source of sand, the island's ability to create and maintain natural dunes is limited.

Located within the Atlantic Coastal Plain Physiographic Province, Wallops Island is underlain by approximately 2,150 m (7,000 ft) of sediment. The sediment lies atop crystalline basement rock. The sedimentary section, ranging in age from Cretaceous to Quaternary (approximately 145.5 to 2.5 million years ago), consists of a thick sequence of terrestrial, continental deposits overlain by a much thinner sequence of marine sediments. These sediments are generally unconsolidated and consist of clay, silt, sand, and gravel.

The regional dip of the geologic units is eastward, toward the Atlantic Ocean. The two uppermost stratigraphic units on Wallops Island are the Yorktown Formation and the Columbia Group, which is not subdivided into formations. The Yorktown Formation is the uppermost unit in the Chesapeake Group and was deposited during the Pliocene epoch of the Tertiary Period (approximately 5.3 to 1.8 million years ago). The Yorktown Formation generally consists of fine to coarse glauconite quartz sand, which is greenish gray, clayey, silty, and in part, shelly. The Yorktown Formation occurs at depths of 18 to 43 m (60 to 140 ft) in Accomack County (Commonwealth of Virginia, 1975).

The shoreline beaches consist mostly of sand deposited by wave action subjected to daily tidal flooding. As discussed in Section 2.4.3.2 of this PEIS, sampling of the Wallops Island beach was conducted by the USACE Norfolk District in 2007 to determine the grain size of the sediment on the beach (USACE, 2010a). One-hundred and seventy samples were taken along several transects, including sampling between the top of the beach and the mean low water (MLW) elevation, and at the north and south ends of Wallops Island. The mean grain sizes of the individual samples of native sand on Wallops Island were between 0.20 and 0.21 mm (USACE, 2010a).

In October 2009, sediment sampling of the north Wallops Island beach was conducted by the USACE to further evaluate the material there for suitability for use as renourishment fill (Figure 12). As discussed in Section 2.4.3.4 of this PEIS, 16 samples were collected to a depth of 1.8 m (6 ft) and analyzed for grain size. The sediments generally consisted of tan to gray, poorly graded fine to medium sand with trace shell fragments and silt. The median grain sizes of all 16 samples ranged from 0.18 to 0.27 mm.

3.1.4.3 *Shoreline Changes*

Normal wave conditions produce gradual changes in island morphology, while large changes occur during major storms (Leatherman, 1982; Pekala, 1996). Over a longer time scale, shoreline position, orientation, and length can be affected by variations in sea level, sediment supply, and

wave energy (Pekala, 1996). Leatherman (1982) cites coastal storms as a major contributor to beach and dune erosion, overwash processes, and the opening of tidal inlets on barrier islands.

Like several of the Atlantic coast beaches on the southern Delmarva Peninsula, such as Parramore Island (Richardson and McBride, 2007), the beach at Wallops Island has been in a state of chronic erosion for at least the last 150 years. An analysis of the shoreline between Fishing Point and Gargathy Inlet is shown in Figure 26; this figure is oriented so that land is at the bottom and offshore is at the top. Wallops Island extends from “-2000 m” to “+6500 m” along the horizontal axis.

The 1849, 1857/1858, 1909/1911, 1933, and 1983 shorelines are taken from the U.S. Coast and Geodetic Survey charts. The 1994 shoreline was digitized from a rectified aerial photograph. The 1996 and 2005 shorelines were obtained from Light Detection and Ranging (LiDAR) surveys. The dominant direction of storm wave approach for the Mid-Atlantic coastline shown in this figure is from the northeast (left) and sediment transport is generally to the south (right), though a significant transport reversal occurs on Wallops Island (for more information on waves and longshore sediment transport see 3.1.6.2 and 3.1.6.4, respectively).

Panel A of Figure 26 shows the 1849 and 1857/1858 shorelines. In the mid-1800s the shoreline was much straighter, as Fishing Point spit had not formed. The inlet shown in the 1849 shoreline, now called Assateague Channel, has shifted to the southwest in the 1857 shoreline, suggesting that the main direction of longshore sediment transport was to the south.

By 1909/1911, Fishing Point had started to form (Figure 26, Panel B). Assateague Channel had shifted farther to the southwest. The Wallops Island shoreline had retreated by approximately 75 m (250 ft). By 1933, Fishing Point had formed a distinct hook, but it had not grown enough to redefine the mouth of Chincoteague Inlet.

By 1983 (Figure 26, Panel C) substantial changes had occurred. Fishing Point had grown to the extent that the tip of it and the northern shoulder of Wallops Island had started to re-define the location of the throat section of Chincoteague Inlet. Some aerial photographs from the 1980s show the existence of an emergent ebb shoal. However, the distance between these points was still well over 2 km (1 mi) wide.

The northern end of Wallops Island was now sheltered enough by Fishing Point that it had started to accrete, which was a change from earlier decades, as shown in Panel C. Because the mouth of Chincoteague Inlet was still so wide, it is likely that the majority of the accretion at the northern tip of Wallops Island was due to a transport reversal on Wallops Island, caused by Fishing Point blocking waves from the northeast. The rest of Wallops Island and Assawoman Island were still experiencing substantial erosion. The southern portion of Wallops Island, south of the existing seawall, is currently eroding at a rate of approximately 3 m (10 ft) per year (USACE, 2010a).

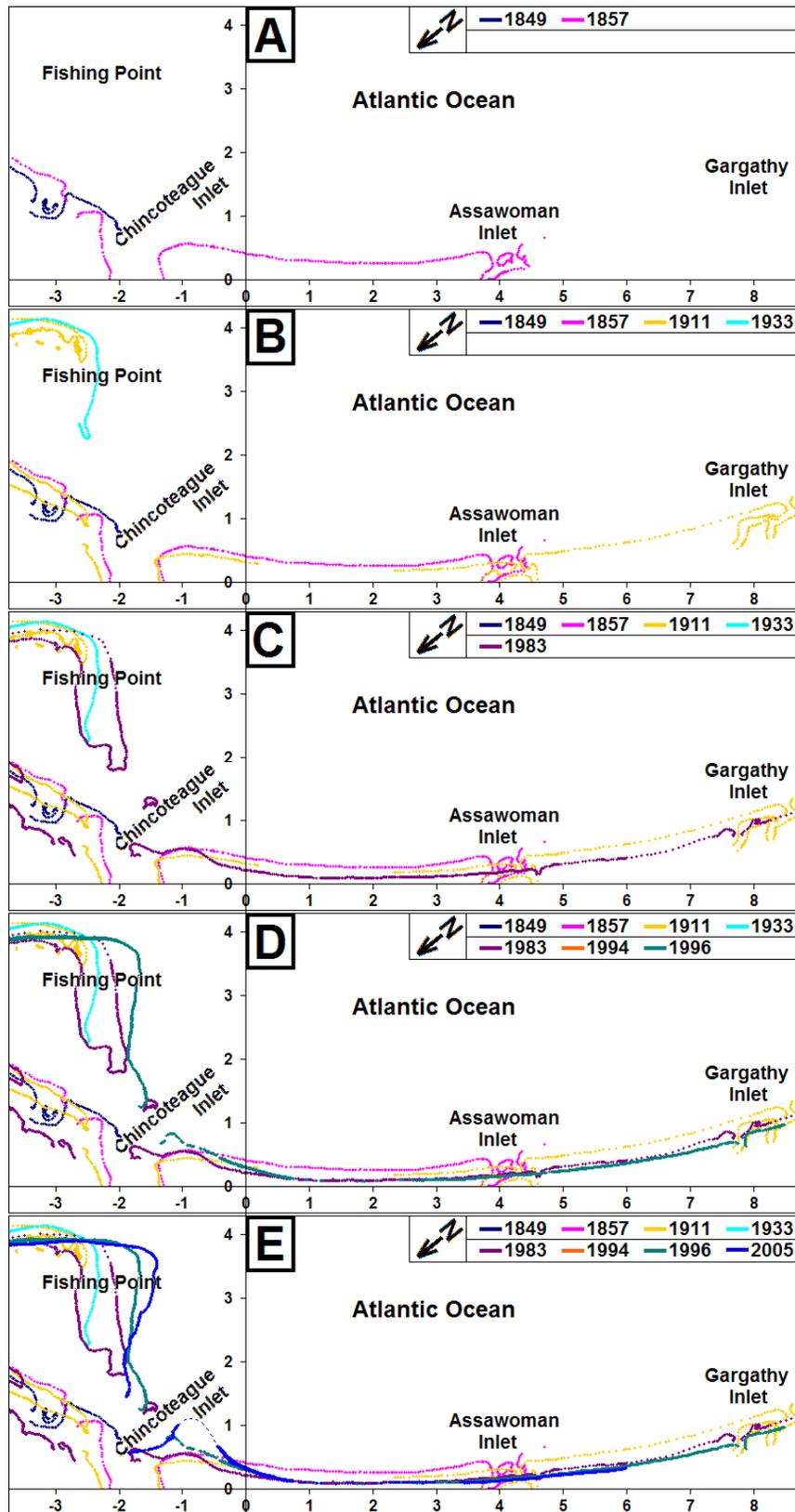


Figure 26: Wallops Island Shoreline Changes between 1849 and 2005

By 1996, Fishing Point and the northeastern shoulder of Wallops Island had both grown enough that the mouth of Chincoteague Inlet was less than a half mile wide, and substantial inlet bypassing (from Fishing Point to Wallops) had started to occur (Figure 26, Panel D). Because of this sedimentation, in 1995 USACE began dredging Chincoteague Inlet at intervals ranging from 1 to 3 years (USACE, 2006). On Wallops Island, the area of accretion at the northern tip had extended farther to the south, though the southern part of the island continued to erode.

Figure 26, Panel E shows the 2005 shoreline. The dashed portion of this shoreline at the northern end of Wallops Island was not covered in the LiDAR survey. Instead, this shoreline is inferred from limited Global Positioning System (GPS) readings taken in 2007. The northern end of Wallops Island has continued to strongly accrete, both as a result of sediment bypassing of Chincoteague Inlet and northward net sediment transport on the northern end of Wallops Island. Today, the beach at the northern tip of Wallops Island contains a series of trapped shallow sloughs. These are the result of ebb shoal bar bypassing and welding to the inlet's downdrift shoreline. These shoals form in the channel and migrate westward, where they weld onto the northern tip of Wallops Island.

Growth of the Southern Tip of Fishing Point

The development and growth of the cape called Fishing Point and the adjacent offshore spit platform and shoal complex has captured sand that would have otherwise been available to nourish Wallops Island and the islands farther south along the Virginia coastline. This is one reason that these shorelines are experiencing substantial erosion. Figure 27 shows National Park Service (NPS) shoreline location data through the spring of 2009 for the very southern tip of Assateague Island and shows that the tip of the island is continuing to grow to the southwest at a rate of approximately 50 m (150 ft) per year. If this trend continues over the next 50 years, the tip will grow to the southwest by about 2.3 km (1.5 mi). This will more strongly shelter the Wallops Island shoreline from ocean waves approaching from the northeast, and will shift the transport divergent nodal point (explained in Section 3.1.5.4, Longshore Sediment Transport), which is estimated to occur between the northern part of Assawoman Island and the southern portion of Wallops Island, to the south by roughly that amount.

Narrowing of the Tom's Cove Isthmus

Another shoreline change feature is the narrowing of the thin strip of land separating Tom's Cove from the Atlantic Ocean. The rate at which this is happening makes it likely that there will be storm-induced breakthroughs between Tom's Cove and the ocean during the 50-year lifetime of the SRIPP. The first breach on this isthmus occurred as a result of a November 2009 Nor'easter (USACE, 2010a). These breaches may close rapidly, or they may cause permanent or semi-permanent inlets to form.

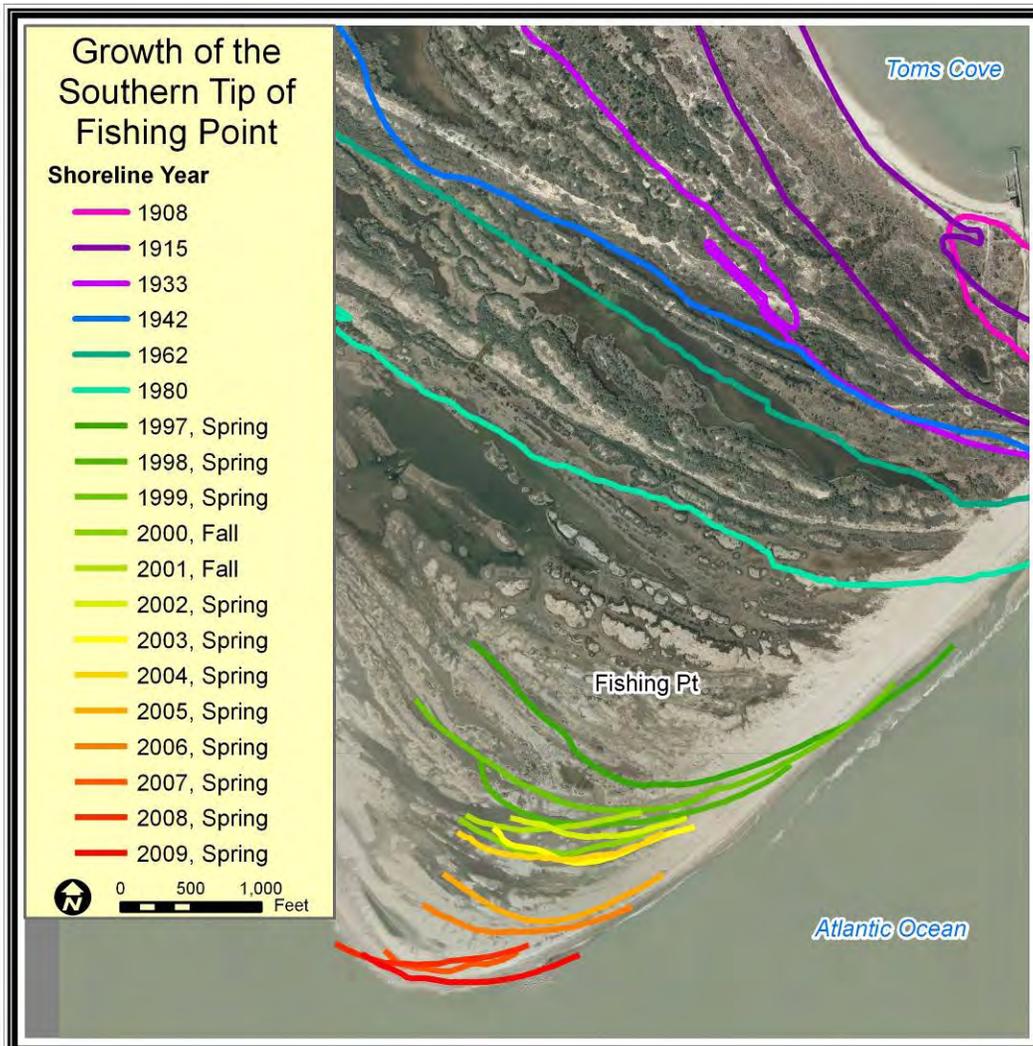


Figure 27: Growth of Fishing Point

Changes in Wallops Island Shoreline Orientation and Chincoteague Inlet Migration

The northern end of Wallops Island is rapidly accreting. This is because sediment is being delivered to this location from two directions: 1) north along the Wallops Island shoreline, and 2) westward by the westward drift of Chincoteague Inlet ebb shoals. Over the short term, sediment may be stored in swash bars, the ebb tidal delta, or the ebb/flood tidal ramp. Over the long term, it is probable that the sediment will be carried into Chincoteague Inlet by tidal currents where it is sequestered in flood shoals. This mechanism will act to slow down the rate of sediment accumulation that would otherwise occur on northern Wallops Island.

The sediment accumulation on north Wallops Island may tend to push Chincoteague Inlet to the east: this appears to already be occurring as documented on recent aerial photographs of the western tip of Assateague Island showing that it has retreated to the east. However, future Chincoteague Inlet locations can be strongly affected by USACE dredging decisions and whether attempts are made to maintain the inlet channel in a fixed location, or to dredge whatever is

found to be the current channel location. The sediment accumulation on north Wallops Island is changing the existing north-south shoreline orientation to one that is much more east-west.

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. Section 3.1.3 provides more detailed information regarding the bathymetry in the SRIPP project area, including a map showing the bathymetry of both Unnamed Shoals A and B from data collected by NASA during a 2009 survey of the shoals.

Swift and Field (1981) categorized the shoals off Maryland into three groups based on their geomorphic characteristics: shoreface, nearshore, and offshore. Unnamed Shoals A and B are offshore sand ridges that are located at the southern end of the Assateague ridge field. In general, the offshore shoals in this ridge field are oriented with their long or main axis in a southwest/northeast orientation directly into the predominant storm wave approach direction. This orientation suggests the wave forces from nor'easters either directly or indirectly account for the origin and maintenance of these features (Hayes and Nairn, 2004). The offshore shoals are asymmetrical with their seaward flanks approximately three times as steep as the landward flanks. The coarsest sediment generally occurs on the shoreward flanks of the shoals (Swift and Field, 1981; Hayes and Nairn, 2004). Based on numerous studies, Hayes and Nairn (2004) conclude that once formed, most ridges in depths of less than 20 m (66 ft) are maintained and even enlarged by present-day hydrodynamics.

See Section 2.4.3.3 and Appendix A for information on the USACE vibracore sampling and results.

3.1.4.5 Summary

The shoreline along Wallops Island has been in a state of chronic erosion for at least the last 150 years. The development and growth of Fishing Point and the adjacent offshore spit platform and shoal complex has captured sand that would have otherwise been available to nourish Wallops Island and the islands farther south along the Virginia coastline. This is one reason that these shorelines are experiencing substantial erosion. The southern portion of Wallops Island, south of the existing seawall, is eroding at a rate of approximately 3 m (10 ft) per year (USACE, 2010a).

The shoreline along northern end of Wallops Island is rapidly accreting. This is because sediment is being delivered to this location from two directions: 1) north along the Wallops Island shoreline, and 2) westward by the westward drift of Chincoteague Inlet ebb shoals. In addition, the growth of Fishing Point has sheltered the northern portion of the Wallops Island shoreline from storm waves that approach primarily from the northeast.

The Wallops Island shoreline is comprised of fine sand with a mean grain size between 0.20 and 0.21 mm. The two offshore shoals identified as potential borrow sites are located at the southern end of the Assateague ridge field and contain sand that is compatible for use as beach fill material.

Affected Environment

3.1.5 Physical Oceanography and Coastal Processes

3.1.5.1 *Tides*

The project area has a semidiurnal tide (two high and two low tides occur each day). The mean ocean tide range is approximately 1.1 m (3.6 ft); the mean spring tide is approximately 1.3 m (4.4 ft). Tidal currents are generally weak except in the vicinity of the ebb and flood tidal jet of Chincoteague Inlet.

3.1.5.2 *Waves*

There is seasonal variability in wave height, period, and direction. The dominant wave direction is from the southeast. Dominant storm waves are from the northeast. The largest and most frequent waves originate from the east-northeast and northeast directions as a result of extratropical storms in the summer and fall, or nor'easters between October and February. Hurricanes, which occur less frequently than nor'easters, are usually fast moving and produce substantial coastal impacts with durations of a day or less. However, because of their low central pressures and high wind speeds, hurricanes can generate large storm surges. In contrast, nor'easters can cause impacts over longer time scales (several tidal cycles), but usually do not produce extremely high storm surges. Individual storms can cause the equivalent change of decades of shoreline in a matter of days (Fenster et al., 2001).

Based on USACE Wave Information Studies (WIS) hindcast data from 1980-1999, the maximum significant wave height was approximately 6 m (20 ft) high with an 11 second period. Average wave heights vary seasonally; the lowest monthly average wave occurs in July and August; the maximum monthly average wave heights occur in December, January, and February. The largest measured wave at Ocean City was 4.4 m (14 ft); this occurred during a January 1992 nor'easter. As discussed in Section 3.1.1, according to Komar and Allan (2008), the waves off the east coast of the United States are gradually increasing in height, especially those generated by hurricanes.

Waves in the area are refracted around Fishing Point. Wave energy is reduced along northern Wallops Island and the east-west oriented section of Fishing Point due to wave sheltering by the recurved spit. Nearshore along Wallops Island there is a strong gradient in the wave height, with the height decreasing to the north (USACE, 2010a).

The most frequent wave approach direction is from the southeast quadrant; however, the waves from the northeast tend to be larger and longer in period. Moffatt & Nichol (1986) reported that waves from the northeast and east northeast account for 71 percent of the total wave energy along the Virginia coast. The general, predominant southerly littoral drift along the Maryland and Virginia coast lines is a result of waves from these directions. The presence of Fishing Point greatly affects the wave patterns seen on the shore at Wallops Island (USACE, 2010a). Wave energy coming from the northeast is largely blocked by Fishing Point, whereas wave energy coming from the southeast arrives at the beach with little change. Waves coming from the southeast have roughly the same height everywhere along the shoreline, but waves coming from the northeast have dramatically decreasing height (and thus energy) the farther north they are along Wallops Island. This phenomenon results in diminished southerly sand transport.

Storm waves also affect the submerged offshore sand shoals. Storm waves from the northeast converge along the crests of both the shore-attached and shore-detached shoal crests such that

wave energy is greatest along the crests. Bed forms on the surface of the sediment such as ripple marks on the shoal crests are evidence of this effect (Appendix B).

3.1.5.3 Currents

The water circulation in this region of the inner continental shelf is characterized by a general southward movement of the surface and bottom water throughout the year. Average southerly currents are on the order of 10 cm/sec (0.3 ft/sec) or about 0.4 km/hr (0.2 knots) (Brooks, 1996). However, from April to September, the surface water movement may periodically reverse and move northward in association with the prevalence of south winds (USACE, 1998). The northeastwardly flowing Gulf Stream in the Atlantic Ocean is well offshore of Wallops and Assateague Islands, generally more than 320 km (200 mi) seaward. Currents may be much larger during nor'easters when synoptic pressure gradients are established north-south from Cape Cod to Cape Hatteras and across the entire MAB. Coupled to nor'easter waves which act to mobilize sediments, these relatively strong currents can transport substantial volumes of suspended sediment in short periods of time.

3.1.5.4 Longshore Sediment Transport

Typical longshore sediment transport along the Mid-Atlantic shoreline is north to south. However, sediment transport can occur in other directions (i.e., south to north) locally. Longshore sediment transport rates can vary significantly and are influenced by the local geomorphology and bathymetry.

Fishing Point at the southern end of Assateague Island has grown to the point that waves coming from the northeast are refracted, or bent, shadowing the northern end of Wallops Island from these high energy waves. Wave refraction around Fishing Point and the Chincoteague Inlet ebb-tidal delta has contributed to the bypassing of sand around the delta and a local reversal in longshore transport from south to north leading to sand accretion on the northern end of Wallops Island. This shoal and inlet complex serves as an efficient sediment trap, allowing only about 5 percent of longshore transport to bypass to the south (Moffatt & Nichol, 1986).

The USACE conducted sediment transport modeling and a sediment budget analyses at Wallops Island for the SRIPP (see Appendix A). This modeling and the SRIPP project design were performed according to current USACE policy. As with all mathematical models applied to natural resources, the models used in the SRIPP analyses have limitations and do not exactly mimic nature. While they do provide significant insights, the fact that they have limitations is one of the principle reasons for utilization of an adaptive management strategy for the SRIPP.

Longshore sediment transport rates along Wallops Island vary from year to year primarily because of yearly variations in the input wave field (USACE, 2010a). To determine the gross and net average transport rates along Wallops Island, the USACE used 20 years of WIS hindcast data (USACE, 2010b) from 1980 and 1999 that was broken into 20 different 4-year blocks (1980–1983, 1981–1984, etc.). The GENESIS model was run using each of these blocks and the sediment transport rates during the 4th year were averaged. USACE analysis of this wave data determined the dominant wave direction at Wallops Island, and thus the dominant direction of net sediment transport.

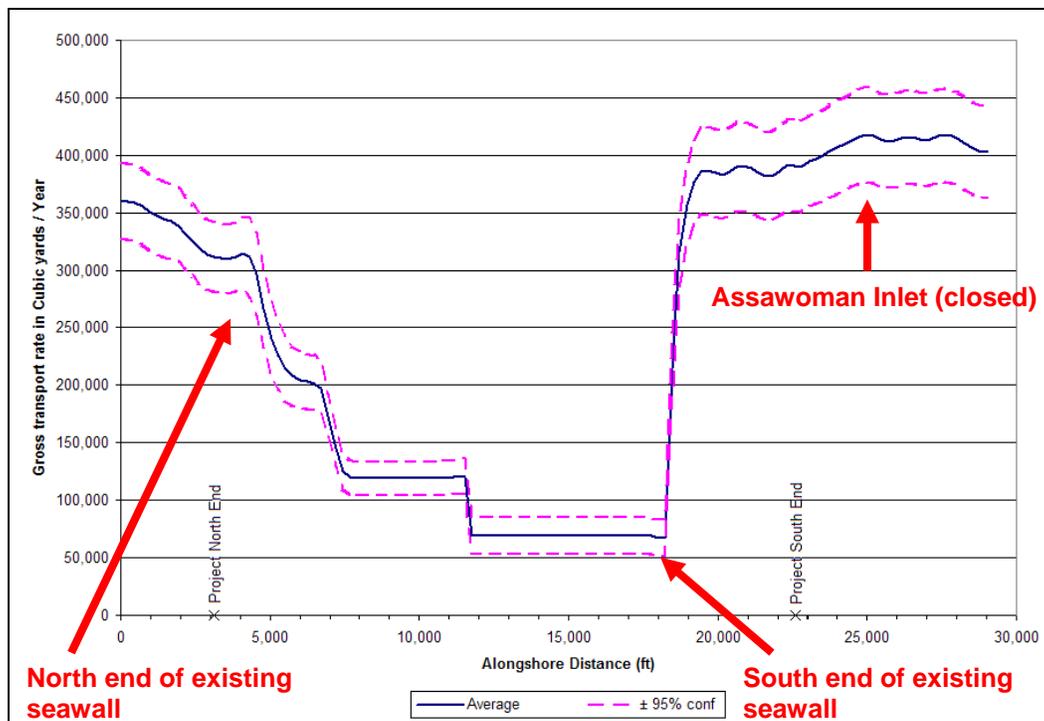
Bathymetry data used in the modeling were obtained from the National Ocean Survey hydrographic surveys that are available in electronic format from the Geophysical Data System (version 4.0)

Affected Environment

developed by the National Geophysical Data Center. Bathymetric surveys collected in the 1960s through the 1990s were used where available, with earlier survey data used to fill gaps in the more recent bathymetry coverage.

Gross sediment transport volumes quantify the total flux of sediment in both directions alongshore whereas net volumes refer to the difference between volumes moving in opposite directions. As with any modeling exercise, there is inherent uncertainty within the transport modeling due to several factors, which include: (1) a short timescale of the data used compared to the time frame of the transport processes, (2) a lack of current, detailed nearshore bathymetry, and (3) estimation of future sea-level rise. To account for some of this uncertainty, the USACE calculated both average longshore sediment rates and rates within the 95-percent confidence limits, as shown on the graphs below.

Figure 28 depicts the estimated average *gross* sediment transport rates along Wallops Island estimated by the USACE (2010a). The 95-percent confidence limits are shown along with the average gross transport rate. This figure shows average gross rates of 300,000 m³ (400,000 yd³) per year to the south of the seawall, greatly reduced transport rates in front of the seawall, and rates of 270,000 m³ (350,000 yd³) per year to the north of the seawall. The gross sediment transport rates within the 95-percent confidence limits varied up to roughly 23,000 m³ (30,000 yd³) from the average.



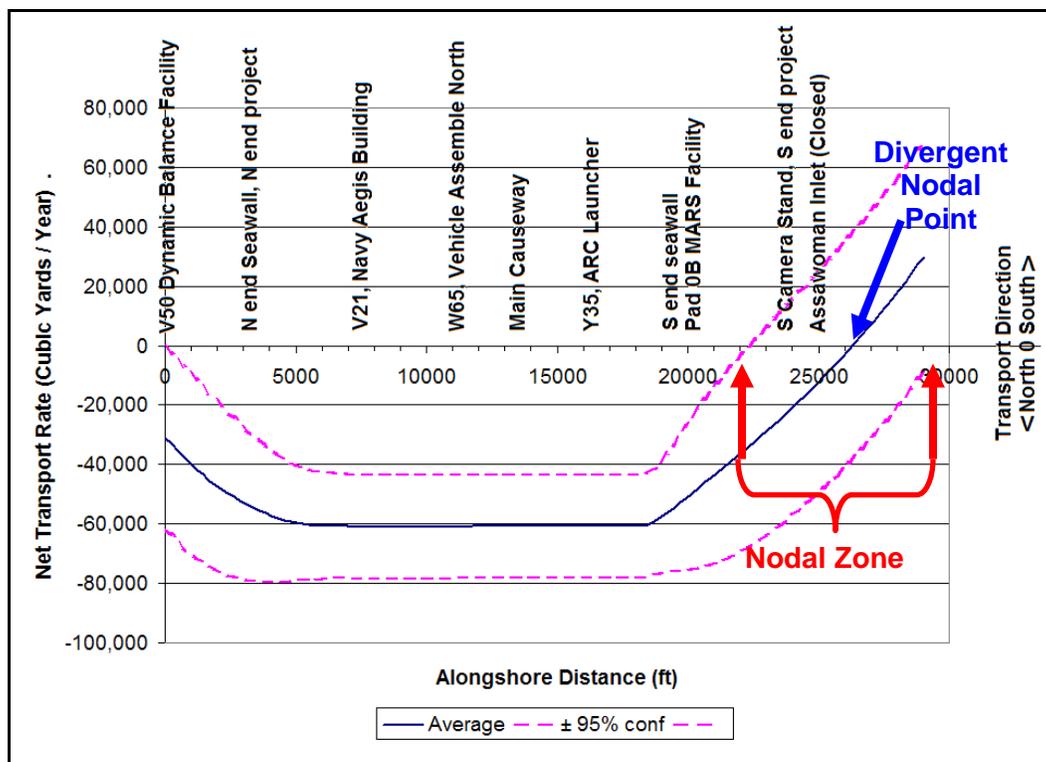
Source: USACE, 2010a

Figure 28: Average Yearly Gross Sediment Transport Rates along Wallops Island

The average *net* sediment transport rates estimated by the USACE (2009a) (Figure 29) vary between 15,000 m³ (20,000 yd³) to 46,000 m³ (60,000 yd³) per year at different locations along the shoreline—the net sediment transport rates within the 95-percent confidence limits vary by roughly 15,000 m³ (20,000 yd³) from the average, indicating the uncertainty in the estimated rates. On Figure 29, positive transport rates (indicating net transport to the south) are on the upper side of the zero

value on the left vertical axis and negative rates (indicating net transport to the north) are shown below the zero line. This figure indicates that for average transport conditions there is a divergent nodal point (a location along the shoreline where net sediment transport switches directions) on the north end of Assawoman Island. Southward of the divergent nodal point, the net sediment transport is to the south, and northward of the nodal point the net transport direction is to the north.

The 95-percent confidence limits indicate that for most years the varying wave conditions shift the divergent point along the shoreline within about a 2.1 km (1.3 mi) window, referred to as the “nodal zone.” Because of the continuing growth of Fishing Point (see Figure 27) along with the southwestward migration of the offshore shoals (Wikel, 2008), the USACE determined that the divergent nodal zone along Wallops Island has been shifting to the south over time (USACE, 2010a).



Source: USACE, 2010a

Figure 29: Net Sediment Transport Rates along Wallops Island

Waves coming from the southeast have roughly the same height everywhere along the shoreline, but waves coming from the northeast have dramatically decreasing height (and thus energy) the farther north they are along Wallops Island. This means that they are less capable of transporting sand to the south. The wave sheltering from Fishing Point and the offshore shoals is the primary reason that the net sediment transport in most years along Wallops Island is to the north. Figure 30 provides another view of the divergent nodal point (represented as zero net sediment transport) and the direction net sediment transport modeled by the USACE. Northerly sediment transport is evidenced by the accumulation of sediment on the southern side of the previously existing groins (Photo 8, taken in 1994) at the northern end of the seawall. Evidence of southerly sediment transport in the past is shown in Photo 9 (taken in 1969 and farther south along the shoreline than Photo 8). However, it

Affected Environment

should be noted that a level of spatial uncertainty exists in interpreting the trends shown in these photographs as they portray two different locations. Additionally, the two photographs may be capturing seasonal reversals thereby making it difficult to conclusively determine net long-term transport directions from the aerial photographs.



Note: The number shown after the “±” indicates the 95 percent confidence intervals for net annual sediment transport.

Figure 30: Wallops Island Sediment Budget

Photo 8: Groin field located at north central part of Wallops Island showing sediment transport direction to the north – photo taken March 20, 1994



Photo 9: Groin field located along central Wallops Island showing sediment transport direction to the south – photo taken in March 1969



3.1.5.5 *Cross-Shore Sediment Transport*

Cross-shore sediment transport refers to the cumulative movement of beach and nearshore sand perpendicular to the shore by the combined action of tides, wind, and waves, and the shore-perpendicular currents produced by them. Unlike longshore sediment transport, which is difficult to observe, cross-shore sediment transport can result in large and highly visible changes in the beach configuration over intervals as short as 1 day (Schwartz, 2005). Cross-shore transport results in an adjustment of the beach toward an equilibrium profile (NOAA Coastal Services Center, 2010).

Dredging of shoals could affect shoreline stability by deepening a portion of the cross-shore profile, thereby inducing seaward cross-shore sediment transport. The shoals under consideration for the SRIPP are detached shoreface ridges and are located over 8 km (5 mi) from the Assateague shoreline. There are deep troughs landward of the two shoals and the crest heights are lower compared to Blackfish Bank (crests ranging from 4 to 7 m [13 to 23 ft]), which is located shoreward of Shoals A and B. As a result, the shoals are essentially isolated from the

Affected Environment

shoreline. The relevant characteristics of Unnamed Shoals A and B relative to cross-shore sediment transport supporting this conclusion are summarized in Table 13.

Table 13: Characteristics of Unnamed Shoals A and B Relative to Cross-Shore Sediment Transport

Shoal	Distance from Assateague Island km (mi)	Elevation Relative to Mean Sea Level in m (ft)	
		Shoal Crest	Trough Landward of Shoal
A	8 (5)	-8 (-26)	-20 (-66)
B	12 (7.5)	-10 (-33)	-26 (-85)

3.1.6 Water Resources

3.1.6.1 *Surface Water and Water Quality*

Wallops Island is separated from the mainland by a marshy bay. The marshes flood regularly with the tides and are drained by an extensive system of meandering creeks. Surface water on Wallops Island flows through numerous tidal tributaries that subsequently flow to the Atlantic Ocean.

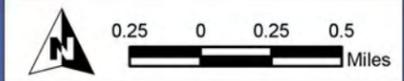
The southern and eastern portions of Wallops Island are part of the Eastern Lower Delmarva watershed, while the western portion is part of the Chincoteague Bay watershed. The remaining Wallops Island surface waters flow into numerous small unnamed watersheds. The Chincoteague Bay watershed has little topographic relief and a high water table. Large areas of the watersheds on Wallops Island are comprised of tidal wetlands. The Atlantic Ocean lies to the east of Wallops Island. Figure 31 shows the water resources on and around Wallops Island.

The northern boundary of Wallops Island is formed by Chincoteague Inlet and its western side is bounded by a series of water bodies that include (from north to south) Ballast Narrows, Bogues Bay, Cat Creek, and Hog Creek (Figure 31). This western boundary of Wallops Island includes a section of the Virginia Inside Passage, a federally maintained navigational channel. No natural perennial streams or ponds exist on the island; however, intermittent water bodies may form after storms or in response to other physical forces such as tides. One constructed stormwater detention pond is located north of building V-20 adjacent to the Navy AEGIS building.

Northeast of Wallops Island, across Chincoteague Inlet, are Assateague and Chincoteague Islands. At the southern portion of Assateague Island is Tom's Cove. Assateague Island is separated from Chincoteague Island by a series of water bodies to its west (north to south): Assateague Bay, Oyster Bay, Little Oyster Bay, and Assateague Channel. South of Wallops Island is Assawoman Inlet, which separates it from Assawoman Island. Assawoman Creek, a tributary of Woman's Bay, is found just south of Wallops Island.



- Stream/ River
- - - WFF Boundary
- - - Existing Unpaved Road
- Existing Road
- Existing Facilities
- Water Body
- Swamp/Marsh



Title: Surface Waters	
	URS Proj No: 15301785
Figure: 31	
Client : NASA	
Shoreline Restoration Environmental Impact Statement	

This page intentionally left blank.

The CWA (33 U.S.C. §1251 et seq.), as amended in 1977, established the basic framework for regulating discharges of pollutants into the waters of the United States. The USACE regulates the discharge of dredged or filled material into waters of the United States, including wetlands, pursuant to Section 404 of the CWA. Section 401 of the CWA requires States to certify permit compliance with Federal laws, regulations, and standards. The Virginia Department of Environmental Quality (VDEQ) is responsible for providing Section 401 Water Quality Certification for Section 404 Federal permits.

Surface waters in the vicinity of Wallops Island are saline to brackish and are influenced by the tides. Saltwater intrusion, which is the movement of saltwater into a freshwater environment, occurs periodically within the marshes at WFF. Most often, saltwater intrusion is caused by ground-water pumping from coastal wells (Barlow, 2003), or from construction of navigation channels. Salt water intrusion can also occur as the result of a natural process like a storm surge from a hurricane.

Outgoing tidal flow is generally north and east to Chincoteague Inlet and out to the Atlantic Ocean; incoming tides flow in the reverse direction. The VDEQ has designated the surface waters around Wallops Island as Class II – Estuarine Waters (VDEQ, 2009). The Atlantic Ocean is designated as Class I – Open Ocean. Surface waters in Virginia must meet the water quality criteria specified in 9 Virginia Administrative Code (VAC) 25-260-50. This set of criteria establishes limits for minimum dissolved oxygen concentrations, pH, and maximum temperature for the different surface water classifications in Virginia. In addition, Virginia surface waters must meet the surface water criteria specified in 9 VAC 26-260-140. This set of criteria provides numerical limits for various potentially toxic parameters. For the Class I and II waters in the vicinity of Wallops Island, the saltwater numerical criterion is applied. Both sets of standards are used by the Commonwealth of Virginia to protect and maintain surface water quality.

No wild or scenic rivers are located on, or adjacent to, Wallops, Assateague, Chincoteague, or Assawoman Islands; therefore, the Wild and Scenic Rivers Act (16 U.S.C. 1271-1287) does not apply to this project (USFWS, 2007).

3.1.6.2 Wetlands

In general terms, wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface. They are transitional areas between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water (Cowardin et al., 1979). Wetlands provide a number of benefits to the environment, including water quality improvement, floodwater storage, fish and wildlife habitat, aesthetics, and biological productivity.

EO 11990 (Wetland Protection) directs Federal agencies to minimize the destruction, loss, and degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetland communities. In accordance with the CWA (33 U.S.C. §1251 et seq.), projects at WFF that involve dredging or filling wetlands require Section 404 permits from the USACE. Title 14 of CFR Part 1216.2 (NASA regulations on Floodplain and Wetland Management) directs WFF and its tenants to minimize wetland impacts.

In addition, permits may be required from the VMRC, Accomack County Wetlands Board, and the VDEQ for work that may impact wetlands. A Joint Permit Application (JPA), filed with

Affected Environment

VMRC, is used to apply for permits for work in the waters of the United States, including wetlands, within Virginia. The VMRC plays a central role as an information clearinghouse for local, State, and Federal levels of review; JPAs submitted to VMRC receive independent yet concurrent reviews by local wetland boards, VMRC, VDEQ, and USACE.

Wallops Island

Extensive wetland systems border Wallops Island and can typically be classified as one of the three following systems:

- Estuarine - tidal wetlands whose salinities exceed 0.5 parts per thousand (ppt), at least partially enclosed by land;
- Palustrine - non-tidal wetlands not adjacent to rivers and lakes and tidal wetlands whose salinity does not exceed 0.5 parts per thousand; and
- Shallow open water - bodies of standing water less than 2 m (7 ft) in depth free of emergent vegetation but may contain floating vegetation.

Wetlands are also classified by the types of vegetation that grow within them. Typical wetland vegetation types encountered on Wallops Island are:

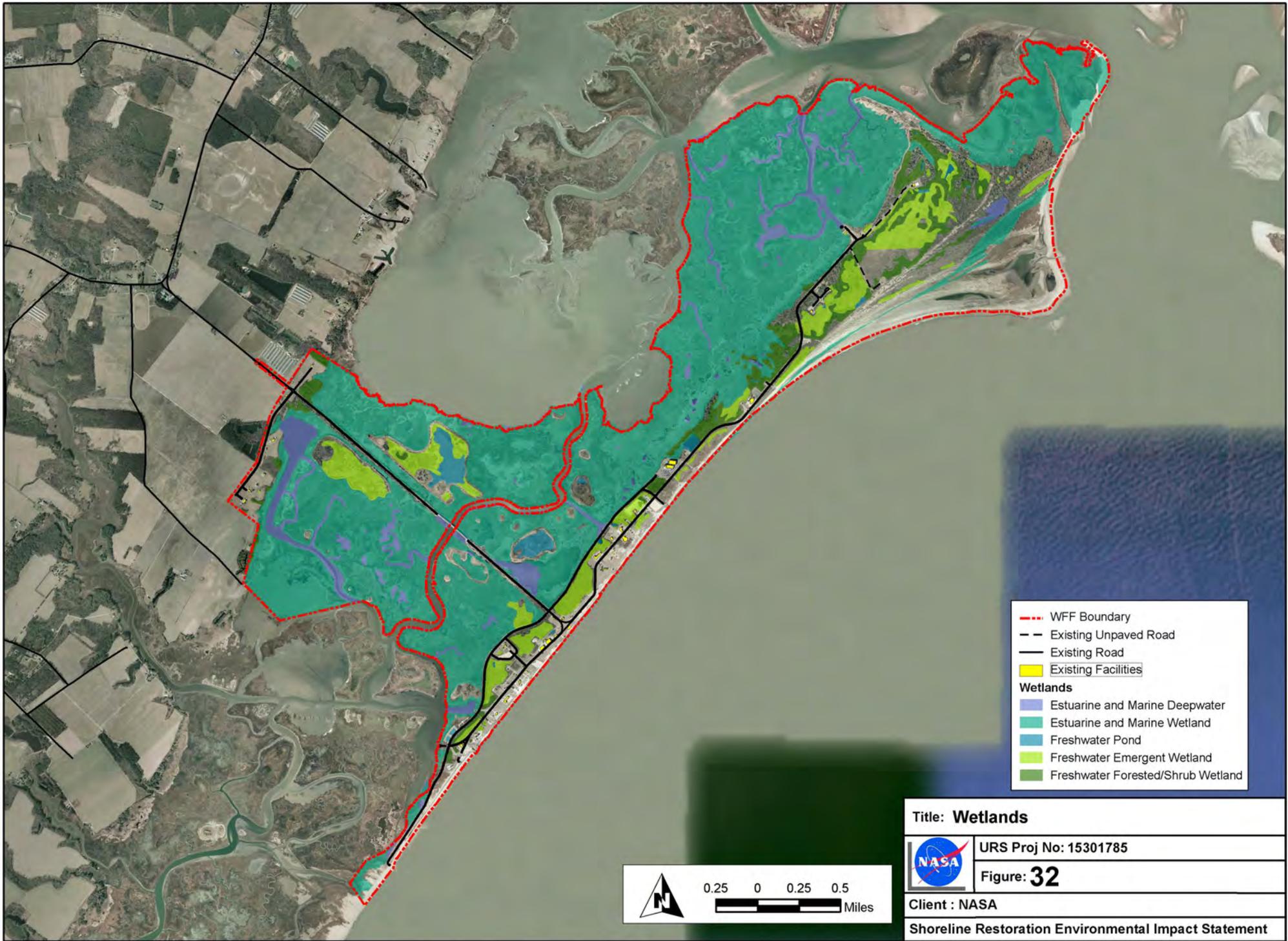
- Emergent - dominated by erect rooted herbaceous, usually perennial plants;
- Scrub-shrub - dominated by woody plants less than 6m (20 ft.) in height; and
- Forested - dominated by woody plants greater than 6m (20 ft.) in height.

Figure 32 provides further details on the types and locations of wetland communities present on Wallops Island. The island has non-tidal freshwater emergent wetlands and several small freshwater ponds in the interior. Freshwater forested/shrub wetlands, estuarine intertidal emergent wetlands, and maritime forests exist on its northern and western edges. Marsh wetlands also fringe Wallops Mainland along Arbuckle Creek, Hog Creek, and Bogues Bay.

Wetland delineations in the vicinity of the existing seawall were conducted in July 2009 and July 2010. Tidal wetlands were found including 1.19 ha (2.95 ac) of palustrine shrub-scrub and 2.21 ha (5.47 ac) of palustrine emergent wetlands. In addition, 2.38 ha (5.87 ac) of the marine intertidal unconsolidated shore (the Atlantic Ocean) was delineated within the study area (Figure 33).

Assateague and Assawoman Islands

The peninsula at the southernmost portion of Assateague Island, forming Tom's Cove, has intertidal marine wetlands along its southeastern shore and slightly inland. Both estuarine intertidal unconsolidated and estuarine intertidal emergent wetlands are found in the center of the peninsula. Where the peninsula widens into the main body of Assateague Island there are numerous freshwater ponds as well as freshwater forest and shrub areas. South of Wallops Island, Assawoman Island has intertidal marine wetlands along its western shore and both estuarine intertidal unconsolidated and estuarine inter-tidal emergent wetlands inland.



--- WFF Boundary
 - - Existing Unpaved Road
 — Existing Road
 ■ Existing Facilities

Wetlands

- Estuarine and Marine Deepwater
- Estuarine and Marine Wetland
- Freshwater Pond
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland

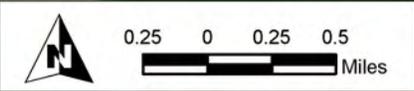
Title: **Wetlands**

 URS Proj No: 15301785

Figure: **32**

Client : NASA

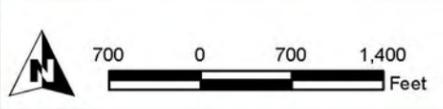
Shoreline Restoration Environmental Impact Statement



This page intentionally left blank.



- Palustrine Emergent Wetlands (Timmons, 2010)
- Palustrine Emergent Wetlands (Timmons, 2009)
- Palustrine Scrub-Shrub Wetlands (Timmons, 2010)
- Ocean
- Limits of July 2010 Wetland Study Areas



Title: Wetlands Identified along Seawall, July 2009 & July 2010

URS Proj No:15301785

Figure: **33**

Client : NASA

Shoreline Restoration Environmental Impact Statement

This page intentionally left blank.

3.1.6.3 Marine Waters

The continental shelf water within the SRIPP study area of the Atlantic Ocean originates from the coastal waters off Canada, moves southward over the continental shelf, and is continuously modified by river runoff and air-sea interaction as it moves to the south. In winter, the temperature of the shelf water mass is much lower than that of the slope water mass due to the cooling effects of the atmosphere. Currents in the shelf water mass have a stronger southwest-directed component in the winter season compared to all other seasons. Development of the shelf water mass along the Mid-Atlantic coast is also dependent on the variations in Gulf Stream transport from the south, as well as forces from the atmosphere and river runoff.

Marine waters in the project area maintain a fairly uniform salinity range (32 to 36 ppt) throughout the year, with pockets of high salinity water (38 ppt) found near the Gulf Stream in the fall (NASA, 2003a). The salinity of nearshore shelf water, influenced by freshwater runoff, is generally lower than offshore water masses. Over the continental shelf, the salinity concentration usually increases with depth. Water masses near the coast are at most times of the year less saline than the corresponding layer offshore, due to freshwater influence from rivers.

A thermocline is a vertical zone of rapidly changing temperature that divides the upper layer of warmer marine water from the colder, deeper layer. Because density is controlled largely by temperature, the thermocline coincides with a vertical zone of rapidly changing density. This phenomenon is referred to as stratification. There are distinct differences in stratification of the Mid-Atlantic Ocean water column between summer and winter. The density gradient causes resistance to vertical mixing and there is little exchange between the surface waters and the deeper, colder waters (Kennett, 1982). In mid-latitude waters, such as the waters within the vicinity of the proposed SRIPP offshore borrow sites, a seasonal thermocline develops in the spring and persists until fall (Hollister, 1973; Kennett, 1982; Adams et al., 1993). This occurs with the onset of stratification due to the warming of the surface waters by solar radiation and the decrease in mixing as storm activity diminishes.

In the SRIPP project area in winter, the water column is vertically well-mixed, with water temperatures averaging 14° Celsius (C) (57° Fahrenheit [F]) at the surface and 11° C (52° F) at depths greater than 20 m (656 ft). In summer, the water column is vertically stratified with 25° C (77° F) water near the surface and 10° C (50° F) water at depths greater than 200 m (656 ft) (NASA, 2003a). Results of the 2009 benthic video survey of Unnamed Shoals A and B (described in Section 3.2.5.4) showed bedforms on both shoal surfaces, which is evidence that wave energy reaches extends to the seafloor and mixing occurs throughout the water column.

3.1.7 Floodplains

EO 11988 (Floodplain Management) requires Federal agencies to take action to minimize occupancy and modification of the floodplain. Specifically, EO 11988 prohibits Federal agencies from funding construction in the 100-year floodplain unless there are no practicable alternatives. As shown on the Flood Insurance Rate Maps (FIRMs) produced by FEMA, the 100-year floodplain designates the area inundated during a storm having a 1-percent chance of occurring in any given year. The 500-year floodplain designates the area inundated during a storm having a 0.2-percent chance of occurring in any given year.

FIRM Community Panels 5100010070B and 5100010100C indicate that Wallops Island is located entirely within the 100-year and 500-year floodplains. Wallops Island is a barrier island

Affected Environment

that experiences flood waters primarily during major storm events (nor'easters, tropical storms, or hurricanes) both from waves and from the marshes and bays on its land-ward side. The wetlands on Wallops Island and the island itself retain floodwaters during storm events and therefore function as flood mitigation for the mainland during storms.

3.1.8 Coastal Zone Management

Barrier islands such as Wallops, Assateague, Chincoteague, and Assawoman Islands are elongated, narrow landforms that consist largely of unconsolidated and shifting sand, and lie parallel to the shoreline between the open ocean and the mainland. These islands provide protection to the mainland, prime recreation resources, important natural habitats to unique species, and valuable economic opportunities to the country. The northern end of Wallops Island also contains coastal primary sand dunes that serve as protective barriers from the effects of flooding and erosion caused by coastal storms (NASA, 2008a).

The Coastal Barrier Resources Act (CBRA [P.L. 97-348], 16 U.S.C. 3501-3510), enacted in 1982, designated various undeveloped coastal barrier islands as units in the Coastal Barrier Resources System. Designated units are ineligible for direct or indirect Federal financial assistance programs that could support development on coastal barrier islands; exceptions are made for certain emergency and research activities. Wallops Island is not included in the Coastal Barrier Resources System; therefore, the CBRA does not apply.

VDEQ is the lead agency for the Virginia Coastal Zone Management (CZM) Program, which is authorized by NOAA to administer the Coastal Zone Management Act of 1972. Any Federal agency development in Virginia's Coastal Management Area (CMA) must be consistent with the enforceable policies of the CZM Program. Although Federal lands are excluded from Virginia's CMA, any activity on Federal land that has reasonably foreseeable coastal effects must be consistent with the CZM Program (VDEQ, 2008a). Enforceable policies of the CZM Program that must be considered when making a Federal Consistency Determination include:

- **Fisheries Management.** Administered by VMRC, this program stresses the conservation and enhancement of shellfish and finfish resources and the promotion of commercial and recreational fisheries.
- **Subaqueous Lands Management.** Administered by VMRC, this program establishes conditions for granting permits to use State-owned bottomlands.
- **Wetlands Management.** Administered by VMRC and VDEQ, the wetlands management program preserves and protects tidal wetlands.
- **Dunes Management.** Administered by VMRC, the purpose of this program is to prevent the destruction or alteration of primary dunes.
- **Non-Point Source Pollution Control.** Administered by the Virginia Department of Conservation and Recreation (VDCR), the Virginia Erosion and Sediment Control Law is intended to minimize non-point source pollution entering Virginia's waterways.
- **Point Source Pollution Control.** Administered by VDEQ, the Virginia Pollutant Discharge Elimination System permit program regulates point source discharges to Virginia's waterways.

- **Shoreline Sanitation.** Administered by the Virginia Department of Health, this program regulates the installation of septic tanks to protect public health and the environment.
- **Air Pollution Control.** Administered by VDEQ, this program implements the Federal Clean Air Act (CAA) through a legally enforceable State Implementation Plan.
- **Coastal Lands Management.** Administered by the Chesapeake Bay Local Assistance Department, the Chesapeake Bay Preservation Act guides land development in coastal areas to protect the Chesapeake Bay and its tributaries.

Because Wallops Island is within Virginia's CMA, NASA activities are subject to the Federal Consistency requirement. The nearby barrier islands of Assateague, Chincoteague, and Assawoman Islands are also included in Virginia's CMA.

3.1.9 Air Quality

The CAA (P.L. 108-201, 42 U.S.C. 85 *et seq.*), as amended, requires EPA to set National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment. The CAA established two types of NAAQS: primary and secondary standards. Primary standards set limits to protect public health, including the health of sensitive populations such as asthmatics, children, and the elderly. Secondary standards protect public welfare, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings.

The EPA has set NAAQS for six principal pollutants that are called "criteria" pollutants. They are: CO, NO_x, O₃—for which VOCs and NO_x are precursors—lead (Pb), sulfur dioxide (SO₂), and particulate matter (PM). EPA divides PM into two categories: inhalable coarse particles (i.e., PM less than or equal to 10 micrometers (PM₁₀) but larger than 2.5 micrometers) and fine particles (i.e., PM less than or equal to 2.5 micrometer (PM_{2.5}). Although States have the authority to adopt stricter standards, the Commonwealth of Virginia has accepted the Federal standards and has incorporated them by reference in 9 VAC 5-30 (VDEQ, 2008b; see Table 14).

Federal regulations designate Air Quality Control Regions, or airsheds, that cannot attain compliance with the NAAQS as non-attainment areas. Areas meeting the NAAQS are designated as attainment areas. Wallops Island and Mainland are located in Accomack County, an attainment area for all criteria pollutants; therefore, a General Conformity Review (under Section 176(c) of the CAA) does not apply to the facilities prior to implementing a Federal action.

Wallops Island and Wallops Mainland are considered a synthetic minor source, and the two land masses are combined into a facility-wide State operating air permit for stationary emission sources (Permit Number 40909, amended August 3, 2006). A facility is considered a major source in an attainment area if all of its sources together have a potential to emit (PTE) greater than or equal to 90.7 mt per year (100 tons per year) of the criteria pollutants, or greater than or equal to 9.1 mt per year (10 tons per year) of a single Hazardous Air Pollutant (HAP) or 22.7 mt per year (25 tons per year) of combined HAPs. Table 15 lists the emissions for Wallops Island and Wallops Mainland based on the 2008 Emission Statement.

Table 14: National Ambient Air Quality Standards

Pollutant	Primary Standards		Secondary Standards	
	Level	Averaging Time ¹	Level	Averaging Time
CO	9 ppm (10 mg/m ³)	8-hour ²	None	
	35 ppm (40 mg/m ³)	1-hour ²		
Pb	0.15 µg/m ³ ³	Rolling 3-Month Average	Same as Primary	
	1.5 µg/m ³	Quarterly Average	Same as Primary	
NO ₂	53 ppb ⁴	Annual Arithmetic Average	Same as Primary	
	100 ppb	1-hour ⁵	None	
PM ₁₀	150 µg/m ³	24-hour ⁶	Same as Primary	
PM _{2.5}	15 µg/m ³	Annual Arithmetic Average ⁷	Same as Primary	
	35 µg/m ³	24-hour ⁸	Same as Primary	
O ₃	0.075 ppm (2008 standard)	8-hour ⁹	Same as Primary	
	0.08 ppm (1997 standard)	8-hour ¹⁰	Same as Primary	
	0.12 ppm	1-hour ¹¹	Same as Primary	
SO ₂	0.03 ppm	Annual Arithmetic Average	Same as Primary	
	0.14 ppm	24-hour ²	0.5 ppm	3-hour ²
	75 ppb ¹²	1-hour	None	

ppm = parts per million

µg = microgram

NO₂ = nitrogen dioxide

¹A NAAQS violation results in the re-designation of an area; however, an exceedance of the NAAQS does not always mean a violation has occurred.

²Not to be exceeded more than once per year.

³Final rule signed October 15, 2008.

⁴The official level of the annual NO₂ standard is 0.053 ppm, equal to 53 ppb, which is show here for the purpose of clearer comparison to the 1-hour standard.

⁵To attain this standard, the 3-year average of the 98th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 100 ppb (effective January 22, 2010).

⁶Not to be exceeded more than once per year on average over 3 years.

⁷To attain this standard, the 3-year average of the weighted annual mean PM_{2.5} concentrations from single or multiple community-oriented monitor must not exceed 15.0 µg/m³.

⁸To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 µg/m³ (effective December 17, 2006).

⁹To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average O₃ concentrations measured at each monitor within an area over each year must not exceed 0.075 ppm (effective May 27, 2008).

¹⁰(a) To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average O₃ concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm.

(b) The 1997 standard – and the implementation rules for that standard – will remain in place for implementation purposes as EPA undertakes rulemaking to address the transition from the 1997 O₃ standard to the 2008 O₃ standard.

(c) EPA is in the process of reconsidering these standards (set in March 2008).

¹¹(a) EPA revoked the 1-hour O₃ standard in all areas, although some areas have continuing obligations under the standard (anti-backsliding).

(b) The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is ≤ 1.

¹²Final rule signed June 2, 2010. To attain this standard, the 3-year average of the 99th percentile of the daily maximum 1-hour average at each monitor within an area must not exceed 75 ppb.

Source: EPA, 2010

Table 15: Calendar Year 2008 Air Emissions at Wallops Island/Mainland

Pollutant	Emissions (mt per year/tons per year)
CO	0.34 / 0.37
NO _x	1.36 / 1.50
SO ₂	2.65 / 2.92
VOC	0.03 / 0.03
PM ₁₀	0.15 / 0.16
PM	0.21 / 0.23

Source: VDEQ, 2008b

Prevention of Significant Deterioration

Separate pre-construction review procedures have been established for projects that are proposed to be built in attainment areas versus non-attainment areas. The pre-construction review process for new or modified major sources is called New Source Review (NSR) and consists of a Prevention of Significant Deterioration (PSD) review for sources located in an attainment area. This review process is intended to keep new air emission sources from causing existing air quality to deteriorate beyond acceptable levels codified in the Federal regulations. Construction of major new stationary sources in attainment areas must be reviewed in accordance with the PSD regulations. The PSD rule defines a major source as any source with a PTE of 90.7 mt per year (100 tons per year) or more of any criteria pollutant for source categories listed in 40 CFR 52.21(b)(1)(i), or 226.8 mt per year (250 tons per year) or more of any criteria pollutant for source categories that are not listed. If a new source is determined to be a major source for any criteria pollutants, then other remaining criteria pollutants would be subject to PSD review if those pollutants are emitted at rates that exceed the following significant emission thresholds:

- 90.7 mt per year (100 tons per year) for CO
- 36.3 mt per year (40 tons per year) for NO_x, VOC, or SO₂
- 13.6 mt per year (15 tons per year) for PM₁₀
- 22.7 mt per year (25 tons per year) for PM

Major sources that exceed any of the PSD thresholds are subject to PSD review for all criteria pollutants. Although Wallops Island and Wallops Mainland are assumed not to be a major source under the PSD program, nor one of the listed source categories, to continue to protect air quality in designated attainment areas, a PSD applicability analysis must be conducted for each Federal project. NASA ensures that before each project is initiated, PTE is calculated to not only assess whether a permit to construct for applicable sources is needed, but also to document that the entire project does not trigger PSD.

Minor New Source Review

The minor NSR permit program applies to the construction, reconstruction, relocation, or modification of any stationary source that will emit regulated air pollutants above minimum exemption levels. If a permit is required, it must be obtained before any activity on the project can begin. Prior to installing any new stationary emission sources, NASA is responsible for

Affected Environment

assessing if a permit-to-construct application is necessary, and if so, for preparing and filing the applicable Form 7 permit application forms.

New Source Performance Standards

New Source Performance Standards (NSPS) regulations (40 CFR 60) establish pollutant emission limits and monitoring, reporting, and recordkeeping requirements for various emission sources based on source type and size. These regulations apply to new, modified, or reconstructed sources. According to the State Operating Permit, and confirmation by NASA environmental personnel, there are no current (i.e., installed) emission sources (i.e., boilers, storage vessels, emergency generators) that are subject to NSPS. However, referencing the NASA Expansion of the WFF Launch Range EA (NASA, 2009a), there were proposed emergency generators associated with the proposed action and alternatives that would be subject to NSPS Subpart IIII regarding emissions from stationary diesel internal combustion engines, which will eventually be included in the facility's permit.

National Emission Standards for Hazardous Air Pollutants

Section 112(a) of the CAA Amendments requires the development of emission standards for listed HAPs from new and modified equipment at stationary major and area sources (i.e., a source that is not a major HAP source). Emission standards promulgated under this subsection require the maximum degree of reduction in emissions of HAPs for specific source categories. The standards are to be established by taking into consideration the cost of achieving such emission reductions, and any non-air quality health and environmental impacts and energy requirements.

National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations, codified at 40 CFR Parts 61 and 63, regulate HAP emissions. Part 61 was promulgated prior to the 1990 CAA Amendments and regulates specific HAPs: asbestos, benzene, beryllium, coke oven emissions, inorganic arsenic, mercury, radionuclides, and vinyl chloride. The 1990 CAA Amendments established an original list of 189 HAPs to be regulated, which resulted in the promulgation of Part 63, also known as the Maximum Achievable Control Technology (MACT) standards. These MACTs regulate emissions from major HAP sources and specific source categories that emit HAPs.

Wallops Island and Wallops Mainland are currently considered a minor (or area) HAP source, and are therefore not subject to NESHAP regulations for major sources. The facility would, however, be subject to any applicable area source NESHAP regulations when these regulations are promulgated by EPA. Condition 19 of the March 24, 2008, Stationary Source Permit to Operate establishes a federally enforceable limit of 8.5 mt per year (9.4 tons per year) of hydrochloric acid and 0.91 mt per year (1.0 ton per year) of Pb. These limits are placed on the combustion of solid fuel propellants during static rocket motor test firing events.

3.1.9.1 Greenhouse Gas Emissions

Each GHG is assigned a global warming potential (GWP), which is the ability to trap heat, and is standardized to CO₂, which has a GWP value of one. For example, N₂O has a GWP of 310, meaning it has a global warming effect 310 times greater than CO₂ on an equal-mass basis. For simplification, total GHG emissions are often expressed as a CO₂ equivalent (CO₂e). The CO₂e

is calculated by multiplying each GHG emission by its GWP and adding the results to produce a combined rate to represent all GHGs.

There are a multitude of State and regional regulatory programs requiring GHG emissions reductions. Although Virginia has no current GHG legislation, the Governor issued Executive Order (EO) 59 in 2007, which established the “Governor’s Commission on Climate Change” (Bryant, 2008). Since then, VDEQ has had a Climate Change Steering Committee and GHG Emissions Workgroup who have focused on possible regional reduction targets, among other items. In addition to State programs, there is emerging Federal climate change-related legislation. In 2007, the U.S. Supreme Court determined that EPA had the regulatory authority to include GHGs as pollutants under the CAA. On October 30, 2009, EPA issued a new rule (Mandatory Reporting of GHGs) that adds substantial additional requirements, such as measurement, monitoring, and reporting, for many industries.

As GHGs are relatively stable in the atmosphere and are essentially uniformly mixed throughout the troposphere and stratosphere, the climatic impact of GHG emissions does not depend upon the source location. Therefore, regional climate impacts are likely a function of global emissions.

Table 16 lists the GHG emissions for Wallops Island/Mainland based on the 2008 annual update forms for Wallops Island, which provides VDEQ with consumption rates from stationary sources. Emissions factors from the EPA’s AP-42 (EPA, 2009b) and Environment Canada’s National Inventory Report (Environment Canada, 2006) were used in conjunction with the Wallops Island/Mainland consumption rates to calculate annual GHG emissions for boilers/heating equipment, emergency generators, and mobile sources (i.e., government-owned gasoline-powered vehicles). GHG emissions were combined into one CO₂e value using approved factors to weight each pollutant.

Table 16: Calendar Year 2008 Greenhouse Gas Air Emissions at Wallops Island/Mainland

Pollutant	Emissions (mt per year/tons per year)
CH ₄	0.06 (0.07)
CO ₂	2,676 (2,950)
N ₂ O	0.14 (0.15)
Total GHG Emissions	2,676 (2,950)

Table 17 depicts estimates of GHG emissions for Wallops Island/Mainland facilities by source categories. Mobile source emissions were based on fuel consumption rather than vehicle miles traveled due to unavailable data. Mobile source emissions for Wallops Island were assumed to be all gasoline dispensed from the Main Base as there was no data available to determine what percentage of gasoline dispensed was used at the Main Base versus Wallops Island/Mainland.

Affected Environment

Table 17: Calendar Year 2008 Greenhouse Gas Emissions at Wallops Island/Mainland in Metric Tonnes per Year (Tons per Year)

Source	CH ₄	CO ₂	N ₂ O	CO ₂ e
External Combustion Sources	0.021 (0.023)	1,823.60 (2,010.15)	0.039 (0.043)	1,835.73 (2,203.96)
Internal Combustion Sources	0.0009 (0.001)	12.23 (13.48)	0.0018 (0.002)	12.81 (14.12)
Mobile Sources	0.043 (0.047)	840.62 (926.61)	0.093 (0.10)	870.03 (959.25)
Total GHG Emissions	0.065 (0.070)	2,676.45 (2,950.24)	0.099 (0.143)	2,718.58 (2,997.33)

3.1.10 Noise

The EPA's Noise Control Act of 1972 (42 U.S.C. 4901 to 4918) as amended by the Quiet Communities Act of 1978, states that it is the policy of the United States to promote an environment for all Americans free from noise that jeopardizes their health or welfare.

3.1.10.1 Fundamentals of Noise

Sound is a physical phenomenon consisting of minute vibrations that travel through a medium, such as air or water. Noise is unwanted sound that may interfere with normal activities or otherwise diminishes the quality of the environment, for either humans or wildlife. Sound is generally characterized by several variables, including frequency and intensity. Frequency describes the sound's pitch and is measured in Hertz (Hz), while intensity describes the sound's loudness and is expressed in decibels (dB). Decibels are measured using a logarithmic scale.

The method commonly used to quantify airborne sounds consists of evaluating all frequencies of a sound according to a weighting system that reflects that human hearing is less sensitive at low frequencies and extremely high frequencies than at the mid-range frequencies. This is called "A" weighting, and the dB level measured is called the A-weighted sound level (dBA) (see Table 18). Sounds levels underwater are not weighted and measure the entire frequency range of interest. Because air and water are two different media with different densities, different reference sound pressure levels are used for each. The most commonly used reference for air is 20 microPascals (μPa) and the most commonly used reference for underwater is 1 μPa . Unless otherwise noted, all airborne noise levels are reported in dBA referenced to 20 μPa and all underwater noise levels are reported in dB relative to 1 μPa in this PEIS.

3.1.10.2 Noise Standards and Criteria

Because sounds in the outdoor environment are usually not continuous, there are a few common metrics used to describe noise. The first is the time-averaged sound pressure level or L_{eq} . The 1-hour L_{eq} is the measurement unit used to describe monitored baseline in-air noise levels in the vicinity of WFF. It conforms to the requirements in 23 CFR Part 772 and is a descriptor recommended by the Federal Highway Administration for describing noise levels during peak traffic periods. The second is the Day Night Level, or DNL, which is a 24-hour average sound level with an added penalty of 10 dB during nighttime hours (10 p.m. to 7 a.m.) to account for

sensitivity of the period when people are typically sleeping. EPA guidelines, and those of many other Federal agencies, recommend that outdoor sound levels do not exceed 55 dB DNL in noise-sensitive land uses such as residences, schools, or hospitals.

The U.S. Occupational Safety and Health Administration (OSHA) regulates noise impacts on workers. OSHA regulations on in-air noise standards ensure that workers are not exposed to noise levels higher than 85 dBA. Exposure to 85 dBA is limited to 15 minutes or less during an 8-hour work shift. Exposure to impulsive or impact noise (loud, short duration sounds) is not to exceed 140 dB peak sound pressure level.

Table 18: Typical Noise Levels of Familiar Noise Sources and Public Responses

Thresholds/Noise Sources	Sound Level (dBA)	Subjective Evaluation ^a	Possible Effects on Humans ^a
Human threshold of pain	140	Deafening	Continuous exposure to levels above 70 dBA can cause hearing loss in the majority of the population
Siren at 100 ft Loud rock band	130		
Jet takeoff at 200 ft Auto horn at 3 ft	120		
Chain saw Noisy snowmobile	110		
Lawn mower at 3 ft Noisy motorcycle at 50 ft	100	Very Loud	
Heavy truck at 50 ft	90		
Pneumatic drill at 50 ft Busy urban street, daytime	80	Loud	Speech interference
Normal automobile at 50 mph Vacuum cleaner at 3 ft	70		
Air conditioning unit at 20 ft Conversation at 3 ft	60	Moderate	Sleep interference
Quiet residential area Light auto traffic at 100 ft	50		
Library Quiet home	40	Faint	
Soft whisper at 15 ft	30		
Slight rustling of leaves	20	Very Faint	
Broadcasting studio	10		
Threshold of Human Hearing	0		

^aBoth the subjective evaluations and the physiological responses are continuums without true threshold boundaries. Consequently, there are overlaps among categories of response that depend on the sensitivity of the noise receivers.

Source: EPA, 1974

Affected Environment

The Accomack County code states that “...any loud, disturbing, or unreasonable noise in the county, which noise is of such character, intensity or duration as to be detrimental to the life, health, or safety of any person, or to disturb the quiet, comfort, or response of any reasonable person” is prohibited (Accomack County, 2001). Table 19 shows the specific noise limitations by land use as regulated by Accomack County.

Table 19: Accomack County Noise Guidelines by Land Use

District/Land Use	Daytime Level (dBA)	Nighttime Level (dBA)
Residential	65	55
Agricultural	65	55
Business	70	60
Industrial	70	60
Barrier Island	65	55

Source: Accomack County, 2001

As a general rule, the above levels should not be exceeded; however, exceptions to the rule exist. According to Article II, Section 38-35 of the Accomack County code, “This article shall not apply to noises generated by commercial or industrial operations except for those noises that emanate from the boundaries of such commercial or industrial site and affect persons who are not working onsite at such commercial or industrial operation.” There are no County-specific regulations regarding unacceptable levels of dBA at noise-sensitive receptors such as schools, hospitals, courts, and churches; although the Accomack County code states that noise would be deemed excessive when it “unreasonably interferes with the workings of such institution or building, provided that conspicuous signs are displayed on or near such building or institution indicating that such is a school, church, hospital, clinic or other public building.”

3.1.10.3 Existing Noise Environment

In 1992, WFF performed a noise monitoring survey and modeling program to determine baseline noise levels around the facility. Of the 13 sites selected for the noise-monitoring program, four were on Wallops Island and one was in the town of Assawoman along the route to Wallops Island.

Noise levels at each site were monitored for periods ranging from 15 minutes to 1 hour, depending on the site and predominant source of noise. A period of 1 hour was used at sites monitored during peak traffic conditions. Shorter periods were used for sites monitored during off-peak traffic conditions and sites in natural environments where noise levels were relatively constant.

Wallops Island was found to contain a wide range of background noise levels. At the northern portion of Wallops Island, natural sounds of wind, trees, and birds are the predominant source of the 53-dBA noise level. At the southern end of the island, as well as along the eastern seawall, the sounds of water and waves generate a noise level of about 64 dBA. In the interior of the island, near roads and buildings, noise levels are about 61 dBA during off-peak traffic periods and 64 to 65 dBA during peak a.m. and p.m. traffic (NASA, 2005).

Existing underwater sound levels are unknown, but existing sources of underwater sound include physical (earthquakes, wind, etc.), biological (marine mammals, fish, invertebrates), and anthropogenic (commercial shipping, recreational vessels, fishing vessels, dredging, and aircrafts).

3.1.11 Hazardous Materials and Hazardous Waste

3.1.11.1 *Hazardous Materials Management*

The WFF Integrated Contingency Plan (ICP), developed to meet the requirements of 40 CFR Part 112 (Oil Pollution Prevention and Response), 40 CFR Part 265 Subparts C and D (Hazardous Waste Contingency Plan), and 9 VAC 25-91-10 (Oil Discharge Contingency Plan), serves as the facility's primary guidance document for the prevention and management of oil, hazardous material, and hazardous waste releases. The ICP includes the following procedures for hazardous materials management at the entire WFF facility, including Wallops Island:

- Each container of hazardous material is labeled in English with the following minimal description: name of chemical and all appropriate hazard warnings.
- Each work area has Material Safety Data Sheets (MSDSs) on file for each hazardous material used onsite. Each MSDS is in English and contains all required information. WFF utilizes an online electronic chemical inventory that contains links to appropriate MSDSs and is accessible to all WFF personnel through the GSFC intranet. Individual WFF support contractor offices train their personnel in the applicable hazardous communication pertinent to the requirements for each employee.
- Spill contingency and response procedures are prepared and implemented.
- The WFF Environmental Office offers annual ICP training to all Wallops and tenant personnel as well as to all visiting project teams.

Vessels operating in the navigable waters of the United States, including trailer suction hopper dredges, are subject to the federal regulation pertaining to hazardous waste materials on board a vessel – 49 CFR Part 176 – Carriage by Vessel. This regulation defines the general vessel operating requirements such as certificates, cargo manifest, special permits, emergency situations, required reporting, and repairs involving welding, burning, and power-activated tools and appliances when hazardous waste materials are on board the vessel.

3.1.11.2 *Hazardous Waste Management*

The regulations that govern hazardous waste management are the Resource Conservation and Recovery Act (42 U.S.C. 6901 *et seq.*) and Virginia's Hazardous Waste Management Regulations (9 VAC 20-60). A solid waste is any material that is disposed, incinerated, treated, or recycled except those exempted under 40 CFR 261.4. All hazardous wastes are classified as solid wastes. Wallops Main Base is separated from Wallops Island and Wallops Mainland by approximately 11.2 km (7 mi) of public roadway. As they are not contiguous, each has been assigned its own EPA hazardous waste generator number. Shipment of hazardous waste between the two sites is illegal except by a licensed hazardous waste transporter. To facilitate the transportation of rocket motors declared hazardous waste from the Main Base to the Wallops Island, NASA has its own hazardous waste transporter license. NASA uses licensed hazardous

Affected Environment

waste transporters to transport hazardous waste off site to licensed treatment, storage, and disposal facilities.

Wallops Island and Wallops Mainland are together classified as a Large Quantity Generator because the area has the potential to generate more than 1,000 kg (2,205 lbs) of hazardous waste per month. In calendar year 2009, 10,585 kilograms (23,335 lbs) of hazardous waste including various expired chemicals, jet fuel mixed with hydraulic fluid, used oil, oily condensate, oily rags, paint cans, and paint thinner were generated on Wallops Island and Wallops Mainland combined. Hazardous wastes generated on Wallops Island are stored on the Mainland at Building U-081, a less-than-90-day accumulation area in which hazardous waste may be stored for up to 90 days from the date of initial accumulation. In addition, Satellite Accumulation Areas are established in individual laboratories, shops, or other facilities designated by the generator for the accumulation of waste, not to exceed 208 liters (55 gallons) of hazardous waste, or 0.95 liter (1 quart) of extremely or acutely hazardous waste.

Wallops Island hazardous waste generators are responsible for the following:

- Properly containerizing waste
- Properly labeling waste containers with information pertaining to the contents and with the words “Hazardous Waste”
- Ensuring that less than 208 liters (55 gallons) of hazardous waste or less than 0.95 liter (1 quart) of acute hazardous waste are accumulated at or near the point of generation
- Properly completing and transferring a disposal inventory sheet to the NASA Environmental Office

3.1.11.3 Petroleum Storage Tank Management

The Wallops Island facilities include 21 aboveground storage tanks (ASTs) and 2 underground storage tanks (USTs). Both the ASTs and USTs are used for the storage and dispensing of heating oil. Occasionally, temporary tanks are brought to Wallops Island during construction activities and typically contain diesel fuel and gasoline. All fuel storage tanks must be operated in accordance with Virginia storage tank regulations (9 VAC 25-91 [AST] and 9 VAC 25-580 [UST]), which are overseen by the VDEQ Tidewater Regional Office.

3.1.12 Munitions and Explosives of Concern

MEC are explosive munitions (bombs, shells, grenades, etc.) that did not function as designed and may pose a risk of detonation. MEC is composed of unexploded ordnance (UXO) and discarded military munitions (DMM).

In 2007 the USACE completed a study assessing relevant information regarding suitability of various borrow site options considered for the SRIPP identified several reported UXO sites, one offshore explosive dumping area and two uncharacterized offshore UXO sites (USACE, 2007).

Ordnance, explosives, and pyrotechnics fired on to or dropped on one or more of the Wallops Island range areas include: Pentolite, HBX-1 Aluminum Explosive, Dynamite, Primacord, Composition C-3, Composition B, Electric Blasting Caps, T-55 Rocket Motors, 2.25-in Solid Rocket Motors, Practice Bombs, 37mm munitions, 30mm munitions, 20mm munitions, Mk 77

Fire Bomb, Mk5 Night Drift Signals, AN-Mk4 Signals, AN-Mk5/Mk23/Mk43, Mk6 Parachute Flares, and Aerial Mines.

There are nine known historic live fire and bombing areas off of Wallops Island. None of these are currently active (USACE, 2007). Four additional areas of concern were identified by the USACE and are listed in Table 20 below. Figure 34 illustrates the location of these 13 areas of potential MEC.

Table 20: Potential MEC Locations within Project Area

ID	Impact Area Name	Impact Area Located Within SRIPP Study Area?
2	Target Center	Yes
5	Strafing Target	Yes
6	Gunboat Point Bombing Area	Yes
7	Machine Gun and Rocket Firing Area	Yes
--	Small Arms Ranges	
14	Explosive Ammunition Test Facility	Yes
PTF	Plate Test Facility	Yes
17	Sea Target	Yes
RA	Restricted Area Danger Zone	No
EOD	Explosive Ordnance Disposal (EOD) Area	Yes
--	Off-Shore Dump Site	No
--	Off-Shore UXO site 1	Yes
--	Off-Shore UXO site 2	Yes

Source: USACE, 2007

Known historic live fire and bombing areas determined to potentially affect the project area are described below.

Target Center

The Target Center was the aiming point for the test range on Wallops Island and was used by the Naval Aviation Ordnance Test Station to analyze aviation ordnance between 1946 and 1959. The test range was instrumented and was used to assess the delivery, aircraft separation, ballistics, and accuracy of aviation ordnance. The impact area for the Target Center was located on land only on the northern eastern tip of Wallops Island. It is inferred from the lack of references to live (high explosive) ordnance use at the Target Center that only practice munitions and pyrotechnics were used at this site. Because the Target Center was located entirely on land, it is not expected that MEC (only UXO in this instance) from this site has migrated to the Atlantic Ocean.

Affected Environment

Strafing Target

The strafing target was used to test aircraft machine guns and cannons at a fixed ground target. The target impact area was located totally on land on the northeastern tip of Wallops Island and the USACE estimates that it is unlikely that MEC from this site has migrated to the Atlantic Ocean.

Gunboat Point Bombing Area

The former bombing area was located on the peninsula at the northeastern extremity of Wallops Island. The Gunboat Point area was used by Naval Aviation Ordnance Test Station to test live, high explosive aircraft delivered ordnance and incendiary devices. During the period of 24 January and 1 July 1952, the Ordnance Department had loaded, dropped, and reported on approximately 920 aircraft parachute flares. The Gunboat Point impact area has changed significantly over the years.

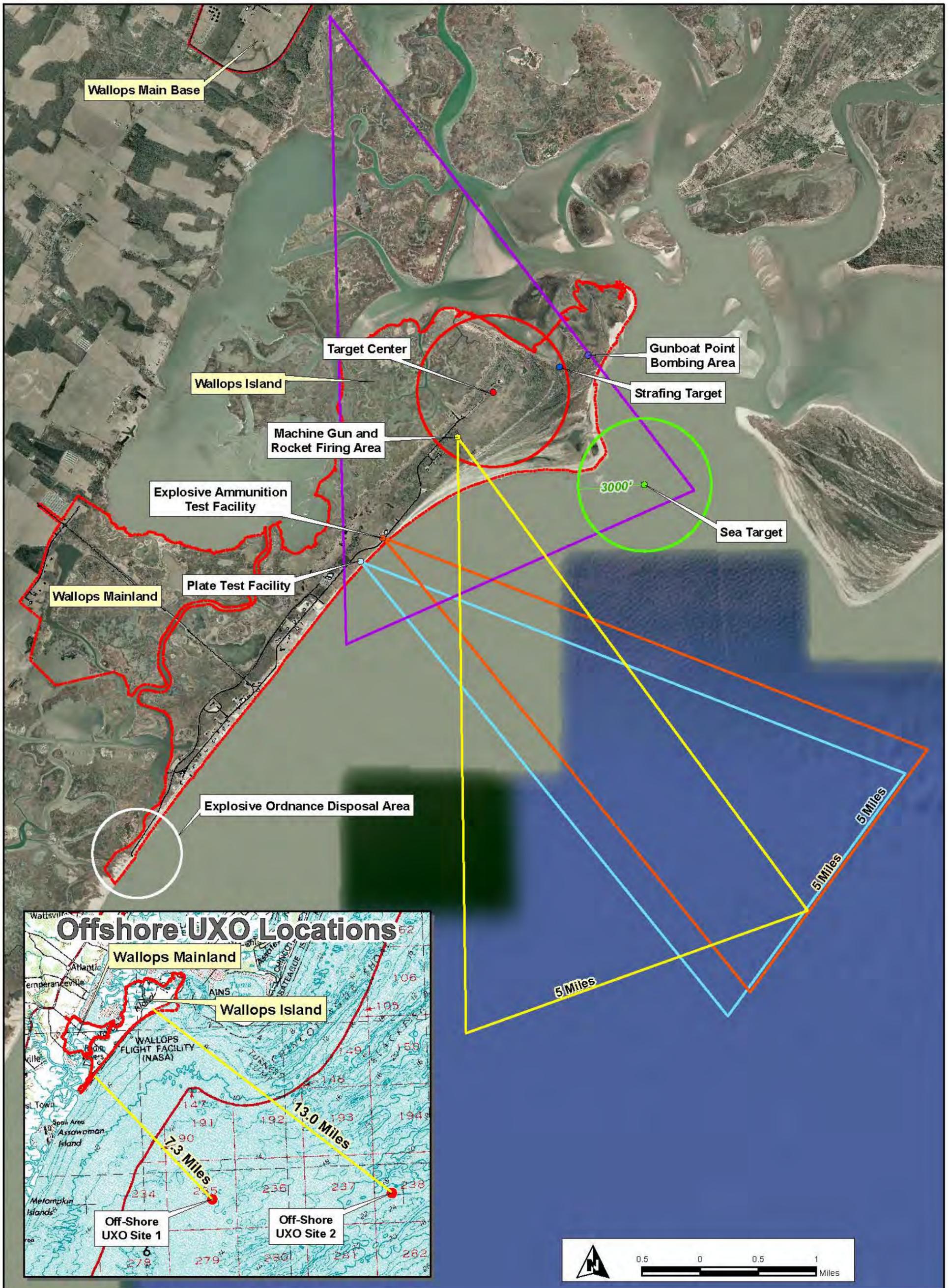
Though most of the impact area was on Wallops Island itself, further characterization of this area is necessary to determine the extent of shoreline and offshore impact. Due to sediment movement, MEC may now be submerged beneath the Atlantic Ocean or the Chincoteague Inlet. The USACE expects that UXO might be present along the northeastern shoreline of Wallops Island (USACE, 2007). Some of the UXO could have migrated to the contiguous Atlantic Ocean beaches.

Machine Gun and Rocket Firing Area

The firing area had two ground ranges, a 685-m (2,250-ft) range and a 230-m (750-ft) range, that were located immediately south of the Wallops Island north boat basin and were oriented southeast toward the ocean. Targets were constructed on the sand dunes along the beach. The machine gun firing area was used to statically test aircraft machine guns and cannons primarily firing 20 and 30 mm munitions. Aircraft rockets were tested at this range. The impact area for this range can be defined as a 40 degree fan originating at the firing point on Wallops Island and extending south-south east about 5,500 m (18,000 ft) into the Atlantic Ocean. UXO is expected to be present in the target area of this range that was located on the sand berms along the Atlantic Ocean beach front.

Sea Target

The Sea Target was probably a pyramid target constructed from wooden slats and telephone poles driven into the ocean bed at a depth of about 10 m (33 ft). UXO from munitions and land-launched rockets fired from Naval Auxiliary Air Station Chincoteague and Wallops Island is expected to be found in the Sea Target impact area. The UXO should be concentrated in a 915-m (3,000-ft) radius circle around the Sea Target center.



- Small Arms Range Safety Fan
- Machine Gun and Rocket Firing Area Arms Safety Fan
- Explosive Ordnance Disposal Area
- Explosive Ammunition Test Facility Safety Fan
- Plate Test Facility Safety Fan
- WFF Boundary

Title: MEC Locations	
	URS Proj No: 15301785
Figure: 34	
Client : NASA	
Shoreline Restoration Environmental Impact Statement	

This page intentionally left blank.

Explosive Ammunition Test Facility

The Explosive Ammunition test complex included the Explosive Ammunition Test Facility (Building W-81) and the Environmental Chamber (Building W-140) and was used to test fire aircraft guns and munitions. The facility included gun mount slabs, target stands, and a Rocket Cluster Site. High explosive munitions were tested at this facility. Targets were constructed on the sand dunes along the beach. The impact area for this range can be defined as a 40 degree safety fan originating at the firing point and extending perpendicular to the beach line and 5,500 m (18,000 ft) into the Atlantic Ocean. MEC is expected to be present in this impact area and in the vicinity of the firing facility.

Navy Plate Test Facility

It is not clear whether the proposed 1953 Plate Test Facility was ever constructed. If constructed, munitions similar to the Explosive Ammunition Test Facility would have been fired east into the Atlantic Ocean. Additionally the impact area for this range would have similar dimensions as the Explosive Ammunition Test Facility. If used, MEC would be expected to be present in this impact area and in the vicinity of the firing facility.

Explosive Ordnance Disposal Area

The NACA and later NASA operated an EOD area on the southern end of Wallops Island. This area was in service until NASA constructed the current Open Burn/Open Demolition facility in the same area. The EOD area was located entirely on shore. It is not expected that MEC (both UXO and discarded military munitions) from this area has migrated to the Atlantic Ocean. However, if further beach loss occurs in this area, MEC may eventually enter the Atlantic Ocean.

Offshore UXO sites

There are two offshore UXO sites in the Atlantic Ocean in the proximity of Wallops Island. The nearer site is located 11.58 km (7.2 mi) from the island at a depth of 13 m (44 ft). The second site is located 21.84 km (13.6 mi) from the island at a depth of 21 m (68 ft). The extent of either ordnance site is not known.

3.2 BIOLOGICAL ENVIRONMENT

The sections below describe the current biological resources present or potentially present within the project action area. Threatened and Endangered species are discussed in Section 3.2.10 below.

Unless otherwise specified, the sources of the information provided herein are the WFF ERD (NASA, 2008a), the NASA Biological Assessment (BA) prepared for this project (Appendix C), and the USFWS and NMFS Biological Opinions (BOs) received in response to the BA (Appendices D and E).

3.2.1 Vegetation

The barrier island system along the Delmarva Peninsula contains various ecological succession stages, including beaches, dunes, swales, maritime forests, and marsh. The natural vegetative

Affected Environment

zones overlap and are constantly in a state of flux as the geographical positions of the islands slowly shift.

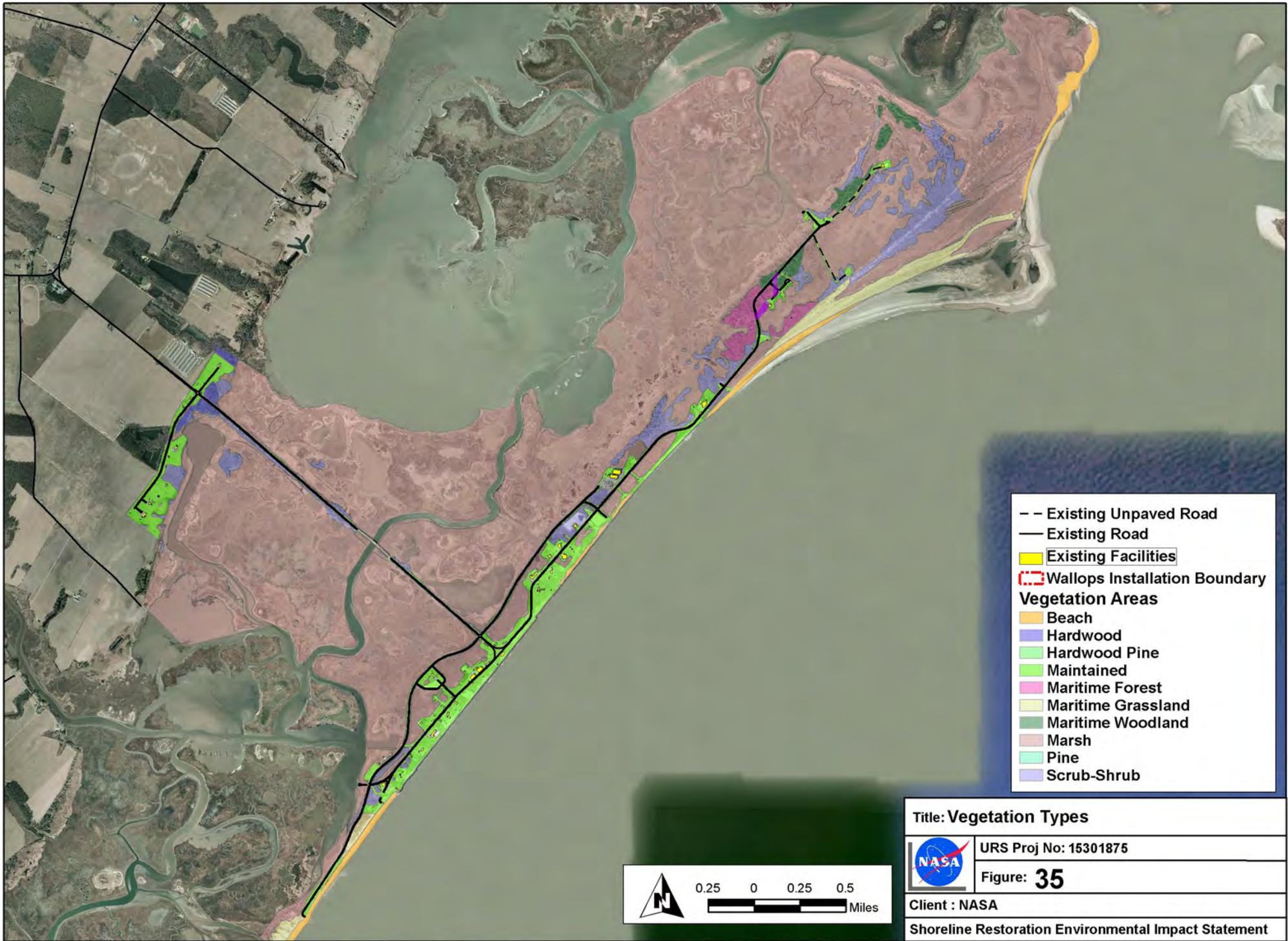
The beach system of the Virginia and Maryland barrier islands from east to west includes the subtidal zone, intertidal zone, and upper beach zone. The subtidal zone on the eastern side of the islands extends from the lower limit of low tide to the seaward-most limit of wave action. Because of the dynamics of wave action, few plants exist in the subtidal zone. Due to shoreline erosion and the presence of the seawall, beach habitat is absent seaward of the seawall on Wallops Island.

The intertidal zone is a transition zone exposed during low tide and totally submerged at high tide. This zone is an extremely dynamic area. Except for algae on the rocks of the existing seawall, plant species are virtually nonexistent in the intertidal zone located on the eastern portion of Wallops Island because of the deleterious effects of wave action on the stability of the zone. Microscopic plants and animals exist in the minute spaces between individual sand grains in the eastern intertidal zone

The northern and southern dune vegetation on Wallops Island directly borders salt marshes (Figure 35). On the southern portion of Wallops Island, the dune and swale zone extends to the tidal marsh on the western side. No maritime forest exists on this part of the island. In the central and northern areas, the dune and swale zone extends to the maritime zone that starts where the secondary dune line once existed. The northern part of Wallops Island within the dune and swale zone is in an almost natural state, and is dominated by northern bayberry (*Morella pensylvanica*), wax myrtle (*Morella cerifera*), groundsel bush (*Baccharis halimifolia*), and American beach grass. The central portion of Wallops Island is dominated by common reed and maintained lawn areas. Common reed is invasive and has the ability to grow in areas with very low habitat value; it is considered to be an undesirable plant. Due to its successful competition with many other plant species, common reed has taken over much of the area in the center of Wallops Island.

A small area of maritime forest zone exists on the central portion of the island, with an expansive thicket zone on the northern part. The thicket zone is dominated by extensive clusters of northern bayberry, wax myrtle, and groundsel bush. The thicket zone in some areas is virtually impenetrable due to dense stands of poison ivy (*Toxicodendron radicans*) and greenbriar (*Smilax* spp.), which is also pervasive on other areas of Wallops Island. The northern maritime forest zone is dominated by loblolly pine (*Pinus taeda*) and cherry trees (*Prunus* spp.), with an understory of northern bayberry, wax myrtle, and groundsel bush. These species are able to thrive in sandy soils with poor drainage.

There are 461 ha (1,140 ac) of tidal marsh between Wallops Island and Mainland. A tidal marsh is an area of low-lying wetlands that is influenced by the tides. The marsh is interlaced with small streams known locally as “guts.” The marsh itself can be divided into the low marsh and the high marsh—each a distinctive community. The low marsh, which is inundated at high tide, is dominated by salt marsh cordgrass (*Spartina alterniflora*). The high marsh, which is flooded by approximately 50 percent of the high tides, is dominated by salt meadow cordgrass (*S. patens*). As the marshes provide suitable habitat for both feeding and reproduction, these areas are of tremendous importance to marine life and to the terrestrial and avian species that depend on the marshes for their existence (NASA, 2008a).



-- Existing Unpaved Road
 — Existing Road
 ■ Existing Facilities
 □ Wallops Installation Boundary
Vegetation Areas
 ■ Beach
 ■ Hardwood
 ■ Hardwood Pine
 ■ Maintained
 ■ Maritime Forest
 ■ Maritime Grassland
 ■ Maritime Woodland
 ■ Marsh
 ■ Pine
 ■ Scrub-Shrub

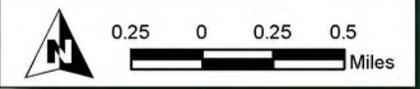
Title: Vegetation Types

 URS Proj No: 15301875

Figure: **35**

Client : NASA

Shoreline Restoration Environmental Impact Statement



This page intentionally left blank.

3.2.1.1 2009 North Wallops Island Vegetation Survey

NASA conducted a vegetation survey of the north Wallops Island area in October 2009 to characterize the vegetation communities within the SRIPP project area. Vegetation communities were identified using a classification system developed for Assateague Island in 1995 by The Nature Conservancy for the NBS/NPS Vegetation Mapping Program at Assateague Island National Seashore.

Vegetation communities observed during the Wallops Island site visit included maritime forest, shrubland, open upland, low marsh, high marsh, sand dune, subtidal open water, sand flat, and ocean beach. Figure 36 shows the approximate locations of these vegetation communities. The outlines of these areas are based on interpretation of the aerial photography and the site visit; precise locations of these communities would require traditional or GPS surveys, which have not been conducted.

In addition to these upland and wetland vegetated habitats, tidal sand flats and shallow open water also exist at the very northern end of the island. Overwash areas are present on the sand flats as evidenced by the burying of salt marsh cordgrass plants with sand. Widgeon grass (*Ruppia maritima*) was observed in the shallow water area located between the sand flats and the beach berm offshore. Stems of eelgrass (*Zostera marina*) were present with the widgeon grass, but were not rooted.

3.2.2 Wildlife

As a barrier island along the Atlantic coast, Wallops Island is home to a diverse array of wildlife species. The Assateague Island National Seashore extends from the northern (Maryland) portion of Assateague Island through Virginia. The southern (Virginia) portion located closest to Wallops Island is part of CNWR. Both protected park areas provide high quality habitat for a variety of wildlife. Assawoman Island to the south of Wallops is also owned by the USFWS and is part of CNWR.

Wildlife species that are not federally listed but designated by the Commonwealth of Virginia as Species of Greatest Conservation Need (SGCN) are discussed in the various resource sections below. The SGCN list identifies species that the Virginia Department of Game and Inland Fisheries (VDGIF) considers to be imperiled or in decline (VDGIF, 2010). Within the SGCN list, species are classified into four tiers that were developed to identify the relative importance of conservation need for each species. A Tier 1 species designation reflects a critical conservation need as the species faces an extremely high risk of extinction or extirpation, whereas a Tier 4 designation applies to species of moderate conservation need that may be either rare within parts of its range or have demonstrated a declining trend over time. Tiers 2 and 3 represent very high and high conservation need, respectively.

3.2.2.1 Invertebrates

Wallops Island, particularly the tidal marsh area, has an extensive variety of invertebrates. Saltmarsh cordgrass marshes provide habitat to herbivorous (plant eating) insects such as the saltmarsh grasshopper (*Orchelimum fidicinium*) and the tiny plant hopper (*Megamelus* spp.). Plant hopper eggs are in turn preyed upon by a variety of arthropods, the group of animals that includes insects, spiders, and crustaceans. The tidal marshes are inhabited by a number of parasitic flies, wasps, spiders, and mites. The spiders prey mostly on herbivorous insects, and

Affected Environment

mites prey primarily on microarthropods (small invertebrates) found in dead smooth cordgrass. Saltmarsh mosquitoes (*Ochlerotatus sollicitans*) and greenhead flies (*Tabanus nigrovittatus*) are prevalent insects on Wallops Island.

Particular species inhabit different areas of the marsh depending on their ability to adapt to the fluctuating tides. Many insects and arachnids (e.g., spiders and ticks) can tolerate lengthy submersions. Insects that cannot sustain long submersions tend to move up the marsh vegetation during high tide. Periwinkle snails (*Littorina irrorata*) and mud snails (*Ilyanassa obsoleta*) can withstand lengthy submersions and are found mainly on the marsh surface.

On the Atlantic side of the island, the upper beach zone is dominated by burrowing organisms, such as ghost crabs (*Ocypode quadrata*), sand fleas (taltrid amphipods), and insects. Ghost crabs are important predators on mole crabs (*Emerita* spp.) and coquina, or bean, clams (*Donax* spp.) clams that live in the lower portions of the beach. They dig burrows up to 1.3 m (4 ft) deep and feed typically at night.

3.2.2.2 Amphibians and Reptiles

A variety of amphibians and reptiles use the dune and swale zones for foraging. Fowler's toad (*Bufo fowleri*) can be found under stands of bayberry. The green tree frog (*Hyla cinerea*) is found in the wetter areas in the northern portion of Wallops Island. Other frogs include the gray tree frog (*Hyla versicolor*) and southern leopard frog (*Rana sphenoccephala*). Some species of reptiles such as the black rat snake (*Elapha obsoleta*), the Tier IV SGCN hognose snake (*Heterodon platirhinos*), the Tier III SGCN box turtle (*Terrapene carolina*), and northern fence lizard (*Sceloporus undulatus*) can be found in low-lying shrubby areas. The northern water snake (*Nerodia sipedon sipedon*) is generally located in close proximity to freshwater and brackish ponds and also in marshes on the western side of the islands. Snapping turtle (*Chelydra serpentina*) and diamondback terrapin (*Malaclemys terrapin*) can be found in saltmarsh estuaries, tidal flats, and lagoons. The diamondback terrapin is recognized as a Tier II SGCN in Virginia's Wildlife Action Plan (VDGIF, 2005).

3.2.2.3 Birds

The Virginia Barrier Island Lagoon System includes the seaward margin of the lower Delmarva Peninsula from the mouth of the Chesapeake Bay to the Maryland Virginia border. According to the Audubon Society (2010), this location is an important bird area in Virginia and along the Atlantic Coast of North America. The area has also been designated as a United Nations Educational, Scientific, and Cultural Organization Biosphere Reserve and a Western Hemisphere Shorebird Reserve Site.

Wallops Island is located within the boundaries of the Barrier Island Lagoon System Important Bird Area (IBA) and is in the path of the coastal route of the Atlantic Flyway, a regular avenue of travel for migrating land and water birds that winter on the waters and marshes south of Delaware Bay. The Barrier Island Lagoon System IBA and the Atlantic Flyway are of great importance to waterfowl and other birds, especially during the spring and fall migration. Ducks, geese, shorebirds, songbirds, and raptors pass through the Atlantic Flyway. The barrier islands, including Wallops, Assateague, Chincoteague, and Assawoman Islands, are particularly important for migratory birds. Some species use these islands as a stopover point, while others use the islands and surrounding habitats as an overwintering area. The bay side of the islands tends to contain the highest concentrations of migratory birds.



- 1. Maritime Forest
- 2. Shrubland
- 3. Sparse Shrubland
- 4. High Marsh/ Sparse Shrubland
- 5. Low Marsh
- 6. Sand Flat
- 7. Open Water/ Submerged Aquatic Vegetation/ Sand Flat
- 8. Beach

Note: Vegetation communities are approximate and have not been surveyed.



Legend

- - Existing Unpaved Road
- Existing Road

Title: WFF North Wallops Island Vegetation Communities Map	
	URS Proj No: 15301785
Figure: 36	
Client : NASA	
Shoreline Restoration Environmental Impact Statement	

This page intentionally left blank.

The Migratory Bird Treaty Act (MBTA, 16 U.S.C. 703-712) was enacted to ensure the protection of shared migratory bird resources. The MBTA prohibits the take and possession of any migratory bird, their eggs, or nests, except as authorized by a valid permit or license. The statutory definition of “take” is “to harass, hunt, capture, or kill, or attempt to harass, hunt, capture or kill.” A migratory bird is any species that lives, reproduces, or migrates within or across international borders at some point during its annual life cycle. Migratory birds, as well as non-migratory birds are discussed in this section. Bird species that are identified as protected species are discussed in detail under Section 3.2.10 Threatened and Endangered species.

A discussion of various bird species is provided below based on their life history and habitat usage.

Terrestrial Birds

Raptors, including the Tier III SGCN Northern Harrier (*Circus cyaneus*), Osprey (*Pandion haliaetus*), and the State threatened Tier I SGCN Peregrine Falcon (*Falco peregrinus*), inhabit the marsh areas, including the marsh west of Wallops Island. The marshland on the western side of the barrier islands provides habitat to wading birds such as the Great Egret (*Ardea alba egretta*), Snowy Egret (*Egretta thula*), Tier III SGCN Glossy Ibis (*Plegadis falcinellus*), Tier III SGCN Tricolored Heron (*Egretta tricolor*), Tier IV SGCN Green Heron (*Butorides virescens*), Great Blue Heron (*Ardea herodias*), Tier III SGCN Black-crowned Night Heron (*Nycticorax nycticorax*), and Tier IV SGCN Clapper Rails (*Rallus longirostris*).

Great Horned Owls (*Bubo virginianus*) can be found in the maritime forest and Tier II SGCN Bald Eagles (*Haliaeetus leucocephalus*) can often be seen flying over WFF; a Bald Eagle nest is located on the northern end of Wallops Island. The maritime forests may also give shelter to Ruby-crowned Kinglet (*Regulus calendula*), Downy Woodpecker (*Picoides pubescens*), White-eyed Vireos (*Vireo griseus*), and the Tier II SGCN Northern Saw-whet Owl (*Aegolius acadicus*) during migration stopovers.

Birds that use the shrub zones include various species of sparrows, Red-winged Blackbirds (*Agelaius phoeniceus*), Boat-tailed Grackles (*Quiscalus major*), and Fish Crows (*Corvus ossifragus*). Birds common in the shrub zone include Song Sparrow (*Melospiza melodia*), Tier IV SGCN Gray Catbird (*Dumetella carolinensis*), Yellowthroat (*Geothlypis trichas*), and Mourning Dove (*Zenaida macroura*). Resident Canada Geese (*Branta canadensis*) are found year-round in open upland portions of the WFF.

Shorebirds

During spring and fall migrations, shorebirds feed on plants and animals in the intertidal zone of the Virginia barrier islands.

Laughing Gulls (*Larus atricilla*), Herring Gulls (*L. argentatus*), and Great Black-backed Gulls (*L. marinus*) commonly forage in the upper beach zone and the intertidal zone.

The Sanderling (*Calidris alba*) is a small pale sandpiper commonly seen in flocks chasing receding waves on ocean beaches, and running away from them when they return. It breeds in the high Arctic and winters along the Atlantic and Pacific coasts from Canada to Argentina (MacWhirter et al., 2002).

Affected Environment

A small dark shorebird with a single band across its chest, the Semi-palmated Plover (*Charadrius semipalmatus*), is the most common plover seen during migration. The Semi-palmated Plover feeds primarily on insects and can be found on the Atlantic coast during the non-breeding winter season (Nol and Blanken, 1999).

The Tier IV SGCN Short-billed Dowitcher (*Limnodromus griseus*) is a speckled shorebird that winters on coastal mud flats and brackish lagoons. The Short-billed Dowitcher can be seen on the beaches within the project area during migration and feeds primarily on aquatic invertebrates such as mollusks and marine worms (Jehl et al., 2000).

The Tier IV SGCN Dunlin (*Calidris alpina*) can be found within the project area during the non-breeding season. Non-breeding plumage for the Dunlin is a dull brownish gray, with a whitish belly. Its main source of food is insects.

The Tier II SGCN American Oystercatcher (*Haematopus palliatus*) is a large shorebird, common in coastal salt marshes and sand beaches throughout the central part of its range. One of the few birds to feed mainly on bivalve mollusks living in saltwater, this species is completely restricted to marine habitats. Eastern oystercatchers regularly winter in large flocks, from Virginia south along the Atlantic coast (Nol and Humphrey, 1994). Of the more than 700 breeding pairs of American Oystercatchers documented in coastal Virginia in 2008, over 50 percent occurred on Virginia's barrier islands, with 40 percent occurring on several islands south of Wallops including Metompkin and Cedar Islands (Wilke et al., 2009). Additionally, American Oystercatcher productivity rates along the barrier island chain are some of the highest reported on the U.S. Atlantic coast, suggesting that the islands may serve as important population sources for the larger East Coast population (Wilke et al., 2007).

The Double-crested Cormorant (*Phalacrocorax auritus*) is found in flocks in diverse aquatic habitats, such as the coastline and estuaries, as well as inland in rivers, lakes, and other bodies of water. They build flat nests made of twigs, seaweed, and flotsam, either in trees or on the ground. The primary prey of the cormorant is small, bottom-dwelling or schooling fish (USFWS, 2009a), but they are also known to eat insects and amphibians (Hatch and Weseloh, 1999).

Marine Birds

Marine birds are found not only in the shoreline/coastal environment but also over the open ocean where they forage. All birds described in this section may be found within the SRIPP project area.

The Tier II SGCN Black Skimmer (*Rynchops niger*) is active at all times of the day, especially at dawn and dusk, and occasionally at night, feeding on fish. It builds its nest on the ground (Gochfeld and Burger, 1994).

The Brown Pelican (*Pelecanus occidentalis*) lives along warm marine coastlines and estuarine areas. Its primary prey is fish, as well as the occasional marine invertebrate. Pelicans are known for swooping down on fish from the air and trapping them in their bills. They build their nests in short trees or shrubs and on the ground, frequently in colonies with other shorebirds (Shields, 2002).

Various species of terns can be found on the beaches of Wallops, Assateague, and Chincoteague Islands. Terns are closely related to gulls and skimmers, but are more specialized in their nesting

habitats, diet, and foraging methods. Most nest in colonies, frequently in proximity to groups of other nesting shorebirds (Gotchfeld and Burger, 1996).

The Caspian Tern (*Sterna caspia*) lives and breeds in a wide variety of coastal habitats, including salt marshes and barrier islands. Nesting occurs in colonies on beaches. The nest is a small indentation in the sand, lined with twigs, pebbles, or leaves. During the winter, they are found along beaches and roosting on the Islands. The Caspian Tern feeds mainly on fish, but also on insects and small crustaceans (Cuthbert and Wires, 1999).

The Common Tern (*Sterna hirundo*) is medium in size and has a black cap and white wings with dark tips. The Common Tern is the most widespread tern in North America and nests on islands, in marshes and sometimes on the beach, and is considered a Tier III SGCN. The Common Tern prefers to eat small fish and small invertebrates (Nisbet, 2002). The Common Tern nests on barrier islands, beaches, and in saltwater marshes. The nests are well-disguised, appearing to be a pile of dead leaves or vegetation on the ground. Its primary prey is fish, with some invertebrates (Nisbet, 2002).

The Tier IV SGCN Forster's Tern (*Sterna forsteri*) is very similar in appearance to several other species of tern. It breeds in the marshes in areas of open water with stands of vegetation. Floating nests are fabricated out of vegetation and are found in open water or on floating vegetation. The Forster's Tern also occasionally makes its nest in mud or sand. In the winter, it is found along the coastline. Prey includes various small fish and arthropods (McNicholl et al., 2001).

The Least Tern (*Sterna hirundo*) is found on the coast, in bays, and in estuaries. Sandy coastal beaches are used for nesting, but the birds also nest on flat elevated surfaces like roofs. On beaches, the nest is a small indentation or "scrape" in the sand, soil, or in pebbles. Like most other terns found on and near Wallops Island, fish and invertebrates are its primary food source (Thompson et al., 1997). The Least Tern is a Tier II SGCN.

The Royal Tern (*Sterna maxima*) nests on low-lying barrier island beaches, in nest scrapes in the sand. The birds are frequently found in colonies, nesting and feeding on fish and shrimp (Buckley and Buckley, 2002). The peak nesting season for the Royal Tern in the coastal Virginia area is June. The Royal Tern is a Tier II SGCN.

Waterbirds such as scoters, loons, and gannets may occur within the offshore portion of the SRIPP project area. In a draft report, Forsell (2003) noted that these were found distributed over shoals in the mid-Atlantic during aerial surveys conducted from December 2001 to March 2003. Preliminary studies indicate that the birds use the mid-Atlantic area as foraging grounds during winter months (Forsell, 2003).

A coastal duck that breeds in the subarctic, the Black Scoter (*Melanitta nigra*) is a stocky diving duck that feeds on aquatic invertebrates, especially aquatic insects and mollusks (e.g., bivalves and gastropods) as well as crustaceans (e.g., crabs) from the seafloor (Bordage and Savard, 1995). The White-winged Scoter (*M. fusca*) and Surf Scoter (*M. perspicillata*) are very similar to the Black Scoter in both appearance and feeding habits. Black Scoters typically feed at depths of less than 10 m (33 ft), while the White-winged and Surf Scoters typically feed at depths less than 5 m (16 ft).

The Common Loon (*Gavia immer*) is a large waterbird whose male territorial call is considered a symbol of the wild north. Duck-like in appearance, the Common Loon has a long pointed bill and a long body that slopes to the rear. It swims underwater to catch fish, propelling itself with

Affected Environment

its feet. It swallows most of its prey underwater. The loon has sharp, rearward-pointing projections on the roof of its mouth and tongue that help it keep a firm hold on slippery fish. In North America, the common loon breeds on clear freshwater lakes surrounded by lakes. It winters primarily in coastal marine areas near shore (McIntyre and Barr, 1997).

The Red-throated Loon (*Gavia stellata*) is the smallest of the loons. Distinctive from the other loon species in behavior, vocalizations, and life history, the Red-throated Loon breeds in low tundra wetlands, bogs, and ponds in forests. It winters in relatively shallow, sheltered marine habitat (Barr et al, 2000).

Breeding in only a few large colonies along the North Atlantic, the Northern Gannet (*Morus bassanus*) spends most of its life at sea. Flocks engage in spectacular bouts of plunge-diving for fish, with hundreds of birds diving into the ocean from heights of up to 40 m (130 ft) (Mowbray, 2002). Northern Gannets feed on fish and squid.

3.2.2.4 Mammals

On Wallops Island, mammals such as white-tailed deer (*Odocoileus virginianus*), opossum (*Didelphis marsupialis*), raccoon (*Procyon lotor*), and gray squirrel (*Sciurus carolinensis*) are plentiful. Raccoon and red fox (*Vulpes vulpes*) are occasionally found in the upper beach zone and the inter-tidal zone. The gray squirrel and opossum inhabit the maritime forest along with other mammals that use other sections of the island for forage and shelter. Raccoon, red fox, white-footed mouse (*Peromyscus leucopus*), meadow vole (*Microtus pennsylvanicus*), rice rat (*Oryzomys palustris*), white-tailed deer, and Eastern cottontail rabbit (*Sylvilagus floridanus*) are found in the dune and swale zone.

While most mammals found on Assateague Island are comparable to those found on Wallops Island, CNWR provides protected habitats to a several additional species. Wild horses (*Equus caballus*) roam freely on the northern side of the island, and are restricted by fencing on the southern portion closest to Wallops Island. The feral horses and non-native sika deer (*Cervus nippon*) feed on the abundant vegetation commonly found in the interdune swale zone and thickets. Assateague Island also provides habitat for the federally and State-endangered (Tier II SGCN) Delmarva fox squirrel (*Sciurus niger cinereus*), which can be found in pine and oak forests in the central portion of the island. Loblolly pines on the island provide habitat for the little brown bat (*Myotis lucifugus*), red bat (*Lasiurus borealis*), and silver-haired bat (*Lasionycteris noctivagans*). Muskrat (*Ondatra zibethicus*) are found in brackish and freshwater impoundments, along with the occasional river otter (*Lutra canadensis*).

3.2.3 Submerged Aquatic Vegetation

The bay side of the Virginia barrier island system has a substantial population of submerged aquatic vegetation (SAV), including a variety of seagrasses. Two true seagrasses—eelgrass and widgeon grass—provide erosion control, habitat, and foraging area for fish, waterfowl, and mammals such as river otters. Water clarity is the most vital component of seagrass survival (Virginia Institute of Marine Science [VIMS], no date). Increases in water turbidity and changes in sediment content and nutrient levels can be detrimental to seagrass growth, the majority of which occurs from March through November. About 85 percent of the SAV within the barrier islands is found on the western side of Assateague Island in Chincoteague and Sinepuxent Bays. Smaller amounts of eelgrass and widgeon grass can be found in the coastal bays of Wallops, Assawoman, and Chincoteague Islands.

According to the 2008 SAV online mapper prepared by the VIMS, the nearest mapped SAV bed to the SRIPP project area is in New Virginia Cove, approximately 11 km (7 mi) from the northernmost point of proposed beach fill on Wallops Island shoreline and approximately 8 km (5 mi) from the mouth of Chincoteague Inlet. The VIMS mapper did not indicate any SAV on the ocean side of Wallops or Assateague Islands, nor in the open ocean waters of the Atlantic off Wallops Island (VIMS, no date). However, during the October 2009 vegetation survey of north Wallops Island, small areas of widgeon grass were observed in the shallow water area located between the sand flats and the beach berm offshore, in addition to stems of eelgrass (*Zostera marina*).

3.2.4 Plankton

3.2.4.1 Phytoplankton

Phytoplankton are small floating plants. Nutrients supplied from coastal runoff and vertical mixing in the water column support a relatively high abundance of phytoplankton out to a depth of about 20 m (65 ft) in the MAB. Peaks in phytoplankton populations vary annually, with highest abundances occurring in spring and late summer to late fall. Phytoplankton are important primary producers and are key prey for zooplankton and fish.

3.2.4.2 Zooplankton

Zooplankton are small floating or weakly swimming animals. Zooplankton include those species that spend their entire lives as plankton (holoplankton), as well as the eggs and larvae of many fish and invertebrates (meroplankton). Holoplankton abundance is highest in late spring, summer, and fall. Meroplankton are most numerous during late spring and summer. There are approximately 400 taxa of zooplankton in this portion of the MAB including copepods, chaetognaths, cladocerans, and larvae of several benthic groups such as barnacles, brachyurans (e.g., crabs), and echinoderms (e.g., sand dollars and starfish) (Sherman et al., 1996). Zooplankton are important prey for many fish.

3.2.4.3 Ichthyoplankton

Ichthyoplankton are the eggs and larvae of fish that are carried passively along with the currents. Olney and Bilkovic (1998) reviewed and presented a synthesis on the ichthyoplankton in the MAB. Ichthyoplankton populations are highly variable due to seasonal and climatic changes, diverse life histories, hydrodynamic processes, natural cycles of abundance, and fishing pressure. In general, fish that spawn in the MAB broadcast pelagic eggs. However, some species such as Atlantic herring (*Clupea harengus harengus*), common mummichog (*Fundulus heteroclitus*), sand eel (*Ammodytes* spp.), silverside (*Menidia menidia*), and winter flounder (*Pseudopleuronectes americanus*) have benthic eggs with a dispersive pelagic larval stage. The ichthyoplankton have the potential to be dispersed throughout the region and into habitats different than the spawning grounds.

Spawning and ichthyoplankton populations vary seasonally in the MAB. The majority of species have a spawning period that includes spring and/or summer (Olney and Bilkovic, 1998). However, Grosslein and Azarovitz (1982) reported that significant quantities of fish larvae are present throughout the MAB all year.

3.2.5 Benthos

Benthos are bottom-dwelling invertebrates that provide a critical link in the productivity of the marine waters off of Wallops Island. The benthos includes organisms that live on the sediment surface (epifauna) such as starfish and sand dollars, as well as organisms that live within the sediment (infauna) such as clams and worms. The majority of the benthos live in the upper 15 cm (6 in) of sediment. Benthic organisms are an important food resource for fish, including those caught by recreational and commercial fishermen.

Benthic habitats within the project area consist of: (1) the intertidal portions of the beach including the surf and swash zones, (2) the intertidal and subtidal portions of the rock seawall, and (3) the offshore or subtidal habitats.

The distribution of beach infauna is controlled by physical factors, particularly sediment grain size, wave energy, and tidal range. Beach slope and wave height, in turn, have been identified as the two factors associated the most with different beach assemblages (McLachlan, 1990). Wave height is important because it is a measure of wave energy: the higher the wave energy, the more stressed and therefore less diverse and abundant the infaunal assemblage. Beach slope is important because beaches with steep slopes have a relatively small swash zone and species such as mole crabs which “ride” the tides in the swash zone may not have sufficient scope for feeding and thus be unable to establish large populations.

In addition to wave energy and tidal range, the distribution of beach infauna is dependent on other physical factors such as sediment texture. Intertidal infauna are usually highest in both abundance and biomass in the summer and lowest during mid-winter. Population numbers are seasonal, with highest abundances in the summer and lowest in the winter. Species composition varies within elevations of the beach, with lower species diversity occurring in the upper beach zone.

The offshore benthic habitats of the nearshore northern Virginia continental shelf, within the region of the SRIPP study area, consist of unvegetated and unconsolidated sand of varying grain size. As described in Section 3.1.3, the shelf also contains topographically high shoals. A detailed description of the underwater sedimentary environment of the project area is provided in Section 3.1.4.

Physical factors play a role in determining the structure of benthic communities of the shallow continental shelf including sediment type, hydrodynamics, and bottom topography. Sedimentary characteristics, such as grain size and organic content, are particularly important factors in determining the distribution and structure of benthic communities on open continental shelf areas (Theroux and Wigley, 1998). Sediment grain size distribution plays an important role in determining substrate stability and food availability, which in turn affects benthic community structure and the benthic trophic groups that may be present as suspension or deposit-feeding taxa (e.g., Rhoads, 1974; Fauchald and Jumars, 1979). Although infaunal species occur across a range of sediment types, the distribution of many infaunal taxa tend to be correlated to specific sedimentary habitats. For this region of the MAB, Wigley and Theroux (1981) reported that bivalves were the most abundant taxonomic group in the sand/shell sediment, while the second most abundant group in this sediment—crustaceans—were in turn the most abundant in sand-dominated sediment.

Hydrodynamic processes (e.g., currents and waves) also affect benthic community structure (e.g., Eckman, 1983; Hall, 1994). Hydrodynamic processes affect benthic larval transport, sediment characteristics, and food resources at a variety of spatial scales (Butman, 1987; Zajac et al. 1998; Palmer, 1988). Storms may affect benthic community composition, especially in shallow water (Hall, 1994; Posey et al., 1996; Posey and Alphin, 2002). Diaz et al. (2004) report that storms are important in structuring benthic communities. Even though individual storm events are unpredictable, their seasonality and frequency have a relatively narrow range over the course of a year. Storms can affect surface sedimentology over relatively short time periods. Niedoroda et al. (1989) concluded that a major storm can deposit a layer of sediment several cm thick at 20 m (65 ft) water depth and several millimeters thick at 40 m (130 ft) water depth.

Local bottom topographic features, such as ridges and troughs, also play a role in determining shallow continental shelf macrobenthic communities. Diaz et al. (2004) reported that shoal-ridge communities are different from the mid-shoal and trough communities. Viscido et al. (1997) reported that the presence of a ridge has a clear influence on the local abundance and distribution of shrimp and crab populations. They reported that the ridge has an assemblage of crab and shrimp different from that on either side of the ridge. The differences may be attributable to the ridge being a high-energy environment or its sediment composition.

In general, the overall abundance of benthic communities is highest in the late spring and early summer. However, a range of reproductive cycles exist for the benthos at the individual species level. Some species reproduce year-round, while others spawn during one or multiple seasons.

The SRIPP project area encompasses two general benthic habitats: (1) the offshore sand shoals and (2) the nearshore beach and surf zone. Currently, beach habitat is absent seaward of the seawall on Wallops Island. An overview of the benthic communities within the offshore and nearshore habitats is provided below.

3.2.5.1 *Beach, Swash, and Surf Zones*

Currently, exposed beach exists only north and south of the seawall (Figure 3). Along the Mid-Atlantic coast, the uppermost zone of the beach is dominated by air-breathing crustaceans such as beach hoppers (taltrid amphipods) and ghost crabs. Between the drift line and mid-tide level is the swash zone, an area dominated by isopods, haustoriid amphipods, polychaetes (e.g., *Scolelepis squamata*), and mole crabs (*Emerita talpoida*). Below mid-tide is the surf zone where coquina clams and a variety of haustoriid amphipods dominate the benthic assemblage. Beyond the surf zone, benthic assemblages are characterized by increasing representation of fauna that is characteristic of offshore waters (described below).

Donax and *Emerita* are key members of the beach benthic community and important prey items for a range of higher trophic levels organisms including ghost crabs, blue crabs, fish that inhabit the surf zone (e.g., Florida pompano), and shorebirds (e.g., Sanderling). *Donax* and *Emerita* are filter feeders and require moving water to feed. They are sensitive to physical characteristics of the beach. Dolan et al. (2004) reported that *Emerita* and *Donax* populations were reduced in areas of finer-grained sediment deposited over time from sand bypassing from the Oregon Inlet to Pea Island, NC. The population reductions were correlated to a higher heavy mineral content that increased the sand density and increased compaction. These physical changes affected the ability of *Emerita* and *Donax* to burrow into and out of the sand. In addition, Bowman and Dolan (1985) report that *Emerita* population densities are strongly influenced by physical processes

Affected Environment

(e.g., wave energy) and physical attributes of the foreshore (e.g., grain size and beach slope). *Emerita* may be sensitive to sediment grain size because of implications for burrowing and or the effects of turbidity on feeding. *Emerita* abundances are highest in the late summer and early fall (Bowman and Dolan, 1985). Alexander et al. (1993) report that *Donax* burrowing rates are slowed by elevated coarse components of sediment including shell hash.

3.2.5.2 Seawall

In its current state with no beach in front of it, the rock seawall provides habitat for benthic organisms. As shown in Photo 10, green algae are present in the upper intertidal and splash zones. Barnacles and mussels are present in the lower tidal zones. The rocks also provide habitat for a variety of benthic organisms such as polychaete worms and amphipods, as well as crabs. The seawall also provides habitat for a variety of insects. Wilber et al. (2003) report that insects comprise a small but consistent component of the food supply of surf zone fish off the northern coast of New Jersey.

Photo 10: Close-up of seawall on Wallops Island



3.2.5.3 Offshore

Relevant recent studies have been conducted of the offshore benthic communities in this region (Maryland and Virginia) of the MAB. Cutter and Diaz (2000), Diaz et al. (2004), and Slacum et al. (2006) reported on the benthic communities of the sand shoals and reference areas offshore of northern Maryland (approximately 35 to 50 km [20 to 35 mi] north of the proposed SRIPP borrow sites). The sampling sites were located approximately 16 to 25 km (10 to 15 mi) offshore in water depths between 10 and 20 m (6 and 12 ft). In addition, VIMS (2006) has examined the Sandbridge Shoal offshore of Virginia Beach approximately 120 km (75 mi) southwest of the SRIPP study area.

Cutter and Diaz (2000) collected benthic grab samples, video, and sediment profile imaging data of sand shoals offshore of northern Maryland and southern Delaware in 1998 and 1999. Cutter and Diaz (2000) and Diaz et al. (2004) reported that in the sediment grab samples they collected offshore of northern Maryland and southern Delaware, they found that the infaunal communities were dominated by annelid worms, followed by mollusks and crustaceans. Mollusks accounted for over 85 percent of the biomass.

Cutter and Diaz (2000) also reported on the epifauna of the area. They found that three crabs (hermit crabs [*Pagurus* spp.], portly spider crab [*Libinia emarginata*], and Atlantic rock crab [*Cancer irroratus*]) were most abundant. Large gastropods such as the whelk (*Busycon canaliculatum*) and moon snail (*Polinices* spp.) were also collected. Other large benthos collected were the infaunal bivalves such as the surf clam (*Spisula solidissima*) and common razor clam (*Ensis directus*). Astartes (*Astarte* spp.), bivalves, known to lie on the sediment surface, were collected along with starfish (*Asterias* spp.) and common sand dollar (*Echinarachnius parma*). Overall, crabs were most abundant in the habitats with biogenic structure, such as tubes created by the polychaetes *Asabellides* and *Diopatra*, and appeared to be using these habitats as nursery areas since most of the individuals were small (<5 cm [<2 in]). Other species were broadly distributed across all habitats such as nudibranchs (*Pagurus* spp.), sand shrimp (*Crangon septemspinosa*), and *Asterias* spp. The two species that appeared to prefer the sandy and more dynamic habitats were *Polinices* spp. and sand dollar.

Slacum et al. (2006) collected large epifauna during their trawling efforts on shoals offshore of Maryland (Table 21). These organisms are expected to occur on the offshore shoals in the project area.

Table 21: Organisms Collected by Slacum et al. (2006) in Trawls Collected on Shoals Offshore of Maryland

Scientific Name	Common Name
<i>Asteroidea</i>	Starfishes
<i>Busycon carica</i>	Knobbed whelk
<i>Busycotypus canaliculatus</i>	Channeled whelk
<i>Callinectes sapidus</i>	Blue crab
<i>Cancer irroratus</i>	Atlantic rock crab
<i>Crangon septemspinosa</i>	Sand shrimp
<i>Echinoidea</i>	Heart urchins
<i>Gastropoda</i>	Gastropods
<i>Libinia emarginata</i>	Portly spider crab
<i>Limulus polyphemus</i>	Horseshoe crab
<i>Nudibranchia</i>	Nudibranchs
<i>Octopus vulgaris</i>	Common octopus
<i>Ovalipes ocellatus</i>	Lady crab
<i>Ovalipes stephensoni</i>	Coarsehand lady crab
<i>Paguridae</i>	Right-handed hermit crabs
<i>Polinices</i> spp.	Moon snails

Affected Environment

Slacum et al. (2006) reported that the abundance of epifaunal groups between two habitats, i.e., the shoal and uniform bottom, showed no differences; this suggests that shoals are not preferred by epifaunal species when compared to their reference site habitat.

3.2.5.4 2009 Benthic Video Survey of Offshore Shoals

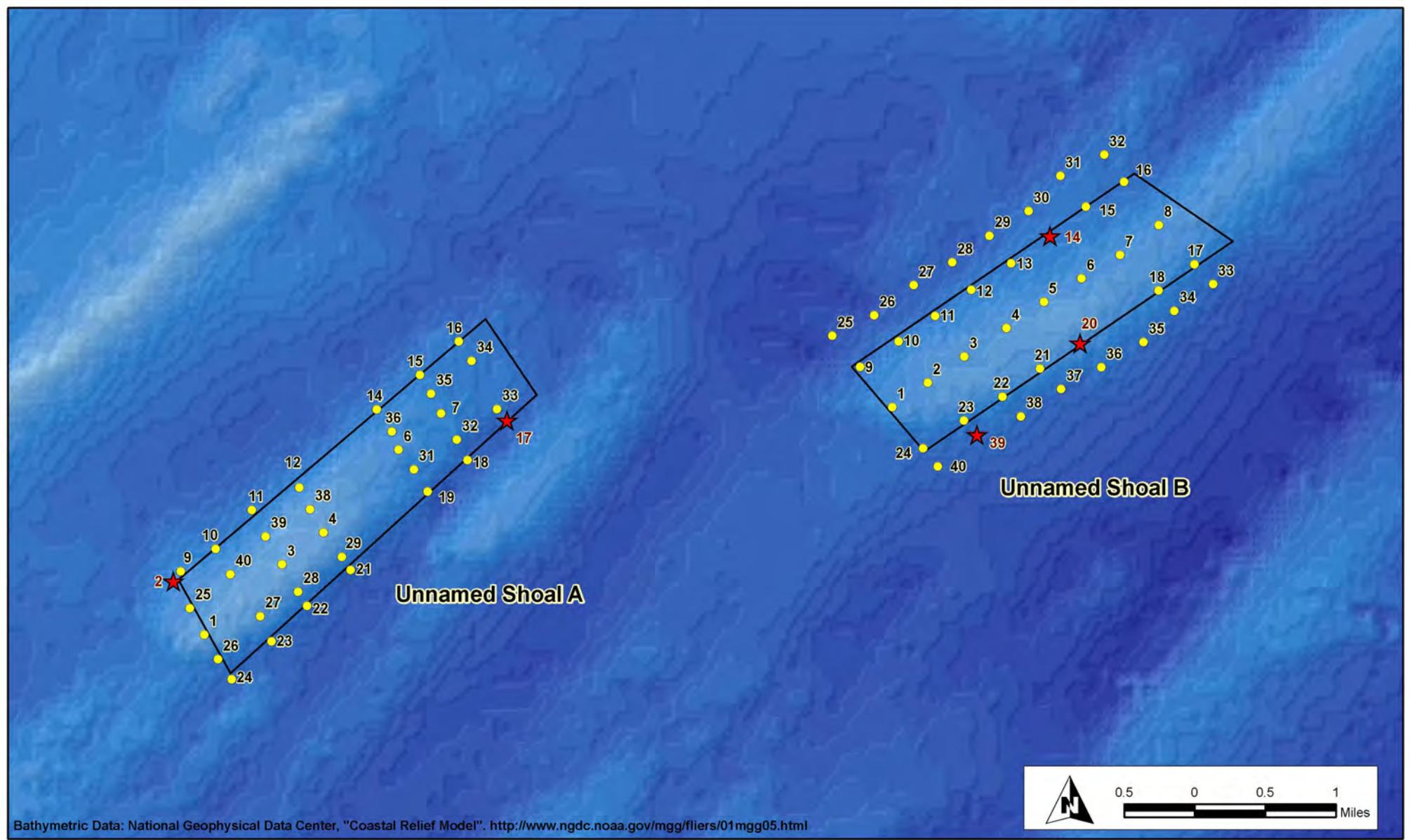
In July 2009, a video survey was conducted of the benthic habitat of the two unnamed sand shoals as part of the baseline data collection for this PEIS (NASA, 2009b) (Appendix B). Video footage was collected at 40 stations (Figure 37) on each of the shoals (80 stations total) for approximately 5 minutes at each station. During collection of the video, the vessel was allowed to drift with the currents. Still images were extracted from the video during post-processing review. Five stations were established along each of eight transects oriented roughly

The survey concluded that both the shoals are similar from a benthic habitat perspective and are comprised of unconsolidated sand with no hard substrate present. In addition, a sub-bottom profile survey conducted in June and July for the offshore cultural resource investigation reached the same conclusion (NASA, 2009c).

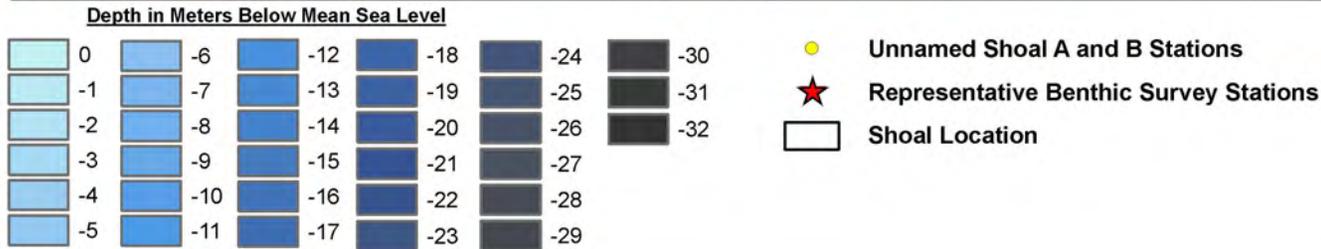
The photos provided below are representative of the habitats present on the shoals. Figure 37 depicts the location of these photo stations. Appendix B provides a more thorough description of the video survey as well as figures depicting all the video stations.

In general, results of the video survey indicated that sediment on the crests and topographically higher portions of the shoals were dominated by physical features such as ripple marks (Photos 11 and 12). The lack of apparent biogenic features does not necessarily indicate a paucity of biological resources (Cutter and Diaz, 2000). In general, benthic organisms in this habitat are dominated by infauna such as polychaete worms, and epifauna such as sand dollars that burrow through the sediment and do not construct tubes; therefore, the sand surface is left with a “clean” appearance (Cutter and Diaz, 2000).

The deeper portions of the shoals were dominated by shell fragments and hash, as well as biological features such as tubes and feeding cones created by benthic organisms. Little or no evidence of ripple marks (Photos 13 and 14) were seen in the deeper portions. Dominant epifaunal benthos included sand dollars (*Echinarachinus parma*) (Photo 15), hermit crabs (*Pagurus* spp.), crabs (*Libinia* spp., *Cancer* spp.), moon shell (*Polinices* spp.), and whelk (*Busycon* spp.). Fish were rarely seen on the video; those observed were sea robins (*Prionotus* spp.) (Photo 16).



Bathymetric Data: National Geophysical Data Center, "Coastal Relief Model". <http://www.ngdc.noaa.gov/mgg/fliers/01mgg05.html>



Title: Benthic Survey Video Station Locations	
	URS Proj No: 15301785
Figure: 37	
Client : NASA	
Shoreline Restoration Environmental Impact Statement	

This page intentionally left blank.

Photo 11: Ripple marks characteristic of Station #20 from Unnamed Shoal B at a depth of approximately 14 m (45 ft). (Photo contains the date and time of collection in upper left and easting and northing coordinates in upper right)

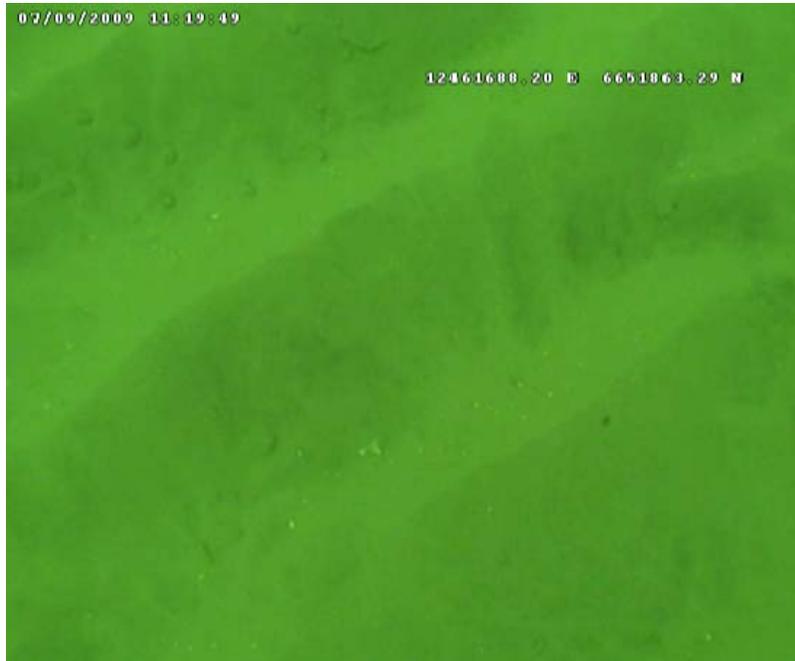


Photo 12: Ripple marks characteristic of Station #39 from Unnamed Shoal B at a depth of approximately 17 m (56 ft)



Photo 13: Shell hash and absence of bedforms characteristic of Station #2 from Unnamed Shoal A at a depth of approximately 17 m (55 ft)



Photo 14: Shell hash and absence of bedforms characteristic of Station #17 from Unnamed Shoal A at a depth of approximately 19 m (64 ft)



Photo 15: Sand dollars (*Echinarachinus parma*) from Station #14 from Unnamed Shoal B at a depth of approximately 15 m (48 ft)



Photo 16: Sea robin (*Prionotus* spp.) in lower right of photo from Station #39 from Unnamed Shoal B at a depth of approximately 17 m (56 ft)



3.2.6 Invertebrate Nekton

The Atlantic waters offshore of Wallops Island include invertebrates that live in the water column. These organisms include a variety of squid, jellyfish, and comb jellies (ctenophores). Comb jellies and jellyfish have limited mobility and generally are carried by currents. Comb jellies were frequently seen in the video collected from the shoals (Appendix B). Diaz et al. (2006) reported two species of squid were present at Sandbridge Shoal, which is located in approximately 13 m (43 ft) of water and 5 km (3 mi) offshore and to the south of the opening of the Chesapeake Bay. The squid species were the Atlantic brief squid (*Lolliguncula brevis*) and Atlantic bobtail squid (*Rossia* spp.). A variety of jellyfish species occur in the area including the sea nettle (*Chrysaora quinquecirrha*) and the moon jellyfish (*Aurelia aurita*). These squid and jellyfish species would likely be present within the SRIPP project area.

3.2.7 Finfish

The project area contains a broad diversity of fish species. The MAB contains over 300 species of fish, most of which are seasonal migrants with only a few species considered endemic to the area (Sherman et al., 1996). The diversity results from the MAB being an area of transition from cold water to the north and warmer waters to the south. Boreal (northern) species are present in the winter and warm-temperate/sub-tropical species are present in the summer (Musick et al., 1986). Many of the species migrate from nearshore to areas offshore or southward seasonally, as dictated by temperature cycles, feeding opportunities, and spawning cycles (MMS, 1999). Generally, fish abundance is low in the winter with a progressive influx in the spring and peak abundances in the fall. In addition, diversity is highest in September and lowest in late winter (February/March) (MMS, 1999). In the offshore waters, spawning occurs over a wide geographical area with the production of pelagic eggs and larvae that are dispersed throughout the shelf water.

In winter, the fauna is dominated by wide-ranging species such as sea herring (*Clupea harengus*), Atlantic mackerel (*Scomber scombrus*), hakes (*Urophycis* spp., *Merluccius* spp.), monkfish (*Lophius americanus*), and spiny dogfish (*Squalus acanthias*) (Musick, 1974; Phoel, 1985; Nammack et al., 1985). In summer, the fauna is dominated by warm temperate and sub-tropical species such as summer flounder (*Paralichthys dentatus*), croakers, drums, and sea trout (Sciaenids), menhaden (*Brevoortia tyrannus*), and large coastal sharks (Carcharhinidae) (Desfosse et al., 1990). In spring and fall, the area is an important migration corridor for striped bass (*Morone saxatilis*) and bluefish (*Pomatomus saltatrix*).

Warm water species such as bluefish and weakfish (*Cynoscion regalis*) enter the region as temperatures rise in the spring and summer, while cold water species such as Atlantic cod (*Gadus morhua*), Atlantic herring, and American shad (*Alosa sapidissima*) migrate north. Similarly, as fall approaches, warm water species such as summer flounder (*Paralichthys dentatus*), butterfish (*Peprilus triacanthus*), and black sea bass (*Centropristis striata*) may migrate offshore toward deeper waters and then move southward, while cold water species move south into the MAB (Grosslein and Azarovitz, 1982). It is also possible for a pelagic species such as Atlantic mackerel to have both a southern and a northern contingent that spawns within the MAB during different periods, or in the case of menhaden, spawning episodes during migrations into and out of the MAB.

Specific discussions of the surf zone and offshore shoals are provided below.

3.2.7.1 Surf Zone

The surf zone provides important habitat for a variety of fish species. It provides foraging areas for adult and juvenile fish, as well refugia from aquatic predators for juvenile fishes. A site-specific study of surf zone fish was not conducted for the SRIPP. However, Layman (2000) conducted a survey (in water depths less than 0.4 m [1.3 ft]) of surf zone fish at the north end of Hog Island, which is located approximately 40 km (25 mi) to the south of the SRIPP project area. The results of his study adequately characterize the anticipated surf zone fish assemblage off Wallops Island.

During his survey from August 1997 to October 1998, Layman (2000) caught 23 fish species of which three species accounted for 94 percent of the total number of fish collected. This low species diversity was characterized by three dominant species that included, in order of abundance, the rough silverside (*Membras martinica*), Florida pompano (*Trachinotus carolinus*), and gulf kingfish (*Menticirrhus littoralis*). The majority of all species were either seasonal juveniles or adult transient species that are much more common in other marine habitats. Only two species, rough silverside and white mullet (*Mugil curema*), were year-round residents. Most species utilize the shallow surf during the summer and early fall and migrate to deeper waters or southward during the cooler months (Layman, 2000). The survey also indicated an increase in species at night. Layman also reported higher species richness and abundance in runnels (the isolated troughs of water behind small sand bars).

3.2.7.2 Offshore Sand Shoals

Recent relevant studies have been conducted of the fish fauna of the sand shoals offshore of Ocean City, MD, located approximately 32 km (20 mi) north of the proposed SRIPP borrow sites (Slacum et al., 2006). Slacum et al. (2006) collected 57 taxa of finfish during seasonal sampling from the fall 2002 to the summer of 2004 using a combination of small otter trawls, large commercial trawls, and gill net sets. Spotted hake (*Urophycis regia*), scup (*Stenotomus chrysops*), and winter skate (*Raja ocellata*) were the dominant species collected; windowpane flounder (*Scophthalmus aquosus*) and winter skate were highly prevalent species, being collected at nearly every site throughout the entire year. This study also included non-species specific bioacoustic studies to assess fish movement and relative abundances.

After two consecutive years of fisheries monitoring in Federal waters off the coast of Maryland and Delaware, Slacum et al. (2006) documented that there are significant seasonal variations in species richness and abundances at the shoals and reference sites in this region of the MAB. They noted yearly variations in abundance, but overall the seasonal patterns of species assemblages were consistent and the majority of the species inhabiting the shoals and reference site habitats were seasonal residents. Comparisons between the net and bioacoustic data suggested that pelagic fish are using habitats differently between day and night. They concluded that: 1) fish occurring in the MAB either have no preference or prefer substrates at uniform-bottom types to sandy shoals during the day; and 2) there are diel (day/night) differences in the abundance of pelagic fish using the shoals and reference sites. Their data suggest fish could be using the adjacent uniform-bottom habitats during the day and move onto the shoals at night to exploit new habitat, in which case shoals could represent an important resource for fish at night.

Finfish abundance and species diversity were generally higher over the seafloor flats than on the shoals. Windowpane flounder (*Scophthalmus aquosus*), butterfish (*Peprilus triacanthus*), and

Affected Environment

spotted hake (*Urophycis regia*) were caught throughout seasonal samples in higher numbers over the seafloor flats than over the shoals. Other finfish species showed seasonal patterns of distribution. Scup (*Stenotomus chrysops*) in fall, winter skate (*Raja ocellata*) in winter, and northern sea robin (*Prionotus carolinus*) in summer are examples of common species that were captured in daytime netting more frequently on the flat uniform-bottom areas than on the shoals. Sand lance (*Ammodytes* spp.) was netted more frequently on the shoals. Finfish netted from the shoals and seafloor flats differed the most in species composition in fall and winter, and were more similar in spring and summer. Nineteen species of finfish were collected only on either shoals or seafloor flat sites but not both. However, 18 of these species were infrequently collected and it is unclear whether their presence/absence resulted from habitat preference or chance. Among these, only bay anchovy (*Anchoa mitchilli*) was commonly captured; it was collected only at seafloor flat sites. Nighttime bioacoustic surveys conducted during spring, summer, and fall found that finfish concentrated on two of the four shoals studied had the greatest topographic relief (Fenwick and Weaver Shoals), indicating that finfish migrate back and forth between the shoals and seafloor flats during the course of the day. Data collected was insufficient to adequately determine which finfish species are making preferential use of these two shoals at night.

Cutter and Diaz (2000) conducted beam trawls to characterize demersal (living on or near the ocean bottom), juvenile fish on shoals offshore of Ocean City. Many fish use the shallow continental shelf as a nursery ground (Able and Fahey, 1998). Cutter and Diaz (2000) collected 20 species, with spotted hake the most abundant species, followed by small mouth flounder (*Etropus microstomus*). These two species accounted for approximately 70 percent of the fish caught. Other species collected included northern sea robin, clearnose skate (*Raja eglanteria*), and sand lance. Differences were noted in the day/night trawls in the polychaete *Asabellides* tube habitats and some of the sand habitats. Associations of fish between habitats appeared related to sediment grain size, bed roughness, and the presence of biogenic structures.

Vasslides and Able (2008) in a study offshore of Little Egg Inlet, NJ, reported that sand ridges of the inner continental shelf appear to be important habitat for a number of fish species. From their trawl studies, they found that the near-ridge habitats had higher species abundances and richness compared to the surrounding inner continental shelf and also contained a distinct species assemblage including both recreationally and commercially important species. They reported that the sandy substrate at the top of the sand ridges provides important habitat for species that bury themselves in the sand such as the northern stargazer (*Astroscopus guttatus*) and snakefish (*Trachinocephalus myops*). In addition, sand lance, which also buries itself in the sand, was found predominantly in the sand substrate.

3.2.8 Essential Fish Habitat

In accordance with provisions of the Magnuson-Stevens Fishery Conservation and Management Act of 1976 (MSA) and the 1996 Sustainable Fisheries Act (16 U.S.C. 1801-1882), as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267), Federal agencies must consult for activities that may adversely influence EFH that is designated in a Federal Fisheries Management Plan (FMP). An EFH is defined as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.” *Waters* consist of aquatic areas and their associated physical, chemical, and biological properties that are currently utilized by fish and may include areas historically used by fish. *Substrate* is defined as sediment, hardbottom, structures beneath the waters, and any associated biological communities. *Necessary* means the

habitat required to support a sustainable fishery and the managed species’ contribution to a healthy ecosystem. *Spawning, breeding, feeding, or growth to maturity* covers all habitat types used by a species throughout its life cycle. Only species managed under an FMP are covered (50 CFR 600). The activities may have direct (e.g., physical disruption) or indirect (e.g., loss of prey species) effects on EFH and may be site-specific or habitat-wide. The adverse effects must be evaluated individually and cumulatively.

The NMFS has designated the “mixing” and “seawater” portions of estuaries, nearshore and offshore bottom, and water column areas within the project area as EFH, in compliance with the MSA. Managed species that may occur in the SRIPP study area are shown in Table 22.

Table 22: NMFS Managed Species that May Occur in Waters Surrounding Wallops Island, VA and Proposed Offshore Borrow Sites

Common Name (<i>Scientific Name</i>)	Eggs	Larvae	Juveniles	Adults
Atlantic angel shark (<i>Squatina dumerili</i>)	---1	X ²	X	X
Atlantic butterfish (<i>Peprilus triacanthus</i>)	---	---	X	X
Atlantic sea herring (<i>Clupea harengus</i>)	---	---	---	X
Atlantic sharpnose shark (<i>Rhizopriondon terraenovae</i>)	---	---	---	X
black sea bass (<i>Centropristus striata</i>)	n/a ³	X	X	X
bluefish (<i>Pomatomus saltatrix</i>)	---	X	X	X
cobia (<i>Rachycentron canadum</i>)	X	X	X	X
dusky shark (<i>Charcharinus obscurus</i>)	---	X	X	---
king mackerel (<i>Scomberomorus cavalla</i>)	X	X	X	X
monkfish (<i>Lophius americanus</i>)	X	X	---	---
red drum (<i>Sciaenops ocellatus</i>)	X	X	X	X
red hake (<i>Urophycis chuss</i>)	X	X	X	---
sand tiger shark (<i>Odontaspis taurus</i>)	---	X	---	X
sandbar shark (<i>Charcharinus plumbeus</i>)	---	X	X	X
scalloped hammerhead shark (<i>Sphyrna lewini</i>)	---	---	X	X
scup (<i>Stenotomus chrysops</i>)	n/a	n/a	X	X
Spanish mackerel (<i>Scomberomorus maculatus</i>)	X	X	X	X
spiny dogfish (<i>Squalus acanthias</i>)	n/a	n/a	---	X
summer flounder (<i>Paralichthys dentatus</i>)	---	---	X	X
surf clam (<i>Spisula solidissima</i>)	n/a	n/a	X	X
tiger shark (<i>Galeocerdo cuvieri</i>)		X		
windowpane flounder (<i>Scopthalmus aquosus</i>)	X	X	X	X

Affected Environment

Common Name (<i>Scientific Name</i>)	Eggs	Larvae	Juveniles	Adults
winter flounder (<i>Pleuronectes americanus</i>)	X	X	X	X
witch flounder (<i>Glyptocephalus cynoglossus</i>)	X	---	---	---
clearnose skate (<i>Raja eglanteria</i>)	---	---	X	X
little skate (<i>Leucoraja erinacea</i>)	---	---	X	
winter skate (<i>Leucoraja ocellata</i>)	---	---	X	X

Source: NMFS, No date

¹The notation “---” indicates that EFH has not been designated within the project area for a given species and life stage.

² notation “X” in the above table indicates that EFH has been designated within the project area for a given species and life stage.

³The notation “n/a” in the table indicates that the species either has no data available for the designated stage, or the particular stage is not present in the species’ reproductive cycle. These species are: spiny dogfish, surf clam, which are referred to as pre-recruits and recruits (this corresponds with juveniles and adults in the table); scup and black sea bass, for which there is insufficient data for the life stages listed, and no EFH designation has been made as of yet for certain life stages, although data are available to describe the applicable life stages for these species.

3.2.9 Marine Mammals

The Marine Mammal Protection Act of 1972 (MMPA, 16 U.S.C. 1361 et seq.) prohibits the taking of marine mammals on the high seas. Section 101(a)(5) of the MMPA directs the Secretary of the Department of Commerce to allow, upon request, the incidental (but not intentional) take of marine mammals. A discussion of marine mammals likely to occur within the project area is provided below. Marine mammals protected under the Endangered Species Act (ESA) are discussed in Section 3.2.10.7.

Table 23 lists marine mammal species that are likely to occur within the area offshore of Wallops Island.

Table 23: Marine Mammals Likely to Occur Offshore of Wallops Island

Common Name	Scientific Name
Humpback Whale*	<i>Megaptera novaeangliae</i>
Fin Whale*	<i>Balaenoptera physalus</i>
North Atlantic Right Whale*	<i>Eubalaena glacialis</i>
Sperm Whale*	<i>Physeter macrocephalus</i>
Sei Whale*	<i>Balaenoptera borealis</i>
Blue Whale*	<i>Balaenoptera musculus</i>
Florida Manatee*	<i>Trichechus manatus latirostris</i>
Dwarf Sperm Whale	<i>Kogia simus</i>
True’s Beaked Whale	<i>Mesoplodon mirus</i>
Blainville’s Beaked Whale	<i>Mesoplodon densirostris</i>
Sowerby’s Beaked Whale	<i>Mesoplodon bidens</i>
Cuvier’s-Beaked Whale	<i>Ziphius cavirostris</i>
Melon-Headed Whale	<i>Peponocephala crassidens</i>

Common Name	Scientific Name
Short-Finned Pilot Whale	<i>Globicephala macrorhynchus</i>
Long-Finned Pilot Whale	<i>Globicephala melas</i>
Rough-Toothed Dolphin	<i>Steno bredanensis</i>
Bottlenose Dolphin	<i>Tursiops truncatus</i>
Atlantic Spotted Dolphin	<i>Stenella frontalis</i>
Common Dolphin	<i>Delphinus spp.</i>
Atlantic White-Sided Dolphin	<i>Lagenorhynchus acutus</i>
Risso's Dolphin	<i>Grampus griseus</i>
Striped Dolphin	<i>Stenella coeruleoalba</i>
Spinner Dolphin	<i>Stenella longirostris</i>
Clymene Dolphin	<i>Stenella clymene</i>
Seals	<i>Pinniped spp.</i>
Harbor Seal	<i>Phoca vitulina</i>

*Listed as federally endangered species under the ESA

Whales, dolphins, and porpoises are known as cetaceans. Cetaceans are completely aquatic mammals, living their entire lives in the water. Because their bodies are constantly supported by water, animals in this order include some of Earth's largest species. Cetaceans are specialized swimmers, with some species able to sustain speeds up to 40 km per hour (25 mi per hour), dive to 3,000 m (10,000 ft), or remain submerged for up to 2 hours (Wynne and Schwartz, 1999). Cetaceans are grouped into two taxonomic suborders: the baleen whales and toothed whales. Baleen whales are filter feeders that catch zooplankton or small schooling fish by skimming or gulping large volumes of prey and water. Toothed whales have a variable number of identical conical or spade-shaped teeth that are used to strain or grasp prey, primarily fish and squid (Wynne and Schwartz, 1999).

The federally listed species shown in Table 23 (humpback whale, fin whale, northern right whale, sperm whale, sei whale, blue whale, and manatee) are discussed under Threatened and Endangered Species within Section 3.2.10.7 (Marine Mammals).

Dwarf Sperm Whale

Dwarf sperm whales attain lengths of 2.1 to 2.7 m (7 to 9 ft) and weigh approximately 280 kilograms (kg) (600 pounds [lbs]) as adults. They are robust, with a shark-like head, dark gray back, and falcate dorsal fin (Wynne and Schwartz, 1999). Dwarf sperm whales are difficult to distinguish from pygmy sperm whales (*Kogia breviceps*) at sea, so abundance estimates include both species. The best abundance estimate for *Kogia* sp. along the U.S. Atlantic coast is 395, derived by combining estimates from two 2004 surveys: Florida to Maryland (37) and from Maryland to the Bay of Fundy (358) (Waring et al., 2007).

Dwarf sperm whales occur worldwide in temperate and tropical waters. Sightings in the western North Atlantic tend to be oceanic—over the continental shelf edge and continental slope, and, occasionally, on the continental shelf (Mullin and Fulling, 2003; Waring et al., 2007; Wynne and Schwartz, 1999).

Affected Environment

Beaked Whales

Cuvier's and *Mesoplodon* spp. beaked whales (including True's, Blainville's, and Sowerby's beaked whales) are difficult to identify to the species level at sea. Much available population and distribution information is, therefore, to the genus level only, and the genera are grouped together for the purposes of stock assessments. The stock structure is unknown, as are the total numbers of either Cuvier's beaked whales or *Mesoplodon* spp. beaked whales off the eastern U.S. Atlantic coast (Waring et al., 2009). The best abundance estimate for beaked whales is a sum of estimates from two 2004 U.S. Atlantic surveys (3,513 whales), where the estimate from the northern U.S. Atlantic is 2,839, and the southern U.S. Atlantic is 674. Beaked whale abundance may be highest in association with Gulf Stream and warm-core ring features (Waring et al., 2009).

Beaked whales occur principally along the continental shelf edge and in deeper oceanic waters (CETAP, 1982; Waring et al., 2007). Most sightings are in late spring and summer, which corresponds to the survey efforts. The distribution is otherwise derived from stranding reports (Waring et al., 2009).

Melon-Headed Whale

Adult melon-headed whales can be 2.6 to 2.7 m (8.5 to 9 ft) in length. They are long and slim, with a dark back and cape and prominent dorsal fin. Their distribution is worldwide in tropical and sub-tropical waters. Their prey is primarily squid and small fish (Wynne and Schwartz, 1999). The abundance of melon-headed whales along the U.S. Atlantic coast is unknown. No estimates are available, as the species is rarely seen during population surveys. Both groups sighted during NMFS surveys (one in 1999 and one in 2002) were in waters >2500 m (>8,200 ft) deep east of Cape Hatteras, NC (Waring et al., 2007).

Pilot Whales (Short-finned and Long-finned)

Pilot whales are recognizable by their bulbous heads, large melons, and diminutive beaks. Sexual dimorphism exists, with males larger in size and exhibiting more rounded dorsal fins than females. Long-finned pilot whales reach 7.6 m (25 ft) for males and 5.7 m (19 ft) for females. Short-finned pilot whales range from 5.2 m (17 ft) for adult females to 6 m (20 ft) for adult males (Wynne and Schwartz, 1999).

The two species of pilot whales in the western Atlantic—the long-finned pilot whale and the short-finned pilot whale—are difficult to distinguish at sea. Therefore, most information below, including seasonal abundance estimates, refers to *Globicephala* spp. The best available estimate is the sum of estimates from two 2004 U.S. Atlantic surveys. This joint estimate (15,728 + 15,411 = 31,139 whales) is considered best because the two surveys together most comprehensively cover the species' habitat. The minimum population estimate for *Globicephala* spp. is 24,866 (Waring et al., 2009).

Short-finned and long-finned pilot whale distributions overlap in the Mid-Atlantic region (Wynne and Schwartz, 1999). Short-finned pilot whales occupy tropical to warm temperate waters and may seasonally extend into shelf-edge waters north of Cape Hatteras (Leatherwood and Reeves, 1983). The long-finned pilot whale is distributed in cold temperate waters, ranging in the North Atlantic from Iceland and West Greenland south to Cape Hatteras (Leatherwood and Reeves, 1983). Pilot whales generally occur in areas of high relief or submerged banks and are

also associated with the Gulf Stream wall and thermal fronts along the continental shelf edge (Waring et al., 1992; NMFS unpublished data, cited in Waring et al., 2009).

Rough-Toothed Dolphin

Rough-toothed dolphins grow to 2.4 to 2.7 m (8 to 9 ft) in length. They are dark in coloration, with a long, slender beak and white lips, throat, and blotches on the sides and belly (Wynne and Schwartz, 1999). The number of rough-toothed dolphins off the U.S. Atlantic Coast is unknown, and abundance estimates are not available. This species is rarely seen during population surveys; there have been no sightings during shipboard or aerial surveys since 1999, except in the Caribbean (Waring et al., 2009).

Rough-toothed dolphin distribution is not well known. They are considered a tropical to warm-temperate species that frequents deep oceanic waters (Leatherwood and Reeves, 1983). They have been seen in both shelf and oceanic waters in the Gulf of Mexico (Mullin and Fulling, 2003).

Bottlenose Dolphin

There are two morphologically and genetically distinct bottlenose dolphin morphotypes (Hoezel et al., 1998) described as the coastal and offshore forms. Both inhabit waters along the U.S. Atlantic coast. North of Cape Hatteras, there is separation along bathymetric lines during summer months (Waring et al., 2009).

Coastal Morphotype

The coastal migratory stock is designated as depleted under the MMPA. Stock structure was revised in 2002 to recognize both multiple stocks and seasonal management units. The 2008 stock assessment report (Waring et al., 2009) identifies seven prospective stocks of coastal morphotype bottlenose dolphins along the Atlantic coast that replace these management units. These are the Central Florida, Northern Florida, Georgia, South Carolina, and Southern North Carolina stocks, and the Southern Migratory and Northern Migratory stocks. Since one or more of the stocks may be depleted, all stocks retain the depleted designation. The species is not listed as threatened or endangered under the ESA (Waring et al., 2009).

The best abundance estimate for the Northern and Southern Migratory stocks is from a summer 2002 survey. There was an apparent separation between the two stocks at approximately 37.5°N latitude and they overlapped little. The resulting abundance estimate was 7,489 for the Northern Migratory stock and 10,341 for the Southern Migratory (Waring et al., 2009).

The coastal morphotype of bottlenose dolphins is continuously distributed along the Atlantic coast south of Long Island, NY, around the Florida peninsula, and into the Gulf of Mexico, although there are strong seasonal differences. During summer, they range from Florida to New Jersey in waters < 20 m (66 ft) deep, including estuarine and inshore waters (Waring et al., 2009). During winter, bottlenose dolphins are rarely observed north of the North Carolina-Virginia border; distribution may be limited by water temperatures < 9.5°C. The Northern Migratory stock migrates south during winter and to waters along the North Carolina coast north of Cape Lookout. The Southern Migratory stock overlaps with the Northern Florida, Georgia, South Carolina, and Southern North Carolina stocks during winter months (Waring et al., 2009).

Affected Environment

Offshore Morphotype

The western North Atlantic offshore bottlenose dolphin is not listed as depleted under the MMPA, or as threatened or endangered under the ESA. Stock status within U.S. Atlantic waters is unknown and data are insufficient to determine population trends. The best available abundance estimate for offshore bottlenose dolphins combines estimates from surveys in 2002 and 2004 that, together, provided complete coverage of the offshore habitat from central Florida to Canada during the summer months. The resulting estimate is 81,588 (Waring et al., 2009).

Offshore bottlenose dolphins are distributed primarily along the OCS and continental slope. Spatial distribution varies seasonally. Sightings occurred along the continental shelf break from Georges Bank to Cape Hatteras during spring and summer (CeTAP, 1982; Kenney, 1990). Genetic analysis showed that bottlenose dolphins in waters >40 m depth were from the offshore morphotype (Garrison et al., 2003). Torres et al. (2003) found a statistically significant break in the distribution of the morphotypes at 34 km (21 mi) from shore, based upon the genetic analysis of tissue samples collected in nearshore and offshore waters. During the winter and over the continental shelf south of Cape Hatteras, the two morphotypes overlap spatially (Garrison et al., 2003; Waring et al., 2009).

Atlantic Spotted Dolphin

The species of spotted dolphins were not differentiated during surveys before 1998, resulting in inadequate data to determine the population trends along the U.S. Atlantic coast. Abundance estimates for Atlantic spotted dolphins were derived from ship and aerial surveys in 2004. The resulting estimate for the area from Maryland to the Bay of Fundy was 3,578 dolphins, and between Florida and Maryland, the abundance estimate was 47,400 (Waring et al., 2007).

Atlantic spotted dolphins occur in tropical and warm temperate waters of the western North Atlantic. Their range extends from southern New England to the Gulf of Mexico and the Caribbean (Leatherwood et al., 1976, cited in Waring et al., 2007). South of the Chesapeake Bay, they may occur in inshore waters. North of the Chesapeake Bay, they are found in waters near the continental shelf edge and continental slope (Payne et al., 1984; Mullin and Fulling, 2003). Atlantic spotted dolphins are also associated with the north wall of the Gulf Stream and warm-core rings (Waring et al., 1992).

Common Dolphin

The common dolphin is one of the most widely distributed cetacean species, yet the total number off the U.S. Atlantic coast is unknown. Data are insufficient to determine population trends or stock status. The best abundance estimate for common dolphins is the sum of estimates from two 2004 U.S. Atlantic summertime surveys. Together, they offer the most complete coverage of the species' range. The estimate for the northern U.S. Atlantic (Maryland to the Bay of Fundy) is 90,547, and for the southern U.S. Atlantic (Florida to Maryland) is 30,196 (Waring et al., 2007), for a combined total of 120,743.

Common dolphins occur worldwide in temperate, tropical, and subtropical waters. In the North Atlantic, they are found over the continental shelf along the 200-2,000-m isobaths or in areas with prominent underwater topography (Evans 1994, cited in Waring et al., 2007). They are widespread from Cape Hatteras to Georges Bank (35° to 42° N) in OCS waters between mid-

January and May (CeTAP, 1982; Payne et al., 1984), then move northward onto Georges Bank and the Scotian Shelf from mid-summer to autumn.

Atlantic White-sided Dolphin

Population trends and total numbers of western North Atlantic white-sided dolphins along the U.S. Atlantic Coast are unknown due to insufficient data (Waring et al., 2009). The best abundance estimate currently available (63,368 dolphins) is an average based on surveys conducted in August of 2002 and 2006 (Waring et al., 2009).

Atlantic white-sided dolphins occur primarily in continental shelf waters, out to the 100-m depth contour, in temperate and sub-polar areas of the North Atlantic. Three separate stocks might exist: Gulf of Maine, Gulf of St. Lawrence, and Labrador Sea stocks (Palka et al., 1997). The Gulf of Maine stock is common in continental shelf waters from Hudson Canyon (approximately 39° N) north through Georges Bank, and in the Gulf of Maine to the lower Bay of Fundy. Observations south of this area consist of a few strandings on beaches of Virginia and North Carolina between January and May. These strandings may represent the southern extent of the species' range (Waring et al., 2009).

Risso's Dolphin

The total numbers of Risso's dolphins off the U.S. Atlantic coast is unknown, and data are insufficient for determining population trends (Waring et al., 2009). The best abundance estimate combines estimates from two 2004 U.S. Atlantic surveys. The estimate from the northern U.S. Atlantic (Maryland to the Bay of Fundy) is 15,053, and from the southern U.S. Atlantic (Florida to Maryland) is 5,426 (Waring et al., 2009), for a total of 20,479.

Risso's dolphins are distributed along the continental shelf edge from Cape Hatteras to Georges Bank during the spring, summer, and fall (CeTAP, 1982; Payne et al., 1984). In winter, they range from the MAB to offshore oceanic waters. Risso's dolphins occur year round on the MAB continental shelf edge (Payne et al., 1984). They are known to be associated with prevalent bathymetric features, Gulf Stream warm-core rings, and the Gulf Stream north wall (Waring et al., 1992).

Striped Dolphin

Little is known about the stock structure of striped dolphins in the western North Atlantic, or how many occur off the U.S. Atlantic coast. The best abundance estimate for striped dolphins derives from the sum of estimates from the two 2004 U.S. Atlantic surveys. The estimate for the northern U.S. Atlantic (Maryland to the Bay of Fundy) is 52,055, and the southern U.S. Atlantic (Florida to Maryland) estimate is 42,407 (Waring et al., 2007), for a total of 94,462.

Striped dolphins off the U.S. Atlantic Coast are distributed along the continental shelf edge from Cape Hatteras to the southern margin of Georges Bank, and offshore over the continental slope and rise in the Mid-Atlantic region (CeTAP, 1982; Mullin and Fulling, 2003). Sightings were generally associated with the 1,000-m (3,280-ft) depth contour during all times of the year (CeTAP 1982).

Affected Environment

Spinner Dolphin

Adult spinner dolphins range in size from 1.8 to 2.2 m (6 to 7.2 ft). They are long and slender, with a tricolor pattern that may be obscure, and a distinct dark stripe from eye to flipper (Wynne and Schwartz, 1999). The number of spinner dolphins off the U.S. Atlantic coast is unknown. Estimates are also unavailable for seasonal abundance, since spinner dolphins are rarely seen during population surveys (Waring et al., 2007).

Spinner dolphin distribution in the Atlantic is not well known. In the western North Atlantic, they are found in deep water along most of the U.S. coast south to the West Indies, Venezuela, and in the Gulf of Mexico. Sightings off the northeast U.S. coast have been exclusively in deeper (>2,000 m [>6,560 ft]) waters (Waring et al., 2007).

Clymene Dolphin

Clymene dolphin adults reach lengths of 1.8 to 2.0 m (6 to 6.6 ft). They have a relatively short, broad beak, falcate dorsal fin, and are tri-colored (dark gray back, gray sides, white belly) (Wynne and Schwartz, 1999). They generally inhabit pelagic and deep waters where they prey upon squid and fish (Wynne and Schwartz, 1999). The number of Clymene dolphins off the U.S. Atlantic coast is unknown, and seasonal abundance estimates are unavailable for this species, since it is rarely seen during population surveys (Waring et al., 2007).

Clymene dolphins occur in tropical and sub-tropical waters of the western North Atlantic, with sightings recorded off the southeastern United States (as far north as New Jersey), the Gulf of Mexico, and the Caribbean Sea (Leatherwood and Reeves, 1983). Four groups were observed in 1998, primarily on the continental slope east of Cape Hatteras, NC; none have been observed during surveys since (Waring et al., 2007).

Seals and Manatee

Seals and manatees are only distantly related mammals that have successfully adapted to a marine existence. Seals belong to a family known as pinnipeds (fin-footed carnivores). Pinnipeds have adapted to an amphibious marine existence. They forage at sea but come ashore for resting and breeding. Pinnipeds are carnivores and consume their prey whole. Many pinnipeds are capable of long, deep, repetitive dives because of their high blood volume and reduced heart rate. Manatees are more closely related to elephants than to other marine mammals. They are completely aquatic and herbivorous, feeding on submerged vegetation along tropical coasts, rivers, and estuaries. Unlike most marine mammals, manatees have poorly developed brains and have physical and behavioral traits that enhance their exposure to human hazards.

Harbor Seal

The harbor seal population along the New England coast has been increasing steadily since passage of the MMPA in 1972. The most recent abundance estimate, corrected for seals not hauled out, was 99,340 in 2001 (Waring et al., 2009). Increased abundance has also been documented at overwintering haul-out sites from the Maine/New Hampshire border to eastern Long Island and New Jersey (Payne and Selzer, 1989; Waring et al., 2007).

In the western north Atlantic, harbor seals range from the eastern Canadian Arctic and Greenland south to southern New England and New York, and occasionally to the Carolinas (Boulva and

McLaren, 1979; Katona et al., 1993; Gilbert and Guldager, 1998; Baird, 2001). Harbor seals occur year-round off eastern Canada and Maine (Katona et al., 1993) and along the southern New England and New York coasts from September through late May (Schneider and Payne, 1983). Harbor seals move north to Maine and Canada prior to pupping from mid-May through June along the Maine coast (Richardson, 1976; Whitman and Payne, 1990; Waring et al., 2007). Scattered sightings and strandings have been recorded as far south as Florida (NMFS unpublished data, cited in Waring et al., 2009).

3.2.10 Threatened and Endangered Species

Under Section 7 of the Federal ESA, as amended, (U.S.C. 1531-1544) Federal agencies, in consultation with the USFWS and NMFS, are required to evaluate the effects of their actions on special status species of fish, wildlife, and plants, and their habitats, and to take steps to conserve and protect these species. Special status species are defined as plants or animals that are candidates for, proposed as, or listed as sensitive, threatened, or endangered by USFWS.

The Virginia Endangered Species Act (29 VAC 1-563 – 29.1-570) is administered by VDGIF and prohibits the taking, transportation, processing, sale, or offer for sale of any State or federally listed threatened or endangered species. As a Federal agency, NASA voluntarily complies with Virginia's Endangered Species Act.

Table 24 shows the State and federally listed threatened or endangered species that may occur within the vicinity of Wallops Island. Figure 38 shows the locations of federally listed threatened or endangered species that may occur or have historically occurred on Wallops Island. Each of the identified species is discussed in the following subsections.

3.2.10.1 *Vegetation*

Seabeach Amaranth

Seabeach amaranth is an annual plant and a member of the Amaranth family (*Amaranthaceae*). The plant occupies a narrow beach zone that lies at elevations from 0.2 to 1.5 m (0.7 to 4 ft) above mean high tide, the lowest elevations at which vascular plants regularly occur. The species is dependent on a terrestrial, upper beach habitat that is not flooded during the growing season, a feature generally absent on beaches experiencing high rates of erosion (USFWS, 2010a).

According to the USFWS (2010), seabeach amaranth occurs routinely on the Wild Beach portion of Assateague Island. Assawoman and Metompkin Islands were surveyed in 2009 and no plants were found. There is potential suitable habitat on the north end of Wallops Island, but there have been no recorded occurrences on Wallops Island to date. NASA conducted a seabeach amaranth survey on Wallops Island in August 2010; no plants were found (NASA, 2010f).

3.2.10.2 *Invertebrates*

Northeastern beach tiger beetles inhabit wide, sandy, ocean beaches from the intertidal zone to the upper beach. Eggs are deposited in the mid- to above-high tide drift zone. Larval beetles occur in a relatively narrow band of the upper intertidal to high drift zone, where they can be regularly inundated by high tides. Eight protected populations exist within the Eastern Shore of the Chesapeake Bay, VA geographic recovery area; however, there are no protected populations on Wallops Island. The northeastern beach tiger beetle is not currently known to occur on

Affected Environment

Atlantic coastal beaches in Virginia. The closest documented population is approximately 30 km (20 mi) southwest of Wallops Island (USFWS, 2008).

3.2.10.3 *Terrestrial Mammals*

The Delmarva Peninsula fox squirrel lives in mature forests of mixed hardwoods and pines with a closed canopy and open understory on the Delmarva Peninsula. The CNWR, located approximately 3.2 km (2 mi) northeast of Wallops Island, is home to a large population of these protected squirrels. The Delmarva Peninsula fox squirrel has not been documented on Wallops Island.

3.2.10.4 *Birds*

Peregrine Falcon

The Peregrine Falcon is found in a variety of habitats, but prefer cliffs for nesting and open areas for foraging (White et al., 2002). A resident pair of Peregrine Falcons nests on a hacking tower on the northwest side of Wallops Island, outside of the project area. Migrating Peregrine Falcons occur along the Wallops Island beach during fall migration (NASA, 2009a).

Bald Eagles

The Bald Eagle was threatened with extinction in the lower 48 states due to habitat destruction and degradation, illegal shooting, and the contamination of its food source, largely as a consequence of DDT (a pesticide) poisoning of its food sources. Protection under the ESA, together with reintroduction programs, brought populations up, and the species was reclassified as Threatened in 1995. The species was delisted in June 2007. The VDGIF still considers the Bald Eagle a threatened species. The Bald Eagle usually breeds in forested areas near large bodies of water (Buehler, 2000). The bird is an opportunistic feeder, but prefers fish. They may also eat large birds, small mammals, and carrion. Bald Eagles can be seen flying over Wallops Island. An active nest was discovered on the northern end of Wallops Island in 2009 (NASA, 2009a) (Figure 38).

Terns

The Gull-billed Tern (*Sterna nilotica*) is medium size and has a black cap, a heavy bill and long legs (Molina et al., 2009). The Gull-billed Tern nests in coastal colonies along the Atlantic coast. North American Gull-billed Terns winter along the Gulf Coast, Pacific coast of Mexico, and into Central and South America. The Gull-billed Tern can be found nesting on the beaches or mud flats on Wallops Island. Although it does feed on fish occasionally, the Gull-billed Tern feeds mostly on insects, small crabs, and occasionally the chicks of other bird species in the area. Breeding and nesting takes place on sandy beaches in the spring and summer. In the winter, the tern moves to salt marshes, estuaries, and lagoons (Parnell, 1995).

The Roseate Tern (*Sterna dougallii*) is a medium-sized tern similar in appearance to several other terns and is primarily a tropical bird, breeding across the globe in tropical oceans habitats. When the Roseate Tern reaches the temperate zone in the northern Atlantic, it breeds on rocky offshore islands, barrier beaches, and salt marsh islands. In the winter, the Roseate Tern is found offshore or along coasts (Gochfeld et al., 1998).

Table 24: Protected Species that May Occur in the SRIPP Project Area

Common Name	Scientific Name	Likelihood of Occurrence Within Onshore Action Area ²	Likelihood of Occurrence Within Offshore Action Area ²	Potential Seasonal Presence	Federal Status	State Status	Jurisdiction
Seabeach amaranth	<i>Amaranthus pumilus</i>	possible	n/a	All	Threatened	n/a	USFWS
Northeastern beach tiger beetle	<i>Cicindela dorsalis dorsalis</i>	highly unlikely	n/a	All	Threatened	Threatened	USFWS/VDGIF
Delmarva Peninsula fox squirrel	<i>Sciurus niger cinereus</i>	highly unlikely	n/a	All	Endangered	Endangered	USFWS/VDGIF
Wilson's Plover	<i>Charadrius wilsonia</i>	Possible	n/a	All	n/a	Endangered	VDGIF
Peregrine Falcon	<i>Falco peregrinus</i>	possible	unlikely	Fall	n/a	Threatened	VDGIF
Gull-billed Tern	<i>Sterna nilotica</i>	possible	n/a	Spring/Fall Migration	n/a	Threatened	VDGIF
Roseate Tern	<i>Sterna dougallii dougallii</i>	possible	possible	Spring, Fall Migration	Threatened	Threatened	USFWS/VDGIF
Bald Eagle	<i>Haliaeetus leucocephalus</i>	possible	unlikely	All	n/a	Threatened	VDGIF
Red Knot ¹	<i>Calidris canutus rufa</i>	known to occur	n/a	Spring/Fall Migration	Candidate Species	n/a	USFWS
Piping Plover	<i>Charadrius melodus</i>	known to occur	n/a	All	Threatened	Threatened	USFWS/VDGIF
Leatherback sea turtle	<i>Dermochelys coriacea</i>	possible	possible	Summer	Endangered	Endangered	NMFS/USFWS/VDGIF
Kemp's ridley sea turtle	<i>Lepidechelys kempii</i>	possible	possible	Spring, Summer	Endangered	Endangered	NMFS/USFWS/VDGIF

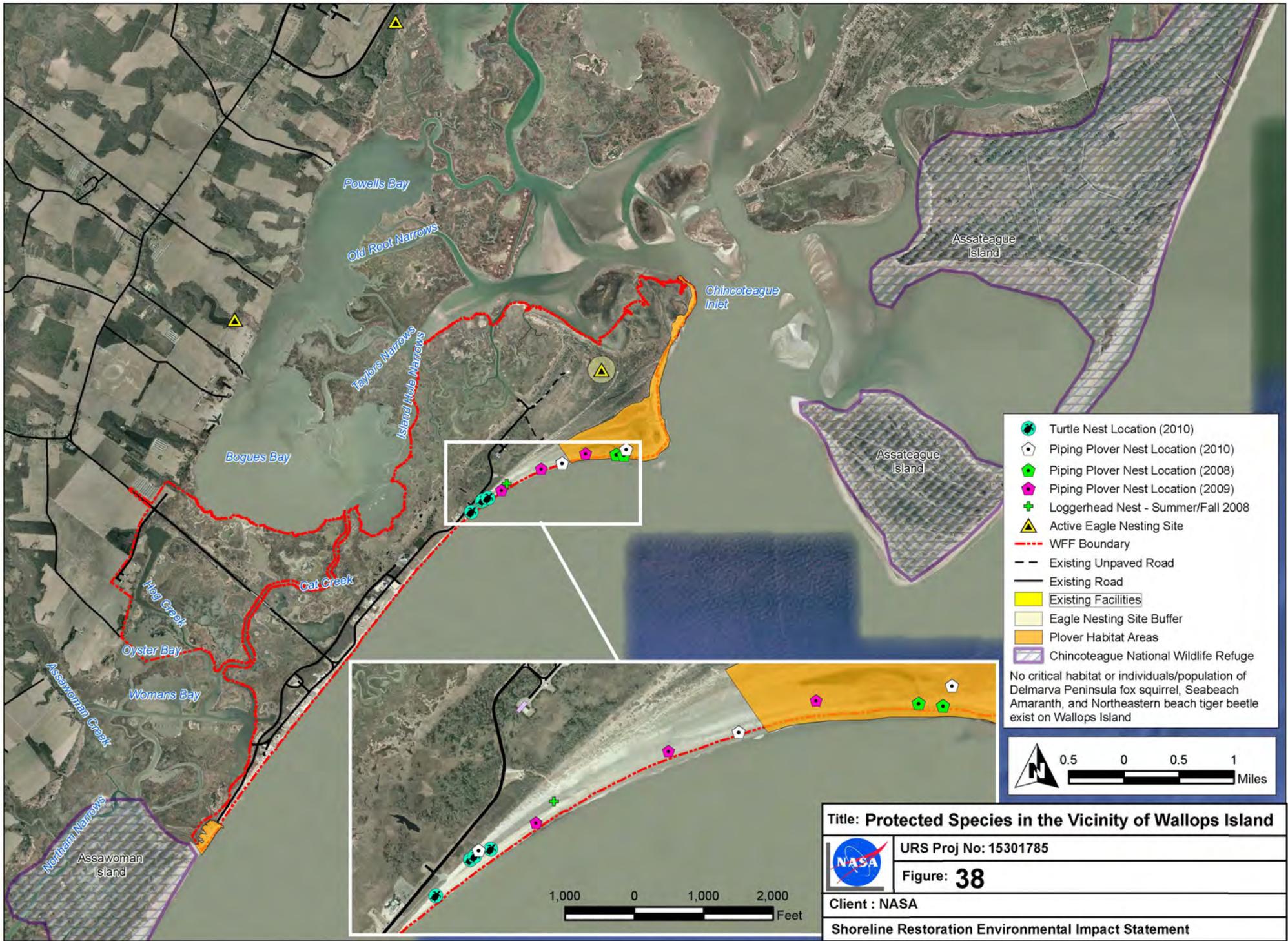
Affected Environment

Common Name	Scientific Name	Likelihood of Occurrence Within Onshore Action Area ²	Likelihood of Occurrence Within Offshore Action Area ²	Potential Seasonal Presence	Federal Status	State Status	Jurisdiction
Loggerhead sea turtle	<i>Caretta caretta</i>	known to occur	Likely	Spring, Summer	Threatened	Threatened	NMFS/USFWS/VDGIF
Atlantic green sea turtle	<i>Chelonia mydas</i>	possible	possible	Summer	Threatened	Threatened	NMFS/USFWS/VDGIF
Shortnose sturgeon	<i>Acipenser brevirostrum</i>	n/a	highly unlikely	All	Endangered	Endangered	NMFS/VDGIF
Humpback whale	<i>Megaptera novaeangliae</i>	n/a	possible	All	Endangered	Endangered	NMFS/VDGIF
Fin whale	<i>Balaenoptera physalus</i>	n/a	possible	Spring/Summer	Endangered	Endangered	NMFS/VDGIF
Right whale	<i>Eubalaena glacialis</i>	n/a	possible	Fall/Winter	Endangered	Endangered	NMFS/VDGIF
Sperm Whale	<i>Physeter macrocephalus</i>	n/a	highly unlikely	Summer/Fall	Endangered	Endangered	NMFS/VDGIF
Sei whale	<i>Balaenoptera borealis</i>	n/a	highly unlikely	All	Endangered	Endangered	NMFS/VDGIF
Blue Whale	<i>Balaenoptera musculus</i>	n/a	highly unlikely	Spring/Fall	Endangered	Endangered	NMFS/VDGIF
Florida Manatee	<i>Trichechus manatus latirostrus</i>	n/a	highly unlikely	Summer	Endangered	Endangered	NMFS/VDGIF

¹Although candidate species are not protected under the ESA, NASA considered the effects of the SRIPP on the Red Knot in its BA.

²n/a = not applicable; Highly unlikely = habitat not available and species is not documented in the action area; Possible = habitat available but species is rarely, if ever, documented in the action area; Likely = habitat available and species is occasionally documented in the action area; Known to occur = habitat available and species regularly documented in the action area.

Sources: USFWS, 2008; NASA, 2009a



Title: Protected Species in the Vicinity of Wallops Island

 URS Proj No: 15301785

Figure: 38

Client : NASA

Shoreline Restoration Environmental Impact Statement

This page intentionally left blank.

Red Knot

The Red Knot is a medium sized, bulky sandpiper. It is a relatively short bird, with short legs. The head and breast are rusty in breeding plumage and gray the rest of the year. Outside of the breeding season, it is found primarily in intertidal, marine habitats, especially near coastal inlets, estuaries, and bays. The Red Knot breeds in drier tundra areas, such as sparsely vegetated hillsides. The Red Knot typically feeds on invertebrates, especially bivalves, small snails, and crustaceans. During the breeding season, the Red Knot also eats terrestrial invertebrates (Harrington, 2001).

During its northern migration, the Virginia barrier islands provide an important stopover area for a large number of Red Knots. In the mid-1990s, 3 years of aerial surveys showed that numbers of Red Knots moving through the barrier islands of Virginia between mid-May and the second week of June reach 8,000 to 10,000 individuals (Watts and Truitt, 2000). During the 2009 migration season, flock sizes of 100 to 145 birds were observed in the Overwash and Hook areas of Assateague Island. In late May 2009, flocks of 5 to 30 individuals were observed on south Assawoman Island. On May 8, 2009, USFWS observed a flock size of almost 1,300 individuals on north Wallops Island (USFWS, 2009b). In late May 2009, flocks of approximately 20 to 200 Red Knots were observed on north Wallops Island (USFWS, 2009b).

Wilson's Plovers

Wilson's Plovers are found exclusively on southern beaches and tidal mudflats, typically in sparsely vegetated areas, including along beaches, sandbars, salt flats, and lagoons. They forage along intertidal mudflats during low tide. They nest either in isolated pairs or in colonies on beaches, commonly near a piece of driftwood or clump of grass. They are known to breed on the northern and southern beaches of Wallops Island and commonly share habitat with Piping Plovers.

Piping Plovers

Piping Plovers are small, sand-colored shorebirds, approximately 17 cm (7 in) long. The Atlantic Coast population breeds on sandy coastal beaches and winters along the Atlantic Coast. Piping Plovers nest on the ground above the high tide line on coastal beaches and barrier islands. Nests are usually found in areas with little or no vegetation. Plovers feed on invertebrates such as marine worms, fly larvae, beetles, crustaceans, and mollusks.

Piping Plovers use wide sandy beaches on Assawoman, Wallops, and Assateague Islands for courtship, nesting, and raising chicks. According to the USFWS (2010), suitable habitat varies along the seaward edge of islands within Delmarva Peninsula barrier islands year to year due to the competing effects of erosion and vegetation succession. The greatest areas of suitable beach occur on Assawoman Island and in the Hook and Overwash portions of Assateague Island.

Over 200 breeding pairs of Piping Plovers are currently found on island overwash beaches along the coast of Virginia, representing approximately 11 percent of the Atlantic coast population. Over 75 percent of these breeding pairs nest on the northern barrier islands closest to Wallops including Assawoman, Metompkin, and Cedar Islands (Boettcher et al., 2007).

Piping Plover nesting habitat has been delineated on the beaches and dunes at the northern and southern ends of Wallops Island (Figure 38). Although Wallops Island is not designated as

Affected Environment

critical habitat, NASA manages portions of the island to protect Piping Plovers known to nest on Wallops Island. The northern and southern beaches have been closed to vehicle and human traffic during the plover's nesting season (March 15 through September 1) since 1986. Biologists from the USFWS, CNWR, and VDGIF monitor Piping Plover nesting activities and provide advice to NASA on protection and management of the species. Biologists from the WFF U.S. Department of Agriculture (USDA) Wildlife Services Office aid with predator control. In recent years, an increasing number of plover nests have been identified in the recreational beach area south of the designated plover nesting areas (Figure 38). Accordingly, NASA has implemented management practices that include regular monitoring and installation of high visibility signage when nests are located to ensure that plovers nesting in this area are also afforded an appropriate level of protection.

As the southern portion of Wallops Island has experienced substantial erosion (3.3 m [11 ft]/year), suitable habitat is increasingly less abundant. In addition, there is a general absence of beach habitat seaward of the existing seawall. According to Mitchell (2009, pers. comm.), no nesting plovers have been observed on south Wallops Island since at least 2000. Simultaneously, north Wallops Island has been accreting, thus presenting additional potential habitat for plover nesting.

There has been an increasing trend in the number of nesting pairs of Piping Plovers at all CNWR units (including Assateague, Assawoman, and Metompkin Islands). Annually between 1996 and 2010, Piping Plovers were observed in increasing numbers at CNWR.

Nests at the north end of Wallops Island were observed in 1996 (three pairs with two chicks total fledged); 1998 (one pair unsuccessful); 2001 (one pair unsuccessful); 2004 (one pair with three chicks fledged); 2005 (two pairs, one nest lost to fox predation and second pair of chicks were lost); and 2006 (one pair of plovers nested, but the nest was abandoned due to attempted predation by a fox). There were no nests observed in 1997, 1999, 2000, 2002, and 2003. Five nesting attempts were made on north Wallops Island during 2007 and 2008, but none were successful in producing fledglings. In 2009, four Piping Plover pairs attempted nests on north Wallops Island. Of these, three were successful, producing a total of 10 fledglings (Scharle, 2009). The resulting fledge rate of 2.5 young fledged per nesting pair was the highest in the state of Virginia for that year. In the 2010 nesting season, three nests were found on north Wallops Island with four chicks fledged (Figure 38).

3.2.10.5 *Sea Turtles*

Sea turtles are air-breathing reptiles with streamlined bodies and large flippers and are well adapted to life in the marine environment. They inhabit tropical and subtropical ocean waters throughout the world (NOAA, 2009b).

There are two families of sea turtles (Wynne and Schultz, 1999). The family Dermochelyidae is comprised of only one genus and species, commonly referred to as the leatherback sea turtle. The Cheloniidae family contains six genera and six distinct species: the loggerhead, green, flatback, hawksbill, Kemp's ridley, and olive ridley. In March 2010, NMFS and USFWS published a proposed rule in the Federal Register to divide the worldwide population of loggerhead sea turtles into nine distinct population segments (DPSs). Loggerhead turtles in the project area would be considered to be in the Northwest Atlantic Ocean DPS and would be proposed to be listed as endangered.

Sea turtles have short, thick, incompletely retractile necks and legs that have been evolved to become flippers (Bustard, 1972). All species, except the leatherback, have a hard, bony carapace (top shell) modified for marine existence by streamlining and weight reduction (Bustard, 1972). The leatherback lacks shell scutes, and head and body scales. The shell is covered by leathery skin. The carapace is divided longitudinally by seven ridges (Wynne and Schwartz, 1999). These physiological differences are the reason for their separate designation as the only species in the family Dermochelyidae.

Much of a sea turtle's life is spent in the water and males of many species may never leave an aquatic environment (Wynne and Schwartz, 1999). The recognized life stages for these turtles are egg, hatchling, juvenile/subadult, and adult (Hirth, 1971). Reproductive cycles in adults of all species involve some degree of migration in which the animals endeavor to return to nest at the same beach year after year (Hopkins and Richardson, 1984). The nesting season ranges from April through September (Hopkins and Richardson, 1984; Nelson, 1988). It is believed that mating occurs just off the nesting beach, although solid evidence of this is lacking. After mating, the nesting female emerges from the water and digs a flask-shaped nest in the sand with her hind flippers, then lays 50 to 170 (depending on the species) ping-pong sized, ball-shaped eggs. After covering the eggs with sand, she returns to the water. The female sea turtle will nest several times in one season. Incubation periods for sea turtles vary by species from 45 to 65 days (Nelson, 1988; Wynne and Schwartz, 1999).

Hatchlings break their shells and dig their way out of the nest at night (Wynne and Schwartz, 1999). They orient themselves toward the sea by following the reflected light from the breaking surf (Hopkins and Richardson, 1984). After entering the surf, hatchlings engage in behavior referred to as "swim frenzy," during which they swim in a straight line for many hours (Carr, 1986). Once into the waters off the nesting beach, hatchlings enter a period referred to as the "lost years" where many species live and feed in floating sargassum (Wynne and Schwartz, 1999). They "reappear" as juveniles in feeding grounds shared with adults, or in some cases, migrate to developmental feeding grounds. Some species, such as the leatherback, spend their entire lives in a pelagic existence, coming inshore only to mate and nest (Wynne and Schwartz, 1999).

The functional ecology of sea turtles in the marine and/or estuarine ecosystem varies by species. The Kemp's ridley sea turtle is omnivorous and feeds on swimming crabs and crustaceans. The green turtle is an herbivore and grazes on marine grasses and algae, while the leatherback is a specialized feeder preying primarily upon jellyfish. The loggerhead is primarily carnivorous and has jaws well adapted to crushing mollusks and crustaceans, and grazing on organisms attached to reefs, pilings, and wrecks.

Sea turtles are believed to play a significant role in marine and estuarine ecosystems. This role has likely been greatly reduced in most locations as a result of declining turtle populations. Population declines are a result of numerous factors, such as disease and predation, habitat loss, commercial fisheries conflicts, and inadequate regulatory mechanisms for their protection. As a result, all sea turtle species have been classified as endangered or threatened.

Due to complex life histories and multiple habitats used by the various species, sea turtle populations have proven difficult to accurately census (Meylan, 1982). Because of these problems, estimates of population numbers have been derived from various indices, such as

Affected Environment

numbers of nesting females, numbers of hatchlings per kilometer of nesting beach, and number of subadult carcasses washed ashore (Hopkins and Richardson, 1984).

Sea turtles are affected by many factors occurring on the nesting beaches and in the water. Poaching, habitat loss, and nesting predation affect hatchlings and nesting females while on land. Fishery interactions, vessel interactions, and dredging operations affect sea turtles in the nearshore and offshore environment.

The leatherback, Kemp's ridley, loggerhead, and Atlantic green sea turtles are known to migrate along U.S. Atlantic Coast beaches, though only the loggerhead, leatherback, Kemp's ridley and Green sea turtle occur in the SRIPP project area, and only during the warmer months (approximately April 1-November 30). The SRIPP project area falls within the geographic range where loggerhead sea turtles, green sea turtles and leatherback sea turtles have shown nesting behavior, but the loggerhead sea turtle is the only species known to nest within the SRIPP project area.

NASA coordinates with CNWR and USDA personnel in monitoring the Wallops Island beaches for sea turtle activity. Sea turtle crawl tracks, a sign of potential nesting activity, have historically seldom been found on Wallops Island beaches, but have increased in recent years. The USFWS recorded five nests on Wallops Island between 1974 and 2009, one of which was a loggerhead sea turtle nest on north Wallops Island in the summer of 2008 (Figure 38). Following flood inundation from several fall storms, CNWR personnel recovered approximately 170 eggs from the nest in October 2008. None were viable. According to a 2009 biological memorandum (USFWS), staff did not locate any sea turtle crawl tracks or nesting related activity on CNWR or Wallops Island from June to September 2009.

For the 2010 nesting season, NASA recorded four loggerhead sea turtle nests on north Wallops Island within the NASA recreational beach area. All of the nests have had the presence of eggs confirmed. In addition, NASA personnel documented a false crawl in the narrow beach in front of the seawall near the northern extent of the existing seawall, where it appears the turtle returned to sea without nesting due to the absence of a suitable beach (USFWS, 2010a).

Leatherback Sea Turtle

The leatherback is the largest, deepest diving, most migratory, and widest ranging of all sea turtles. The adult leatherback can reach 1.3 to 2.4 m (4 to 8 ft) in length and 226 to 907 kg (500 to 2000 lbs) in weight. Also the largest living reptile in the world, the endangered leatherback turtle lacks a hard shell and is covered by leathery skin. The leatherback is the only black marine turtle in the Atlantic (Wynne and Schwartz, 1999). The most recent population estimate for the North Atlantic is a range of 34,000 to 94,000 adult leatherbacks, which is considered a stable population (NMFS, 2007). Leatherbacks are predominantly a pelagic species and feed on jellyfish. The greatest causes of decline and the continuing primary threats to leatherbacks worldwide are long-term harvest and incidental capture in fishing gear. Harvest of eggs and adults occurs on nesting beaches, while juveniles and adults are harvested on feeding grounds. Incidental capture primarily occurs in gillnets, but also in trawls, traps and pots, longlines, and dredges (NOAA, 2009b).

The leatherback turtle may pass through the Mid-Atlantic during migration. Concentrations may be found between the Gulf of Maine and Long Island (Shoop and Kenney, 1992), in coastal areas of New Jersey and Delaware, and around the mouth of the Delaware Bay (USACE, 1995).

Kemp's Ridley Sea Turtle

The smallest sea turtle, the Kemp's ridley turtle's shell ranges from 0.6 to 0.8 m (2 to 3 ft) in size. The average Kemp's ridley turtle weighs between 40 to 50 kg (88 to 110 lbs) (Wynne and Schwartz, 1999). Kemp's ridley turtles are less widespread than many other sea turtle species, occurring primarily in the Gulf of Mexico and the northern half of the Atlantic Ocean, with an unknown portion of the population migrating to U.S. Atlantic Ocean waters (NMFS, 2007). Kemp's ridley sea turtles are relatively common in Virginia and Maryland State waters in May and June, where they feed on crabs, mollusks, shrimp, and sometimes fish. In addition to poaching and impacts from fishery interactions, Kemp's ridleys face natural threats such as destruction of nesting habitat from storm events and natural predators.

Loggerhead Sea Turtle

Loggerhead turtles reach 1.2 m (4 ft) in length and weigh on average approximately 115 kg (254 lbs) (Wynne and Schwartz, 1999). Loggerhead turtles are found in temperate and subtropical waters and inhabit pelagic waters, continental shelves, bays, estuaries, and lagoons. Loggerheads are primarily benthic feeders and prefer crustaceans and mollusks. NMFS estimates that there are at least five western Atlantic loggerhead subpopulations, and that individuals from three of these are expected to occur within the project area (NMFS, 2007).

In Maryland and Virginia waters, loggerheads are the most common sea turtle species. Loggerheads can be found in the Chesapeake Bay from April through November, and the Bay is an important summer feeding ground. Loggerheads can be found in the Bay south of Baltimore within all the major tributaries, along the Virginia and Maryland Atlantic coast, and in the lagoons and channels in the barrier island systems (Lutcavage, 1981; Lutcavage and Musick, 1985; Byles and Dodd, 1989). The lower Chesapeake Bay estuary and the Atlantic Coastline provide important developmental habitat for immature sea turtles because of submergent vegetation beds and a rich diversity of bottom-dwelling fauna that afford cover and forage. Occasionally, adult females use Virginia's ocean facing beaches as nesting sites (VDGIF, no date). The horseshoe crab, which favors water depths from 4 to 20 meters (13 to 67 feet), is an important benthic food species for the loggerhead.

Loggerheads face the same danger as other sea turtles, including boat collisions, poaching, and fisheries interactions.

Atlantic Green Sea Turtle

Green turtles are the largest hard-shelled sea turtle, with an average span of 1 m (3.3 ft) and weighing 150 kg (331 lbs) (Wynne and Schwartz, 1999). Pelagic-stage hatchlings and juveniles eat mollusks, jellyfish, and crustaceans. As juveniles mature, the diet shifts to seagrasses and macroalgae. Green turtles can be found worldwide. The Atlantic population of the green sea turtle, which ranges from Massachusetts to Argentina, is listed as threatened under the ESA, while the breeding populations in Florida and on the Pacific Coast of Mexico are listed as endangered. Since it is difficult to differentiate between breeding populations away from the nesting beaches, all green sea turtles are considered endangered (NMFS, 2007). Green sea turtles have been occasionally encountered in the SRIPP project area but their occurrence is expected to be rare.

Affected Environment

3.2.10.6 *Finfish*

The shortnose sturgeon is the smallest of the three sturgeon species that occur in eastern North America, having a maximum known total length of 1.4 m (4.7 ft) and weight of 23 kg (50.7 lbs). The shortnose sturgeon is a benthic feeder and lives mainly in the slower moving riverine waters or nearshore marine waters, and migrates periodically into faster moving fresh water areas to spawn. Juveniles are believed to feed on benthic insects and crustaceans. Mollusks and large crustaceans are the primary food of adult shortnose sturgeon.

Shortnose sturgeon occur in most major river systems along the eastern seaboard of the United States. The shortnose sturgeon is found in the Chesapeake Bay system and in South Carolina, but no populations are reported in Virginia or North Carolina (NOAA Office of Protected Resources, 2009). No protected populations exist in the vicinity of the project area.

3.2.10.7 *Marine Mammals*

Humpback Whale

Adult humpback whales grow to be about 11 to 16 m (36 to 52 ft) in length. Their body is black or dark gray, with very long flippers that are usually partially white (Jefferson et al., 1993). Humpback whales feed on a variety of invertebrates and small schooling fish including krill, herring, mackerel, sand lance, sardines, anchovies, and capelin. An estimated 11,570 humpback whales occur in the North Atlantic (Stevick et al., 2003). A Recovery Plan was published in 1991 and is currently in effect (NMFS, 1991).

Although humpback whales typically travel over deep, oceanic waters during migration, their feeding and breeding habitats are mostly in shallow, coastal waters over continental shelves. Humpback whales occur on the continental shelf and in deep water in the vicinity of Wallops Island in fall, winter, and spring as they migrate between calving and breeding grounds in the Caribbean and feeding grounds off the New England coast (Corkeron and Connor, 1999; Stern, 2002). Humpback whales have recently been observed (as sightings and as strandings) along the Mid-Atlantic States from New Jersey to North Carolina, primarily during the winter months. These areas may represent a supplemental winter feeding area for humpback whales (Barco et al., 2002).

Fin Whale

The adult fin whale can reach 24 m (79 ft) in length, making it the second largest whale species after the blue whale. Fin whales feed on a variety of small, schooling prey such as herring, capelin, sand lance, squid, krill, and copepods (Kenney et al., 1985; NMFS, 2006a). The fin whale is listed as endangered under the ESA and is managed by the NMFS. NOAA estimates that there are about 2,250 individual fin whales in the U.S. Atlantic waters, though the accuracy of this number is unclear (Waring et al., 2007). A Draft Recovery Plan for fin whales is currently available for review (NMFS, 2006a).

Fin whales are found in deep, offshore waters of all major oceans, primarily in temperate to polar latitudes (NOAA, 2009a). Off the U.S. Atlantic coast, sightings are almost exclusively limited to continental shelf waters from the southern Gulf of Maine to Cape Hatteras, North Carolina (CETAP, 1982; Hain et al., 1992). Survey data from Cape Hatteras to Nova Scotia (dated 1978 to 1982) suggest that fin whales prefer mid-depths, with 65 percent of sightings in the 21 to 100

m (69 to 330 ft) range. The mid-shelf in the MAB appears to be a seasonally important area for fin whales. Density off the mouth of Delaware Bay is highest in winter and summer and highest in spring off Chesapeake Bay (Hain et al., 1992). The fin whale may occur offshore of Wallops Island during these times.

Right Whale

North Atlantic right whales can reach up to 18 m (59 ft) in length. Right whales feed on zooplankton, particularly large copepods. The North Atlantic right whale is one of the most endangered large whale species (Perry et al., 1999; IWC, 2001). According to the North Atlantic Right Whale Consortium (NARWC), the North Atlantic right whale is not showing any signs of recovering from historical whaling. The NARWC estimates there are only approximately 350 individuals left (NARWC, 2009). A Recovery Plan is in effect for the North Atlantic right whale. Originally published in 1991, it was recently revised in 2004 (NMFS, 2005).

Right whales migrate from their calving grounds off the coast of Florida and Georgia towards their feeding grounds in New England and Canada during the spring and early summer months and would be expected to pass through the project area during this time (Winn et al., 1986). According to the NARWC, the migration routes and wintering grounds of most right whales are not known (NARWC, 2009).

Right whales seasonally transit Mid-Atlantic waters between November and April, with peaks in December, March, and April. Knowlton et al. (2002) analyzed survey data, satellite tag data, whale strandings, and opportunistic sightings from the Mid-Atlantic migratory corridor (Georgia/South Carolina border to waters off southern New England). Most sightings (94 percent) were within 56 km (35 mi) of shore, with over half (64 percent) within 18.5 km (11.5 mi) of shore. Right whales preferred shallow waters, with 80 percent of all sightings in depths <27 km (17 mi), and 93 percent in depths <45 km (28 mi) (Knowlton et al., 2002). Of the ports cited in the study, Chesapeake Bay and Delaware Bay are closest to Wallops Island. Sightings near Chesapeake Bay occurred in October through December, February, and March. There are few sightings from Delaware Bay (one each in October, December, May, and July), making it difficult to discern any patterns of occurrence there (Knowlton et al., 2002).

Sperm Whale

The sperm whale is the largest toothed whale species. Adult females may grow to lengths of 11 m (36 ft), while adult males can be as long as 16 m (52 ft) and weigh three times as much as the female (NOAA, 2009a). The sperm whale is distinguished by its extremely large head which can take up as much as 35 percent of its body length. The sperm whale prefers large squid but will also eat large demersal and mesopelagic sharks, skates, and fishes (NOAA, 2009a). The best available estimate for sperm whales in the U.S. North Atlantic is 4,702 individuals (NOAA, 2009a). Sperm whales are listed as endangered under the ESA. A Draft Recovery Plan for sperm whales was written and is available for review (NMFS, 2006b).

Sperm whales spend most of their time at great depths, and are capable of dives that last over an hour at depths of 1,000 m (3,280 ft). Sperm whales are abundant east and northeast of Cape Hatteras in the winter. In spring, the distribution shifts northward to east of Delaware and Virginia, but is widespread (NOAA, 2009a). Sperm whales may occur landward of the shelf break in the vicinity of the project area during all seasons.

Affected Environment

Sei Whale

The sei whale can reach lengths of about 12-18 m (40-60 ft) and weigh 45,000 kilograms (100,000 pounds). Sei whales have a long, sleek body that is dark bluish-gray to black in color and pale underneath (NOAA, 2009a). In the North Atlantic, the sei whale's major prey species are copepods and krill (Kenney et al., 1985). While there are no estimates for the North Atlantic population of sei whales, NOAA estimates that the worldwide population is about 80,000 individuals (NOAA, 2009a). Sei whales are listed as endangered under the ESA. A Recovery Plan for this species was written and is awaiting legal clearance (Waring et al., 2009).

The sei whale can be found worldwide, though they appear to prefer temperate waters in the mid-latitudes (NOAA, 2009a). In the Atlantic Ocean, the sei whale is primarily seen on Georges Bank (Wynne and Schwartz, 1999). The distribution and movement patterns of sei whales are not well known, but they may occur in the vicinity of the project area year round, more likely however, they occur in deeper offshore waters (Rice, 1998; Perry et al., 1999).

Blue Whale

The blue whale is the largest animal ever known to have lived on Earth. Adult blue whales range from 23 to 27 m (75 to 89 ft) and can weigh over 150,000 kg (330,000 lbs) (NOAA, 2009a). Blue whales have a long, sleek body and have a mottled grey color pattern that appears light blue when seen through the water (NOAA, 2009a). It is estimated that less than 1,500 individuals currently exist in the North Atlantic (Wynne and Schwartz, 1999). The blue whale is listed as endangered under the ESA and a Recovery Plan for this species was published in 1998 (Reeves et al., 1998).

The overall distribution of blue whales in the North Atlantic extends from the subtropics to Baffin Bay and the Greenland Sea. Blue whales are most frequently sighted in the waters off eastern Canada, with the majority of recent records from the Gulf of St. Lawrence, where they are present throughout most of the year. They are most common during the summer and fall feeding seasons and typically leave by early winter to avoid ice entrapment. Although they are rare in the shelf waters of the eastern U.S., blue whales have been occasionally sighted off Cape Cod, Massachusetts. Although it is believed this region may represent the current southern limit of the blue whales' feeding range (NOAA, 2009a), they could occur within the SRIPP project area.

Manatee

West Indian manatee and Florida manatee are large grayish marine mammals that grow to be about 2.5 to 4.5 m (8 to 15 ft) long and 1,600 kg (3,530 lbs). Manatees prefer warm, tropical waters. In the West Atlantic Ocean, the manatee is most common in the Florida peninsula and south east Georgia, but range from the Texas gulf coast all the way to Rhode Island (Wynne and Schwartz, 1999). Sightings as far north as Virginia (Waring et al., 2002) and Rhode Island are rare and considered extralimital. It is highly unlikely, but still possible, that the manatee would be encountered within the project area.

3.3 SOCIAL AND ECONOMIC ENVIRONMENT

The following sections provide background information on the social and economic characteristics of Wallops Island and the surrounding area. The majority of the data presented

was collected from the U.S. Department of Commerce Bureau of Census 2000 data, with supplemental information gathered from WFF and local sources.

3.3.1 Land Use

Wallops Island consists of 1,680 ha (4,150 ac), most of which is marshland, and includes launch and testing facilities, blockhouses, rocket storage buildings, assembly shops, dynamic balancing facilities, tracking facilities, U.S. Navy facilities, and other related support structures. Wallops Island is zoned as agricultural by Accomack County. The marsh area between Wallops Mainland and Wallops Island is designated as undeveloped in the County's Comprehensive Plan. Wallops Mainland consists mostly of marshland and is bordered by agricultural land to the west, Bogues Bay to the north, and an estuary to the south.

Wallops Island is geographically proximate to a number of areas managed for conservation purposes. Northeast of Wallops Island is Assateague Island, managed by the USFWS as part of the CNWR. Immediately south is Assawoman Island, also a part of CNWR. Further south, a majority of the remaining undeveloped barrier islands are owned and managed by the Nature Conservancy as components of the Virginia Coast Reserve.

The mainland areas west of Wallops Island consist of rural farmland and small villages and are regulated by local county government and several town councils (NASA, 2008a). Corn, wheat, soybeans, cabbage, potatoes, cucumbers, and tomatoes are examples of the commodities produced on the surrounding farms. Area businesses include fuel stations, retail stores, markets, and restaurants.

3.3.2 Recreation

Virginia's Eastern Shore is a popular tourist destination. Many tourists and vacationers visit Accomack County throughout the late spring, summer, and early fall. Regional attractions include the Assateague Island National Seashore and CNWR. Winter hunting season draws people to hunt local game including dove, quail, deer, fox, and many types of geese and ducks. The Wallops Island shoreline is also a popular location for local fishermen who fish from their boats in the nearshore environment.

Recreational boating occurs occasionally on the open ocean throughout the project area, depending on season and weather conditions. Recreational boating typically occurs during summer months in the area. Travel between the most popular cruising destinations along the Virginia coast does not require traversing the project area. Large recreational vessels may sometimes use the area, but there are few vessels of this type and their presence is uncommon. The most popular diving sites off the coast of Virginia are shipwrecks and five artificial reefs. Popular shipwreck diving destinations occur at depths between 15 m and 49 m (50 ft and 160 ft). However, despite the presence of potential offshore diving locations, in a statewide survey, diving was not given as a significant reason for recreational boating among boat owners (Responsive Management, 2000).

3.3.3 Fisheries

Commercial and Recreational Fisheries

WFF is located on one of several Atlantic Ocean barrier islands that contribute to a diverse marine ecosystem. This ecosystem supported what historically was a robust local recreational

Affected Environment

and commercial fishing industry on Chincoteague Island and in the region. Over the last 60 years, however, the economy of commercial fishing has gradually diminished, although some parts of the commercial fishing industry have seen improvement since the 1990s. Diseases destroyed much of the oyster harvesting potential, and this change spurred the establishment of the clam aquaculture industry throughout Chincoteague. Since the 1990s, clam farming has become increasingly important to the island's economy, producing close to \$30 million annually and increasing average employment rates in the area by 13 percent (based on 2005-2006 data). Commercial fishing, along with agriculture and forestry industries, makes up more than 6 percent of the Chincoteague labor force (U.S. Census Bureau, 2000). The Draft Chincoteague Comprehensive Plan establishes as one of its primary objectives: "To maintain the protections afforded by these barrier islands from storm events and to protect the diverse and unique ecology of the areas that serves as the basis for the Town's economy..." (Town of Chincoteague, 2009).

A popular recreational fishing spot, Blackfish Bank Shoal, is located approximately 8 km (5 mi) east of Assateague Island and approximately 11 km (7 mi) northeast of the Wallops Island shoreline. Blackfish Bank Shoal has been developed as an artificial reef (by sinking subway cars on the shoal) through the efforts of the Town of Chincoteague and the Chincoteague Island Charterboat Association. Blackfish Bank's artificial reef is the closest artificial reef to the proposed SRIPP borrow sites – the next closest are two artificial reefs, both approximately 32 km (20 mi) away: Parramore Reef, located southwest of the proposed SRIPP borrow sites, and Jackspot artificial reef to the northwest.

2009 SRIPP Survey

In April and May 2009, guides and recreational fishermen¹ in Chincoteague, Wachapreague, and Ocean City were surveyed to determine their use of Blackfish Bank Shoal, Unnamed Shoal A, and the Wallops Island shoreline. At the time of the survey, Unnamed Shoal B had not been selected as a potential borrow site therefore was not include in the survey. The survey was designed to assess commercial and recreational fishermen's perceptions of potential impacts on the fishing industry from SRIPP activities. The fishermen were encountered by visiting known ports of entry in Chincoteague, VA; Wachapreague, VA; and Ocean City, MD, from April 7–10, 2009. The harbormaster at Chincoteague and the Chincoteague Fisheries Cooperative were also contacted, as were fishermen and staff at the various marinas and bait and tackle shops in all three towns (NASA, 2009d). A total of 66 responses were received during the survey.

Slightly less than half the survey respondents (30) indicated that they did fish in the study area. Eighty-six percent of survey respondents who reported fishing in the area indicated they fished there at least in the spring and summer, with several respondents also fishing the area in the fall. About 30 percent of the same survey respondents reported fishing in the area all year. Thirty-six of the respondents (55 percent) reported fishing within 8 km (5 mi) of either Blackfish Bank Shoal or the Wallops Island shoreline. Of those 36 respondents, 24 said they fished at Blackfish Bank Shoal (NASA, 2009d).

¹ Survey respondents who indicated that they are "guides/commercial/recreational" fishermen, meaning they own and/or operate charter boats are categorized as "guides" rather than "commercial" fishermen. This is to distinguish charter activities from fishermen who are associated with commercial fisheries, even though the guides are technically commercial fishermen for licensing purposes. Commercial fishermen were also included in the study, but they were largely unresponsive and are not discussed here.

According to the 2008 NOAA permit database, 13 commercial fishing vessels are registered with Chincoteague as their home port city and 8 vessels are registered with Wachapreague as their home port city. Three vessels were identified as having Ocean City as their principal port, though those vessels had Norfolk as their home port city. According to NMFS Northeast Regional Office, the majority of vessels that list their home port in the vicinity of the project area had permits for bluefish, black sea bass, scup, squid/mackerel/butterfish, and summer flounder, indicating those are the most commonly harvested species in the area. The VMRC tracks finfish and shellfish landings in Virginia waters. This provides information on the economic contribution to the Accomack County as well as an inventory of aquatic life in county waters. According to the 2008 updated Accomack County Comprehensive Plan (Accomack County, 2008), 1,066,604 kilograms (2,351,459 pounds) of finfish were sold dock-side in 1992 at a value of \$1,209,789. Total landings for shellfish were 383,719 kilograms (845,956 pounds) with an economic value of \$1,258,308. The economic value of the landings represents 4 percent of all landings in Virginia. This information was obtained from mandatory reporting by fishermen in the area.

Subsistence Fishing

According to VMRC, there is no available information suggesting that subsistence fishing takes place within the SRIPP project area (Travelstead, pers. comm., 2010).

3.3.4 Population

In 2006, the U.S. Census Bureau reported that the population of the Commonwealth of Virginia was about 7.6 million, and Accomack County's population was 39,345, with a population density of 218 people per km² (84.2 people per mi²) (U.S. Census Bureau, 2000). The population growth rate in Accomack County between 2000 and 2006 was approximately 2.7 percent (U.S. Census Bureau, 2008a).

The village of Assawoman, approximately 8 kilometers (5 miles) to the southwest, is the closest residential community to Wallops Island. The towns of Wattsville and Atlantic are the closest incorporated communities to Wallops Island and are located approximately 13 kilometers (8 miles) and 8 kilometers (5 miles) northwest of Wallops Island, respectively. There is no specific census data available for Wattsville because it is an unincorporated residential area.

Chincoteague Island, Virginia, is approximately 13 kilometers (8 miles) northeast of Wallops Island. The Town of Chincoteague is the most densely populated area in Accomack County, with a resident population of 4,317 people. Area populations fluctuate seasonally. During the summer months the population increases due to tourism and vacationers who visit the nature reserve and beaches of Assateague Island. Daily populations often reach up to 15,000 in the summer months. Special events, such as the annual pony swim and roundup/auction, sponsored by the Chincoteague Volunteer Fire Department in July, draw crowds of up to 40,000.

3.3.5 Employment and Income

This section provides general background information on employment and income data for the WFF region. Information includes employment, unemployment, income, and poverty characteristics of the region compiled by the 2000 U.S. Census, the Virginia Employment Commission (VEC) and by Virginia Polytechnic Institute (Eastern Shore Chamber of Commerce, 2007). The section also includes employment statistics for WFF itself.

Affected Environment

In 2008, the monthly unemployment rates in Virginia were as low as 4.1 percent and as high as 7.0 percent (VEC, 2009a). In 2008, Accomack County was approximately average in the Delmarva region in terms of unemployment rates. The total labor force of Accomack County is 19,375 people, 18,202 of whom are employed, resulting in an average annual unemployment rate of 6.1 percent (VEC, 2009b). Employment fluctuates seasonally in Accomack County and the Town of Chincoteague, with decreased unemployment occurring from June through October (VEC, 2009b). Overall, the unemployment rates in Virginia and Accomack County have been declining since 2000 (VEC, 2009a; VEC, 2009b).

Table 25 lists the distribution by broad occupational categories for Virginia, Accomack County, and Chincoteague, as reported by the U.S. Census Bureau.

Table 25: Occupational Distribution (percent)

Category	Virginia	Accomack County	Chincoteague
Management, professional, and related occupations	38	24	26
Sales and office occupations	26	22	26
Production, transportation, and material moving occupations	13	20	9
Service occupations	14	17	17
Construction, extraction, and maintenance occupations	10	11	15
Farming, fishing, and forestry occupations	1	6	7

Source: U.S. Census Bureau, 2000

Table 26 shows the income and poverty rates of the Commonwealth of Virginia, Accomack County, and Chincoteague. Accomack County and Chincoteague both have a higher percentage of families below the poverty level and a lower per capita income than Virginia as a whole; however, Accomack County and Chincoteague do not include major urban centers.

Table 26: Income and Poverty

Region	Median Household Income (2007)	Per Capita Income (2007)	Percent of Families Below Poverty Level (2007)
Virginia	\$59,575	\$41,727	11.9
Accomack County	\$36,616	\$24,342	23.4
Chincoteague	\$36,566	\$24,549	13.4

Source: U.S. Census Bureau, 2008a

In 2008, WFF employed a total of 1,485 people; 1,027 of those supported NASA (including 238 civil servants and 789 contractors), MARS employed 3 full-time people, and the remainder worked for either NOAA or the U.S. Navy (NASA, 2008a). The VEC reported that in 2008 NASA was the fourth largest employer in Accomack County; other large employers on the

Eastern Shore are Perdue Farms (1,900 employees) and Tyson Foods (950 employees) (VEC, 2009b).

Employment categories at WFF consist largely of managerial, professional, and technical disciplines with higher than regional average salaries. The mean salary of NASA employees for fiscal year 2008 was \$88,047, while the median salary is in the \$80,000-\$90,000 range (NASA, 2008a). The median family income for Accomack County in 2008 was \$41,845. Due to the wide gap between salaries of WFF employees and most area residents, the facility contributes considerably to the local economy (NASA, 2009a).

3.3.6 Health and Safety

Three local emergency health services are located in the vicinity of WFF. WFF has its own health unit which operates from 8:00 a.m. to 4:30 p.m.; after-hours emergency medical care is provided by Emergency Medical Services staff of the WFF Fire Department. The Chincoteague Medical Center on Chincoteague Island and the Atlantic Medical Center in Oak Hall, VA, also provide emergency assistance, and both are located within 8 km (5 mi) of WFF. Four hospitals are also located in the region, all within 64 km (40 mi) of WFF. These hospitals include:

- Atlantic General Hospital in Berlin, MD;
- McCready Memorial Hospital in Crisfield, MD;
- Peninsula Regional Medical Center in Salisbury, MD; and
- Shore Memorial Hospital in Nassawadox, VA.

The Peninsula Regional Medical Center in Salisbury serves as the regional trauma center for the Delmarva Peninsula. If additional trauma care is needed, Sentara Norfolk General Hospital is 19 minutes away (by helicopter) from the Shore Memorial Hospital in Nassawadox, VA. Accomack and Northampton County Health Departments offer clinical services. Worcester, Somerset, and Wicomico Counties also have health departments. Five nursing homes on Virginia's Eastern Shore and eight nursing homes on Maryland's Lower Eastern Shore are available to the surrounding communities.

The WFF Fire Department provides emergency services to the neighboring community and has a Mutual Aid Agreement with the Accomack-Northampton Fireman's Association for any outside assistance needed at WFF (NASA, 2008a). There are 24-hour fire and protection services, and personnel are also trained as first responders for hazardous materials, waste, and oil spills. There are 21 existing Fire and Rescue stations in Accomack County. The local fire companies closest to Wallops are in the towns of Atlantic, Chincoteague, and New Church, VA.

WFF maintains a security force that is responsible for the internal security of the base and provides 24-hour-per-day protection services. One entrance gate serves as the control and monitoring point for Wallops Mainland and Wallops Island, combined.

3.3.7 Cultural Resources

The National Historic Preservation Act (NHPA) of 1966, (P.L. 89-665; 16 U.S.C. 470 *et seq.*) as amended, outlines Federal policy to protect historic sites and values in cooperation with other nations, Tribal Governments, States, and local governments. Subsequent amendments designated the State Historic Preservation Officer as the individual responsible for administering State-level programs. The NHPA also created the Advisory Council on Historic Preservation (ACHP), the

Affected Environment

Federal agency responsible for providing commentary on Federal activities, programs, and policies that affect historic resources.

Section 106 and Section 110 of the NHPA and its implementing regulations (36 CFR 800) outline the procedures to be followed in the documentation, evaluation, and mitigation of impacts for cultural resources. The Section 106 process applies to any Federal undertaking that has the potential to affect cultural resources. This process includes identifying significant historic properties that may be affected by an action and mitigating adverse effects to properties listed, or eligible for listing, in the National Register of Historic Places (NRHP) (30 CFR 60.4). Section 110 of the NHPA outlines the obligations Federal agencies have in regard to historic resources under their ownership.

Section 106 of the NHPA requires Federal agencies take into consideration the effects of their undertakings on historic properties and to allow the ACHP the opportunity to comment on such undertakings. As defined in the NHPA, “historic properties” are one of five resource types—buildings, structures, object, sites, or districts—that are listed in or eligible for listing in the NRHP. Resources less than 50 years of age are not generally eligible for listing in the NRHP, but may be if they are of exceptional importance. Accordingly, to be in compliance with Section 106 of the NHPA, NASA must consider the effects of the proposed undertaking on all properties that are listed in or eligible for listing in the NRHP—both those owned by NASA within the boundaries of WFF, as well as those located outside of WFF that may be affected.

In November 2003, NASA prepared a *Cultural Resources Assessment of Wallops Flight Facility, Accomack County, Virginia* that examined each of the three land areas of the facility within WFF’s property boundaries: Wallops Main Base, Wallops Mainland, and Wallops Island (NASA, 2003b). The study was completed to assist NASA in meeting its obligations under Sections 106 and 110 of the NHPA. For planning purposes, this study evaluated properties constructed prior to 1955, using 1955–2005 as the youngest applicable 50-year period. Additionally, the cultural resources assessment (CRA) established a predictive model for understanding the archaeological potential over the entire WFF property.

3.3.7.1 Terrestrial

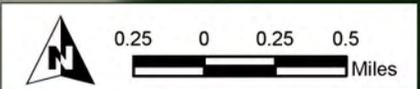
Archaeology

The CRA determined that the cultural resources at WFF consist of six archaeological sites, two of which are historic sites on Wallops Island (Figures 39 and 40); and a total of 166 structures that are at least 55 years old, 25 of which are located on Wallops Island. In a letter dated December 4, 2003, the Virginia Department of Historic Resources (VDHR) concurred with the recommendations of the CRA and VDHR accepted the predictive model for archaeology at WFF, noting that many of the areas with moderate to high archaeological potential are unlikely to be disturbed by future construction or site use.



Legend

- Existing Road
- - Existing Unpaved Road
- Existing Facilities
- - - Wallops Installation Boundary
- Archaeological Sites - Historic**
- High; High-H
- Moderate; Moderate-H



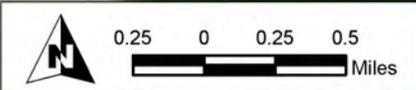
Title:	Wallops Mainland and Wallops Island Historic Archaeological Site Sensitivity
	URS Proj No: 15301785
	Figure: 39
Client : NASA	
Shoreline Restoration Environmental Impact Statement	

This page intentionally left blank.



Legend

- Existing Road
- - Existing Unpaved Road
- Existing Facilities
- - - Wallops Installation Boundary
- Archaeological Sites - Prehistoric
 - High; High-H
 - Moderate; Moderate-H



Title: Wallops Mainland and Wallops Island Prehistoric Archaeological Site Sensitivity	
	URS Proj No: 15301785
Figure: 40	
Client : NASA	
Shoreline Restoration Environmental Impact Statement	

This page intentionally left blank.

In anticipation of the need for shoreline restoration measures, NASA conducted a pedestrian survey of 6.2 km (3.85 mi) of beach/coastline on Wallops Island on September 18, 2006. The purpose of the archaeological survey was to identify any potentially significant cultural resources, including both aboveground resources, i.e., historic structures, and archaeological sites, which may contribute to knowledge of the cultural resources heritage of Accomack County. During the survey, field archaeologists searched for all significant cultural materials within the project area. No significant cultural remains or archaeological sites were discovered during this evaluation. Based upon this information, no further archaeological evaluation of the beachfront was necessary.

In anticipation of the need for slurry pits for installation of geotextile tubes, NASA conducted a limited cultural resources survey along 2.98 km (1.85 mi) of beach on January 22, 2007. This survey included a portion of beachfront that was revealed by the predictive model to have moderate potential for the presence of historic archaeological sites. During the survey, field archaeologists searched for all significant cultural materials within the geotextile tubes project area. No significant cultural remains or archaeological sites were discovered during this evaluation. An architectural historian identified and evaluated three buildings on the beach within the Area of Potential Effect (APE). The Tracking Camera Turret with Dome (WFF #Z-35, VDHR #001-0027-0122), was previously determined to be ineligible for listing in the NRHP in the *Historic Resources Survey and Eligibility Report for Wallops Flight Facility* (2004). The two other buildings—the Launch Pad Terminal Building (WFF #Z-42) and Launch Control Center (WFF #Z-40)—were evaluated and found to be ineligible for listing in the NRHP. Based upon the findings of the cultural resources survey of the APE, NASA determined no further archaeological evaluation of this beachfront was necessary and that no historic properties would be affected by the installation of the geotextile tubes. NASA submitted this determination to VDHR in a letter dated January 24, 2007 (see Appendix F). In a response letter dated January 25, 2007, VDHR concurred with NASA's determination that the proposed undertaking would have no adverse effect on historic properties and stated that no further consultation or work was required.

Aboveground Resources

Following the initial 2003 reconnaissance survey task, an intensive-level historic resource survey and historic research were conducted to develop a historic context for WFF. This context provided the necessary information with which to make NRHP eligibility determinations for the surveyed buildings and structures constructed prior to 1956. The findings were presented in the *Historic Resources Survey and Eligibility Report for Wallops Flight Facility* (NASA, 2004). The historic context developed for the report, in conjunction with field observations, served as the basis of evaluation for the buildings and structures determined to be (or soon to be) 50 years of age or older at Wallops. Of the 124 buildings assessed that pre-date 1956, 25 still exist on Wallops Island.

Two resources—the Wallops Coast Guard Lifesaving Station (VDHR #001-0027-0100; WFF# V-065) and its associated Coast Guard Observation Tower (001-0027-0101; WFF# V-070)—were determined to be eligible for listing in the NRHP and Virginia Landmarks Register (NASA, 2004). The other surveyed resources were determined not to be NRHP eligible because they lacked the historical significance or integrity necessary to convey significance.

Affected Environment

In a letter dated November 4, 2004, the VDHR concurred with the findings and determinations in the *Historic Resources Survey and Eligibility Report*, confirming that the Wallops Coast Guard Lifesaving Station is eligible for listing in the NRHP, with the Observation Tower as a contributing structure to the historic property (NASA, 2004). NASA has determined that the Wallops Coast Guard Lifesaving Station is located inside the explosive hazard arc of a nearby rocket motor storage facility and as a result, is planning the demolition or removal of the Lifesaving Station and Observation Tower. In compliance with Section 106 of the NHPA, NASA and VDHR are currently negotiating an MOA to resolve the effects of demolition or removal.

Since the 2004 report, no additional identification and evaluation of above-ground historic properties has been conducted at WFF. Accordingly, as the inventory of facilities age, there will be a need to survey buildings as they turn 50 and update the 2004 study.

3.3.7.2 Underwater

Virginia regulates and permits activities in Commonwealth waters from the shoreline out to 5.5 km (3 nautical miles [nmi]). BOEMRE regulates and permits activities within Federal waters (outside 5.5 km [3 nmi]) of the OCS for projects that would potentially disturb the sand and gravel resources on the ocean floor. NASA, however, has been designated as the lead Federal agency for Section 106 compliance.

Cultural Resources Study of Unnamed Shoal A and Unnamed Shoal B

Between March and September 2009, NASA conducted a cultural resources study within a 5.2-km² (2-mi²) block on each of the two proposed SRIPP offshore borrow sites (NASA, 2009c) (Appendix F). The primary objective of this study, which included archival research and a remote sensing survey, was to identify maritime related cultural resources, particularly submerged watercraft, and buried prehistoric sites within the two survey areas. This survey was undertaken in consultation with BOEMRE, and in accordance with guidelines established in MMS Notice to Lessee (NTL) 2005-G07 (MMS, 2005).

Survey operations were conducted from a 14 m (46 ft) research vessel, and the survey array consisted of a Hemisphere Crescent R130 Digital Global Positioning System (DGPS), a Geometrics G882 marine cesium magnetometer, an Odom Hydrotrac digital echo sounder, and a 600 kHz Marine Sonics side scan sonar system. Survey control and data quality control were achieved with Hypack's *Hypack 2009a* survey software. Magnetic and acoustic (side scan sonar, sub bottom profiler, and echo sounder) bathymetric data were reviewed during data collection for anomalies, and reviewed a second time during post-processing efforts using the *Hypack* (version 2009a) data review module and Golden Software's *Surfer* (Version 8). These software programs were used to assess the duration, amplitude, and complexity of individual magnetic disturbances, and to plot the positions of these anomalies within the survey areas to better understand spatial patterning and their association with acoustic and bathymetric anomalies.

Archaeologists maintained field notes on the locations of modern sources of ferrous material such as discarded or lost fishing equipment (clamming and crab trawls, anchors, or other jettisoned debris). Acoustic imaging data (Side scan sonar and sub bottom profiler) were reviewed for anomalous returns that could be associated with significant submerged cultural

resources. Acoustic images and magnetic contouring were checked against bathymetric data for potential correlation.

The sub bottom profiler data was reviewed in conjunction with the other remote sensing instruments in order to map out the extent of the objects encountered. The sub bottom profiler did not record any buried cultural resources or geomorphic features associated with prehistoric activities.

Sub bottom profiler data indicated that sediment patterns varied little between Unnamed Shoal A and Unnamed Shoal B; both shoals are comprised of relatively homogenous sand (similar grain sizes throughout the shoal). This sediment homogeneity has likely resulted from long term grain size sorting by currents, wave action, and large storm events. This sediment sorting has reduced the potential for these shoals to contain intact maritime cultural resources and prehistoric features.

A total of 28 magnetic anomalies and 30 acoustic anomalies (side scan sonar) were recorded during the remote sensing survey of both shoals. Unnamed Shoal A contains 18 side scan sonar anomalies and 24 magnetic anomalies, which yielded five target clusters for further analysis. Unnamed Shoal B contained 12 side scan sonar anomalies, four magnetic anomalies, and no target clusters.

The greatest amount of ferrous material was detected in Unnamed Shoal A, which is located approximately 2.4 km (1.5 mi) east of Blackfish Bank Shoal. The acoustic and magnetic anomalies on Unnamed Shoal A are consistent with debris that originated from two sources: 1) sport and commercial fishermen, who often lose anchors, chains, wire rope sections, trawls and general flotsam, and 2) barges that have transported and dropped a variety of ferrous debris to create an artificial reef on Blackfish Bank Shoal. Some of these objects have slowly migrated east and then “hung up” on the shoals, which is supported by the fact that there are far fewer anomalies at Unnamed Shoal B, which is over 3 km (2 mi) east of Unnamed Shoal A. The greater the distance from the more commonly trafficked and fished areas, the lower the number of recorded ferrous materials and acoustic anomalies.

Data analysis, when coupled with the commercial and recreational fishing that takes place at or near Unnamed Shoal A and Unnamed Shoal B, indicated that none of the detected anomalies have potential to represent significant submerged cultural resources.

Cultural Resources Study of Proposed Breakwater and Groin Locations

A cultural resources study was conducted in August 2009 to identify maritime related cultural resources, particularly submerged watercraft, and buried archaeological sites within the survey areas (Appendix G). The survey consisted of four tasks: remote sensing of the proposed breakwater location, a scientific diving survey of the proposed groin location, a pedestrian survey of the Wallops Island shoreline, and archaeological monitoring of geotextile tube installation on the shoreline. A total of 37 ha (92 ac) was evaluated during the survey efforts.

The archaeological predictive model presented in the CRA identified the potential to encounter pre-historic and historic sites on WFF (which was approved by VDHR in a letter dated December 4, 2003), including the Atlantic coast shoreline and near shore waters. This report indicated that there was a moderate potential to encounter significant historic resources on this portion of WFF.

Affected Environment

No significant cultural resources were identified during the Phase I pedestrian survey of the Wallops Island shoreline, the archaeological monitoring of geotextile tube placement, and the scientific diving survey of the proposed groin location. A total of five target groups were identified during the remote sensing survey of the proposed breakwater. These target groups consisted of magnetic or acoustic anomalies that may be potentially associated with adjacent anomalies based upon magnetic signature, duration of magnetic signal response or side scan sonar data that records an image of an anomaly in close proximity to recorded magnetic anomalies. Analysis of the target groups indicates that none of the target groups have the potential to represent significant submerged cultural resources. They instead represent debris associated with the previous structure (evidenced by wooden piling and steel cable) that was demolished or debris that was dumped at the location of the proposed breakwater. The archaeological studies undertaken for the SRIPP did not identify any significant cultural resources.

3.3.8 Environmental Justice

The goal of environmental justice from a Federal perspective is to ensure fair treatment of people of all races, cultures, and economic situations with regard to the implementation and enforcement of environmental laws and regulations, and Federal policies and programs. EO 12898, *Federal Action to Address Environmental Justice in Minority Populations and Low Income Populations*, (and the February 11, 1994, Presidential Memorandum providing additional guidance for this EO) requires Federal agencies to develop strategies for protecting minority and low-income populations from disproportionate and adverse effects of Federal programs and activities. The EO is “intended to promote non-discrimination in Federal programs substantially affecting human health and the environment.”

Accomack County is on the lower end of income measures in the region, with a 2005 median family income of \$32,837. As a result, the county is also on the higher end of poverty levels in the region based on U.S. Census Bureau data reports. The per capita income in Accomack County in 2007 was reported to be \$18,468, with an estimated 18 percent of people below the poverty level (U.S. Census Bureau, 2008a). The per capita income in the Commonwealth of Virginia in 2007 was reported to be \$28,255, with an estimated 9.9 percent of people below the poverty level statewide (U.S. Census Bureau, 2008b).

In order to ensure compliance with EO 12898, NASA prepared an Environmental Justice Implementation Plan (EJIP) in 1996. NASA evaluated the demographic information in the vicinity of WFF and identified areas that have a higher concentration of minority persons and low-income persons based on federal guidelines. The EJIP also includes an evaluation of all programs at WFF, including tenant activities that could potentially affect human health and the environment. The EJIP demonstrates that NASA will continue to incorporate environmental justice in all its activities and monitor all programs to determine any potential environmental justice impacts on persons in the area. Minority communities are defined as those exceeding a 50 percent minority population. Table 27 provides a review of Accomack County Census data used to determine the baseline for the facility’s EJIP.

Table 27: Environmental Justice Concerns – by Census Tract, Accomack County, VA

Tract	Location	Percent Minority 2000	Percent Low Income 2000	Percent Poverty 2000
9901	MD/VA line south including Fisher’s Point	1.97	51.53	12.80
9902	MD/VA line south including Wallops Island to Assawoman Inlet	41.75	49.96	16.38
9903	West of 9902 and 9904, MD/VA line south to Ann’s Cove Road	24.66	55.94	19.28
9904	East of Mears Station Road, South of 9902 south to Horseshoe Lead	59.14	51.61	27.14

Source: NASA, 2008a

As seen in Table 27, census tract 9904 is considered to be a minority community. All four census tracts are higher than state average poverty level, though only tracts 9903 and 9904 exceed the average poverty level for the county. Figure 41 shows the distribution of minority persons by census block.

Chincoteague Island, at approximately 13 km (8 mi) northeast of Wallops Island, is the closest populated area to the seaward side of Wallops Island. No minority or low-income communities exist on the portion of Chincoteague Island that lies within a 4-km (2.5-mi) radius of Wallops Island. Assateague Island has no year-round residents, as it is comprised of several protected parks controlled by Assateague Island National Seashore, Assateague State Park, and CNWR.

EO 13045, *Protection of Children from Environmental Health Risks and Safety Risks*, encourages Federal agencies to consider the potential effects of Federal policies, programs, and activities on children. The closest day care centers, schools, camps, nursing homes, and hospitals are addressed within the EJIP.

No nursing homes, hospitals, or schools are located near WFF. The closest hospital, McCready Memorial Hospital in Crisfield, MD, is located approximately 32 km (20 mi) northwest of Wallops Island. One public campground, Trail’s End, is located approximately 13 km (8 mi) northwest of the Wallops Island launch pads. One day care center, Emma’s World Daycare & Preschool, is located approximately 9 km (5.5 mi) northwest of central Wallops Island. The closest schools are: Arcadia High School, located approximately 10 km (6 mi) northwest of central Wallops Island, and Kegotank Elementary School, located 6 km (4 mi) west of central Wallops Island.

3.3.9 Transportation

3.3.9.1 Land-Based

The Eastern Shore of Virginia is connected to the rest of the State by the Chesapeake Bay Bridge-Tunnel. The primary north-south route that spans the Delmarva Peninsula is U.S. Route 13, a four-lane divided highway. Local traffic travels by arteries branching off U.S. Route 13.

Affected Environment

Activities at Wallops Island and Wallops Mainland generate traffic along Route 803. Primary access to WFF is provided by Route 175, a two-lane secondary road. Traffic in the region varies with the seasons. During the winter and early spring, traffic is minimal; during the summer and early fall, traffic increases due to the number of tourists in the area.

Wallops Main Base and Wallops Mainland are connected by approximately 10 km (6 mi) of the paved, two-lane Route 679. A NASA-owned road, bridge, and causeway link Wallops Mainland to Wallops Island. Hard surface roads provide access to most buildings at WFF and are maintained by NASA and its tenants. Most organizations at WFF own and maintain a variety of vehicles ranging from sedans and vans to trucks. There is no public transportation on the facility. Many WFF employees carpool to and from the facility.

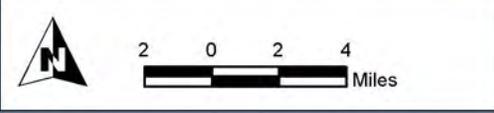
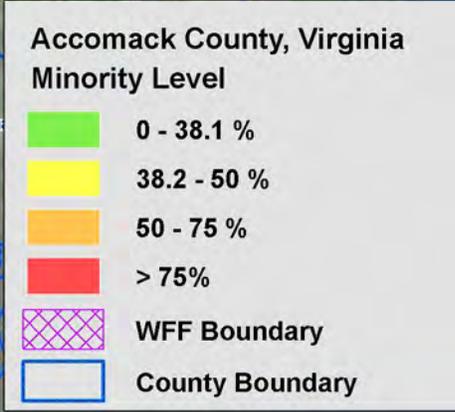
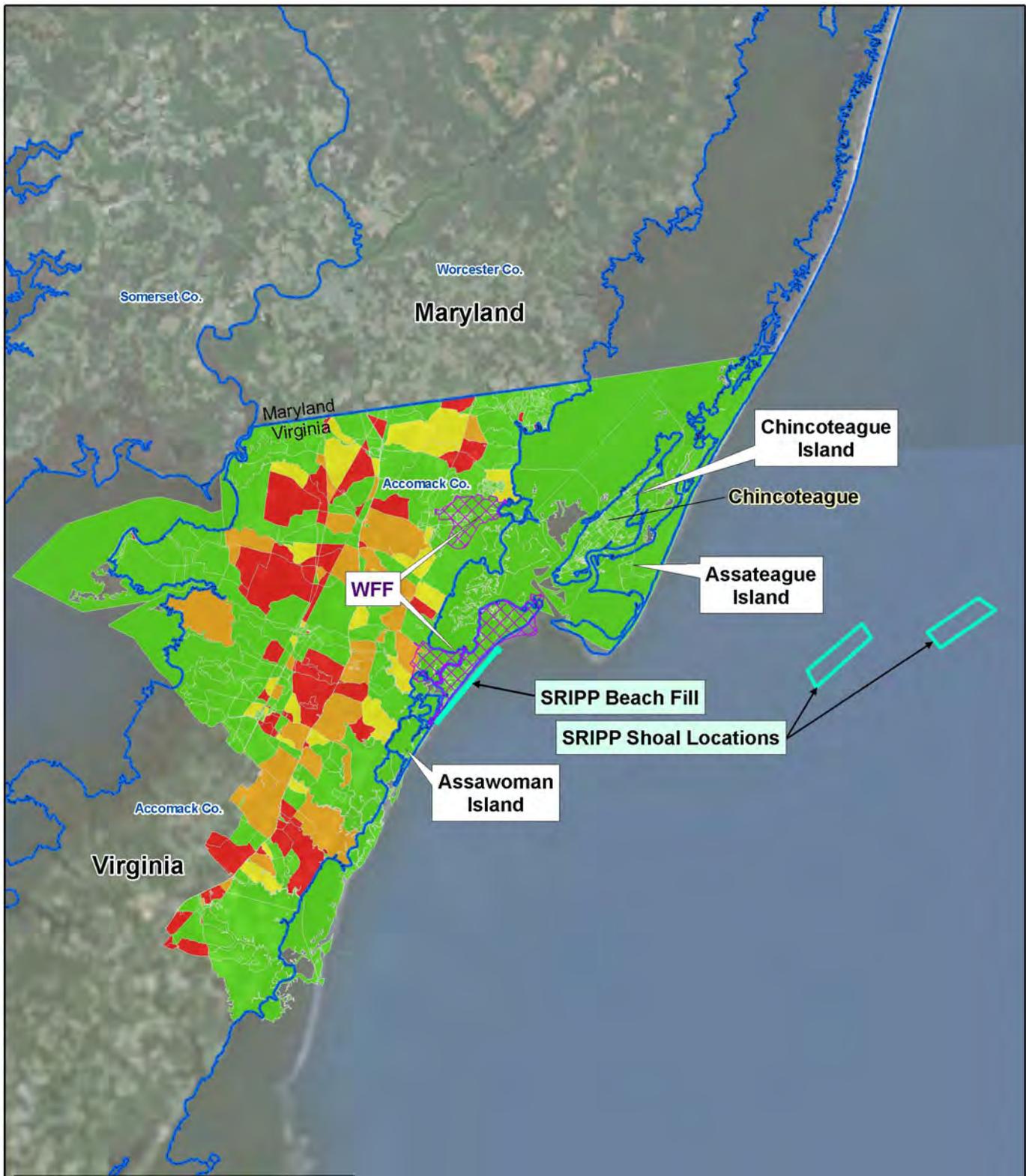
Commercial air service to the area is provided through the Norfolk International Airport, about 145 km (90 mi) to the south, and the Salisbury Regional Airport, about 64 km (40 mi) to the north. Air service is also available approximately 40 km (25 mi) south of WFF through the Accomack County Airport in Melfa, which normally provides flights during daylight hours. Surface transportation from the airports to WFF is by private rental vehicles, government vehicles, and commercial bus or taxi. In addition, ground transportation to the Salisbury Airport is occasionally provided by a WFF Shuttle Bus for WFF employees. Chartered and private aircraft that have the appropriate clearance may land at the WFF Airport for business purposes. Air-freight services are available from the Salisbury Regional Airport.

Rail freight service is provided to the Delmarva Peninsula by Bay Coast Railroad, although no rail freight service is available directly to WFF. The closest railhead to WFF (and typically the one most frequently used for unloading cargo) is the LeCato site in New Church, approximately 11 km (7 miles) to the southwest of WFF. Cargo transported to the area by rail is offloaded and hauled over-the-road to its ultimate destination at WFF. No rail passenger service is available to WFF. Eleven motor freight carriers that serve the eastern United States are authorized to provide service to the Accomack-Northampton District, and therefore, WFF.

3.3.9.2 *Maritime*

Commercial, recreational, and military maritime traffic all use the area off the coast of Virginia, one of the busiest areas in the world for maritime traffic. Traffic Separation Schemes (TSSs), specified in 33 CFR, are one-way ship traffic lanes marked by buoys. The purpose of the TSS system is to prevent vessels from striking each other. The nearest TSS lanes to the project area are the southernmost approaches of the Delaware Bay, which are approximately 44 miles north of Unnamed Shoal B, and the northernmost lanes of the Chesapeake Bay approach, which are approximately 65 miles south of Blackfish Bank Shoal. The triangle-shaped Wallops Island Approach Zone is found at the mouth of the Chincoteague Inlet. This zone is designated to encourage boaters to exercise caution while entering and exiting the Inlet, a popular waterway for recreational and fishing boats.

In addition, the USCG designates Regulated Navigation Areas (RNAs) to control vessel traffic by specifying times of vessel entry, movement, or departure to, from, within, or through ports, harbors, or other waters. The closest RNA to the project area is in the Chesapeake Bay Entrance, near Hampton Roads, VA; the SRIPP study area is also outside of this RNA. A Private Aid to Navigation (PATON) permit would need to be obtained from the USCG to place temporary buoys for dredging activities (USCG, 2009b).



Title: Minority Persons by Census Block Accomack County, Virginia	
	URS Proj No: 15301875
	Figure: 41
Client : NASA	
Shoreline Restoration Environmental Impact Statement	

This page intentionally left blank.

Military and Government Traffic

The VACAPES is the location of maritime combat testing and training for the Navy. This 94,875 km² (27,661 square nautical miles [nmi²]) area of the Atlantic Ocean extends from Rehoboth Beach, DE, to Cape Fear, NC. The boundary starts 6 km (3 nmi) off the coast and terminates approximately 278 km (150 nmi) east in certain areas. The Navy also harbors approximately 67 vessels in the Port of Virginia, located in Norfolk, up to 10 of which are typically operating in the VACAPES area on any given day. These vessels include submarines and surface vessels like aircraft carriers. However, the submarine transit lanes are over 111 km (60 nmi) southeast of the Chincoteague Shoals area. Operations involving the use of the surface vessels vary widely, from several hours up to two weeks (U.S. Department of the Navy, 2009). Data from a study conducted by R.J. Filadelfo for the Center for Naval Analyses from February 2000 to January 2001 reported that the total number of Navy ships on the east coast within 370 km (200 nmi) was 12 at any given time (NOAA/NMFS, 2008). In addition to the Navy, USACE and USCG vessels are regularly found in the SRIPP study area (NOAA/NMFS, 2008). The USCG issues periodic notices to mariners regarding information about navigation, hazards to navigation, and navigational safety, which can be obtained on their Web site.

Commercial Traffic

Numerous small harbors are located throughout Accomack and Northampton Counties, which are used primarily for commercial and recreational boats. Commercial ocean cargo shipments are typically offloaded at the Port of Baltimore, MD, or Cape Charles, VA, and transferred to commercial trucks or rail for transport to WFF. A sea-based option also exists, utilizing Chincoteague Inlet and offloading cargo at one of two boat docks at WFF (one on Wallops Main Base and one on the north end of Wallops Island). Commercial cargo, container ships, and tankers pass by the Virginia barrier islands daily en route to destinations such as the Port of Baltimore, MD, and the Port of Virginia.

From February, 2000 to January, 2001, commercial traffic density averaged about 202 ships within 93 km (50 nmi) of the coast, and increased to 266 ships within 100 nmi, and 358 ships within 370 km (200 nmi). In terms of spatial distribution, commercial ship traffic is relatively uniform along the coast, with certain concentrations around major port areas (Filadelfo, 2001).

Recreational Traffic

Fishing and recreational boating traffic occurs throughout the SRIPP study area in the inlets of Wallops and Assateague Islands, and at offshore shoals and artificial reefs year round. However, the majority of recreational and fishing traffic occurs in the spring and summer.

In April and May 2009, guides and recreational fishermen in Chincoteague, Wachapreague, and Ocean City were surveyed to assess their use of the SRIPP project area, and were asked to indicate if they utilized Wallops Island shoreline, Blackfish Bank Shoal (located 11 km [7 mi] from the Wallops Island shoreline), Unnamed Shoal A (15 km [10 mi] offshore), or any combination of the above, for commercial, recreational, or guided fishing (NASA, 2009d). At the time of the survey, Unnamed Shoal B (21 km [13 mi] offshore) had not been identified as a potential SRIPP borrow site, so no data for it was collected in this survey. Of the 66 surveys that were collected, 14 respondents indicated that they used Unnamed Shoal A for recreational

Affected Environment

fishing and/or guide use. Twenty-one of the respondents indicated that they used the Wallops Island shoreline for recreational fishing and/or guide use.

The VDEQ's 161 km (100 mi) long Seaside Water Trail runs between the Eastern Shore of Virginia National Wildlife Refuge at Cape Charles and Chincoteague Island. The trail is utilized by recreational boaters and kayakers. The "Wisharts Point Landing to Curtis Merritt Harbor" leg of the trail is approximately 11 km (7 mi) long and originates on the western shore of Bogue's Bay, crosses Chincoteague Inlet, and ends on the southern tip of Assateague Island.

Chincoteague Inlet, located between Assateague Island and Wallops Island, is considered to be the most trafficked natural inlet by both commercial and recreational fishing boats on the Atlantic coast (The Local Fisherman, 2009).

CHAPTER FOUR: ENVIRONMENTAL CONSEQUENCES

4.1 INTRODUCTION

Chapter 4 presents the potential impacts on existing resources described in Chapter 3 that may result from the alternatives described in Chapter 2. This chapter contains discussions on potential impacts on resources under the three main categories of Physical Environment, Biological Environment, and Social and Economic Environment.

Chapter 4 focuses on addressing the type, context, intensity, and duration of the project-related environmental impacts for each resource area included in this PEIS. The impacts can be described in different ways including:

- Type (beneficial or adverse)
- Context (site-specific, local, or regional)
- Intensity (negligible, minor, moderate, or substantial)
- Duration (short- or long-term)

The levels of impacts and their specific definitions vary based on the resource that is being evaluated. For example, the scale at which an impact may occur (local, regional, etc.) would be different for wetland impacts as compared to economic resources.

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).

Additionally, mitigation measures that would reduce the potential for an impact are identified in Chapter 5.

4.2 PHYSICAL ENVIRONMENT

4.2.1 Bathymetry

No Action Alternative

Under the No Action Alternative, the SRIPP would not be implemented; however, maintenance activities and emergency repairs such as hauling in additional rock to add to the existing seawall, hauling and placing sand on the beach or behind the existing seawall or geotextile tubes, installing sheet piling in or near the high tide level, or emergency geotextile tube installation would occur. Sand would only come from upland sources, so no impacts on bathymetry would occur as a result of emergency and maintenance activities. Due to the dynamic nature of offshore environments, bathymetry would continue to change in response to physical processes such as waves, wind, and tides. Water depths immediately seaward of the existing seawall may increase due to wave reflection and continued undermining of the seawall. Direct adverse effects on the bathymetry in the area immediately east of the seawall would continue.

Environmental Consequences

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

The extension of the existing rock seawall would limit shoreline retreat along the additional 1,400 m (4,600 ft) of the extension. During Year 1 of the SRIPP, the seawall extension without beach fill would result in direct impacts on nearshore bathymetry by fixing the shoreline position and preventing natural maintenance of beach and nearshore slopes (effectively resulting in lowering of the bathymetric profile). In Year 2 when beach fill is placed (sand placement would first occur in the area of the new seawall extension), the nearshore bathymetric profile would be raised, reversing the impacts of the seawall extension from Year 1. The bathymetric profile after the initial beach fill would extend seaward underwater for an additional 52 m (170 ft) (Figure 16) from the newly constructed beach. Direct long-term beneficial impacts on bathymetry in the nearshore environment east of Wallops Island would occur by restoring a beach profile at the shoreline.

Dredging activities would result in direct long-term changes to the bathymetry of the selected offshore borrow site. The crest of Unnamed Shoal A is approximately 8 m (25 ft) below MSL with the adjacent troughs approximately 20 m (70 ft) below MSL. The crest of Unnamed Shoal B is approximately 9 m (30 ft) deep (see Figures 23-25). Dredging would be conducted in a manner to remove a uniform thickness of material from the chosen borrow area. Dredging could deepen parts of the shoal within the proposed borrow area by approximately 3 m (10 ft) during each dredging event (dredging for initial fill and each renourishment cycles).

CSA International et al. (2009) and Dibajnia and Nairn (*in press*) provided an evaluation of the potential effects of dredging on shoals in the mid-Atlantic. After removal of material from a shoal, the shoal would reform itself with a smaller volume of sand. For shoals in water deeper than 10 m (33 ft), the volume removed by dredging is not compensated by the material outside the shoal. The reformed shoal may attain the same height as that of the pre-dredge shoal under certain dredging scenarios based on the volume extracted and local hydrodynamic conditions. There is no indication that there is a critical threshold for dredging that once exceeded, ridge and shoal features deflate and lose their morphologic integrity (CSA International, Inc. et al., 2010; Dibajnia and Nairn, *in press*).

Within the borrow area, dredging would remove sediment at least several meters deep, therefore increasing the water depths. Dredging may occur once in a given area of a shoal or multiple times. The area impacted within the borrow site during a typical renourishment event would depend on the volume of sand needed and the thickness of material dredged. Although the limits of the offshore shoals are difficult to define, NASA estimates that the proposed 5.2 km² (2 mi²) borrow site area covers approximately 70 percent of the total surface area of Unnamed Shoal A. The proposed 5.2 km² (2 mi²) borrow area covers approximately 33 percent of the total surface area of Unnamed Shoal B. Therefore, the SRIPP would result in direct, long-term impacts on the bathymetry at either of the shoals.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

For the seawall construction and beach fill, impacts would be the same as those described under Alternative One. The construction of a groin structure would result in long-term site-specific changes to bathymetry at the construction site. Indirect impacts resulting from changes to the physical oceanographic processes due to the groin structure are anticipated and are discussed in Sections 4.2.2.1 and 4.2.3.4. The impacts of dredging activities under Alternative Two are the same as those described under Alternative One.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

For the seawall construction and beach fill, impacts would be the same as those described under Alternative One. The construction of a nearshore breakwater structure would result in long-term site-specific changes to bathymetry at the construction site. Additional changes may occur in the nearshore bathymetry due to movement of finer sand transported from the newly placed beach fill through tidal wave action. Impacts on sediment transport from the construction of the breakwater structure would occur and are discussed in Sections 4.2.2.1 and 4.2.3.4. The impacts of dredging activities under Alternative Three are the same as those described under Alternative One.

4.2.2 Geology and Geomorphology

4.2.2.1 Virginia Barrier Island System

No Action Alternative

Under the No Action Alternative, the SRIPP would not be implemented, but emergency measures may still be implemented to protect at-risk infrastructure. Impacts on sediments, including compaction and displacement, would be caused by the equipment used to reach facilities to perform emergency operations. In addition, without a beach to provide a source of sand, the island’s ability to create and maintain natural dunes is limited. As mentioned in Chapter 2, emergency measures could include hauling in additional rock to add to the existing seawall, hauling and placing sand on the beach or behind the existing seawall or geotextile tubes, installing sheet piling in or near the high-tide level, or emergency geotextile tube installation, which would result in changes to topography and effect shoreline processes at Wallops Island.

Erosion of the shoreline south of the end of the existing seawall would continue. Using the 2005 LiDAR-mapped shoreline, USACE used GENESIS to estimate the amount of shoreline erosion that would occur at Assawoman Inlet if the SRIPP was not implemented. The results are based on 10 years of estimates. The USACE modeling predicted that between 2.8 m (9.3 ft) and 3.4 m (11.3 ft) per year of the shoreline south of the seawall (no loss of the shore would occur north because there is no beach) at Assawoman Inlet would be eroded (Appendix A). Table 28 shows results of USACE GENESIS modeling that estimated volumes of erosion within an area 3.2 km (2 mi) south of the existing seawall in one year, two years, and 10 years; the 95 percent confidence limits are shown along with the average erosion volumes. The values shown in Table 27 are not gross or net sediment transport rates, rather they represent the amount of sediment eroded, or lost, within the geographic region modeled (between the existing southern end of the seawall on Wallops Island and 3.2 km [2 mi] south of the southern end of the seawall).

Table 28: Erosion Volumes South of Existing Seawall

	Minimum¹	Average	Maximum
1 year	55,000 m ³ (72,000 yd ³)	73,000 m ³ (96,000 yd ³)	92,000 m ³ (120,000 yd ³)
2 years	116,000 m ³ (152,000 yd ³)	143,000 m ³ (187,000 yd ³)	170,000 m ³ (223,000 yd ³)
10 years	617,000 m ³ (807,000 yd ³)	680,000 m ³ (889,000 yd ³)	742,000 m ³ (970,000 yd ³)

¹The minimum and maximum values represent the 95 percent confidence interval

Environmental Consequences

Continual loss of the shoreline south of the seawall would result in critical infrastructure on Wallops Island remaining at-risk from storm damages. Because the central portion of Wallops Island does not currently contain a beach, the no further erosion would occur but the seawall would be exposed to on-going storms and would need periodic maintenance and repair. The northern part of Assawoman would continue to experience erosion.

Existing and previous structures, such as groins and the seawall, have been implemented to reduce shoreline retreat on Wallops Island and have disturbed the natural sediment transport processes. These structures limited shoreline retreat, but have also resulted in the complete erosion of the beach seaward of the seawall and prevented long-term natural maintenance of the gently sloping nearshore and beach systems that would have existed under natural conditions. These structures have also prevented overwash processes from occurring, which serve to maintain beach and dune systems. Continuing to prevent the beach and dune system from responding to changing conditions would likely result in the loss of surface area on the landward side of Wallops Island, resulting in island narrowing as the sea level rises, although the timescale over which this would occur is uncertain.

As discussed in the existing conditions of Chapter 3, the shoreline in the vicinity of Wallops Island is not in a state of static equilibrium, and based on past trends of sediment transport and erosion in the region, it is reasonable to assume that substantial changes would continue to occur. The changes that would occur under the No Action Alternative would be the same as those described for the existing conditions in Section 3.1.4.3.

Effects of Sea-Level Rise

For coastal engineering projects, including the SRIPP, prediction of sea-level rise is a necessary component of the project design. The anticipated sea-level rise at Wallops Island and surrounding areas was calculated using USACE guidelines (USACE, 2009d). The guidelines recommend that projects take into account three different methods to include the possibility of sea-level rise: 1) adaptive management, which allows for future modifications to the project after the effects of sea-level rise can be confirmed; 2) facilitating future modifications, which means that projects will be designed for the current sea level, but are still adaptable to future rises; and 3) design for the future, which means that the current project is also designed based on an estimate of future sea levels (NRC, 1987).

Available data on global and relative MSL trends, the effect of existing infrastructure, LiDAR-mapped topography, and computer modeling were all examined. These data were used to calculate the range of water level rise in the SRIPP project area, which is estimated to be between 0.25 m (0.84 ft) and 0.78 m (2.53 ft) during the 50-year life span of the SRIPP (USACE, 2010a). This range of sea-level rise values determined by USACE is attributed to the low and high scenarios from the three plausible variations in eustatic sea level to the year 2100 (NRC, 1987). See Appendix A for more detailed information on the methodology the USACE used to calculate sea-level rise values.

Sea-level rise is anticipated to increase the vulnerability of Wallops Island shoreline to storms by contributing to shoreline erosion. When a beach area is eroded, it no longer functions as effectively in protecting inland areas from the waves and flooding associated with storms. In their 1991 report to Congress, FEMA estimated that U.S. Coastal Zones would experience a 36-58 percent increase in annual damages for a 0.3 m (1 ft) rise in sea level, and a 102-200 percent increase for a 0.9 m (3 ft) rise (FEMA, 1991). In addition, according to a study by Komar and

Allan (2008), wave height has gradually increased over a 30-year period, which is believed to be associated with the rise in frequency and intensification of hurricanes due to climate change. Therefore, the Wallops Island shoreline will be even more acutely affected by wave overtopping and flooding associated with storm events.

Sea-level rise will likely reduce the rate of southwesterly growth of Fishing Point and the accretion on the north end of Wallops Island (USACE, 2010a). It may cause any shoreline breaches in the Tom's Cove area to be more likely and more frequent. The shoreline that is "fixed" by the seawall would become increasingly underwater due to rising sea levels.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

Sand Placement and Seawall Extension

Implementation of the beach fill component would result in significant changes to the Wallops Island shoreline. The initial beach fill would extend the existing shoreline a total distance of 73 m (240 ft) (Figure 16) to the underwater seaward extent of the fill, 21 m (70 ft) of which would be the aboveground beach. The initial beach fill would create a beach profile with a 1.8-m-high (6-ft-high) berm and a 4.3-m-high (14-ft-high) dune at the seawall (Figure 16). Because there is no beach along the 6.0-km (3.7-mi) fill area proposed under the SRIPP, the Proposed Action would result in elevating the sediments along the Wallops Island shoreline between the northern end of the rock seawall and the southern end of the existing geotextile tubes. The renourishment fills would restore the shoreline to the same position that would exist after the initial fill is completed.

Beach nourishment would be done so that the beach is restored to a comparable sediment type (a similar percentage of sand, silt, and clay), grain size, and color as the existing beach material. Between renourishment cycles, beach fill sand would erode as part of the dynamic nature of the ocean environment. The frequency of beach renourishment cycles may vary depending on the severity and frequency of storm events.

Because of the height of the dune and seawall, the beach fill and seawall extension would continue to prevent overwash processes from occurring on Wallops Island, which would likely result in the loss of surface area on the landward side of Wallops Island and island narrowing as the sea level rises, although the timescale over which this would occur is uncertain.

Construction activities related to the seawall extension would disturb surface sediments on the beach. 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.

The seawall extension would serve as a last line of defense to protect critical infrastructure if the fill placed seaward of the seawall were to be eroded. The existing seawall and proposed extension would result in a "fixed" shoreline if the sand seaward of it were to completely erode.

Impacts on the Shoreline from Seawall Extension

The fact that sand behind the seawall extension would be retained instead of eroded (erosion in the area of the seawall extension would occur under No Action Alternative) would lead to the potential to exacerbate the erosion on the adjacent shoreline south of the extension. The USACE

Environmental Consequences

conducted modeling (methodology discussed under the No Action Alternative of this section) to estimate the potential effects of the seawall extension on the 3.2 km (2 mi) stretch of shoreline south of the existing seawall during the period of time after the extension is constructed and before the beach fill occurs (i.e., SRIPP Years 1 and 2). The USACE also modeled the erosion of this area 10 years after construction of the extension assuming no beach fill were to occur, to estimate potential impacts from a worst-case scenario.

NASA is committed to the implementation schedule shown in Table 9 with the seawall construction occurring in Year 1 and the initial beach fill starting in Year 2. However, the modeling also looked at the effect of delays in implementation of the beach fill after a seawall extension was constructed. While any delay is unlikely, if one were to occur, it would most likely mean that there was a 2-year time period between seawall extension construction and beach fill placement. Longer delays, which would be a worst-case scenario, were assessed as a 10-year period between seawall construction and beach fill placement. Therefore, the modeling looked at 1-year, 2-year, and 10-year shoreline impacts.

The USACE modeling predicted that after construction of the 1,400-m (4,600-ft) seawall extension, between 3.0 m (9.7 ft) and 4.2 m (13.7 ft) per year of the shoreline at Assawoman Inlet would be eroded over a 10-year period assuming no beach fill were to occur (Appendix A). Table 29 shows that the average shoreline change rate (negative values indicate erosion) at Assawoman Inlet attributed to construction of the seawall would be less than the variability in the change rate caused by yearly changes in the wave climate; stormy years are expected to cause greater shoreline change than the seawall extension in years of normal waves. It is expected that any negative impacts would be mitigated following beach fill placement.

Table 29: Average Shoreline Change Rate at Assawoman Inlet

	Total Shoreline Change Rate meters (feet)/year			Shoreline Change Rate Attributed to Seawall Construction meters (feet)/year		
	Minimum	Average	Maximum	Minimum	Average	Maximum
No Seawall Extension (No Action Alternative)	-2.8 (-9.3)	-3.1 (-10.3)	-3.4 (-11.3)	n/a	n/a	n/a
Seawall Extension	-3.0 (-9.7)	-3.6 (-11.7)	-4.2 (-13.7)	-0.03 (-0.1)	-0.4 (-1.4)	-0.8 (-2.7)

Table 30 shows results of USACE GENESIS modeling that estimated volumes of erosion within an area 3.2 km (2 mi) south of the existing seawall in one year, two years, and 10 years after construction of the 1,400 m (4,600 ft) seawall extension; the 95 percent confidence limits are shown along with the average erosion volumes. The values shown in Table 30 are not gross or net sediment transport rates, rather they represent the amount of sediment eroded, or lost, within the geographic region modeled (between the existing southern end of the seawall on Wallops Island and 3.2 km [2 mi] south of the southern end of the seawall). The No Action Alternative is provided in Table 30 for comparison.

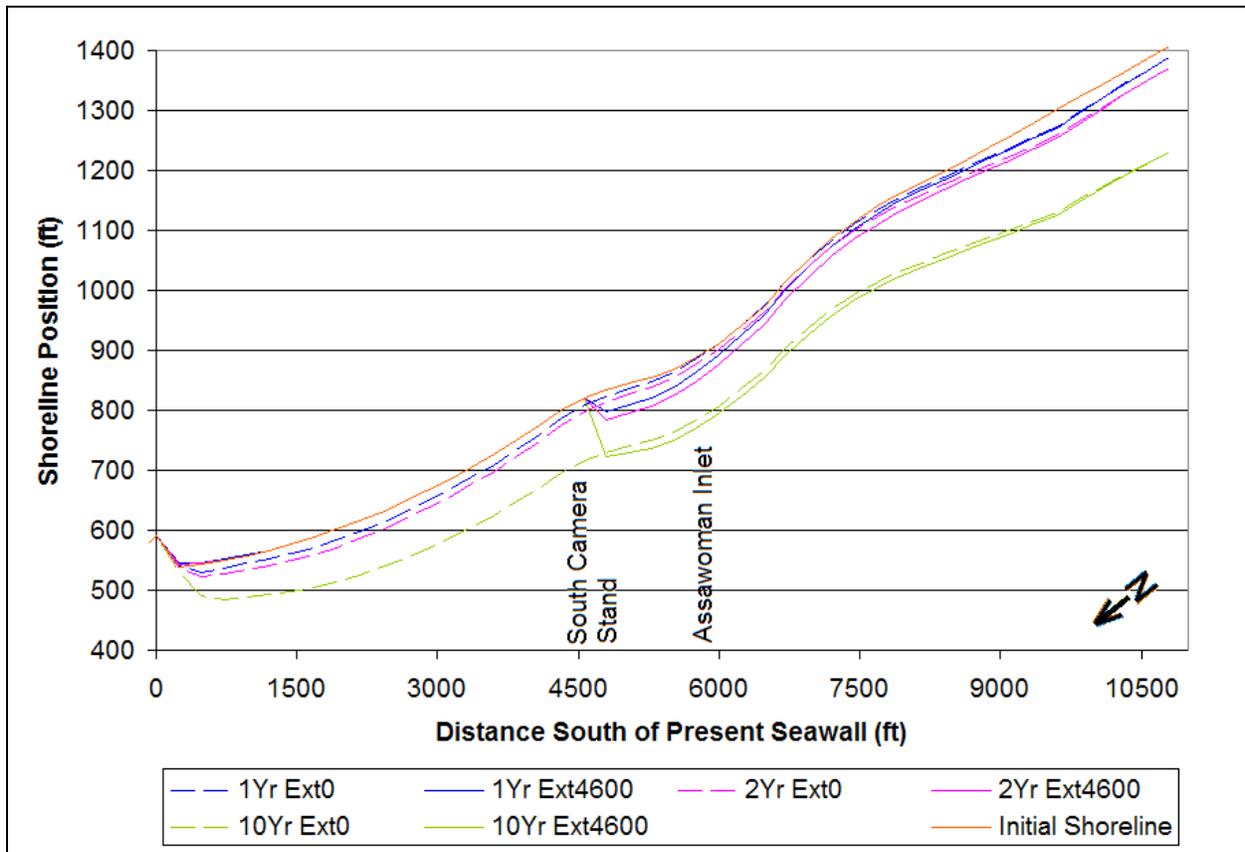
Table 30: Erosion Volumes South of Existing Seawall

		Proposed Action Alternatives	No Action Alternative
1 year	Minimum ¹	50,000 m ³ (66,000 yd ³)	55,000 m ³ (72,000 yd ³)
	Average	68,000 m ³ (89,000 yd ³)	73,000 m ³ (96,000 yd ³)
	Maximum	86,000 m ³ (113,000 yd ³)	92,000 m ³ (120,000 yd ³)
2 years	Minimum	102,000 m ³ (134,000 yd ³)	116,000 m ³ (152,000 yd ³)
	Average	126,000 m ³ (165,000 yd ³)	143,000 m ³ (187,000 yd ³)
	Maximum	151,000 m ³ (197,000 yd ³)	170,000 m ³ (223,000 yd ³)
10 years ²	Minimum	452,000 m ³ (591,000 yd ³)	617,000 m ³ (807,000 yd ³)
	Average	493,000 m ³ (645,000 yd ³)	680,000 m ³ (889,000 yd ³)
	Maximum	534,000 m ³ (699,000 yd ³)	742,000 m ³ (970,000 yd ³)

¹The minimum and maximum values represent the 95 percent confidence interval

²Assumes no beach fill would occur to estimate potential impacts of a worst-case scenario

Figure 42 shows model predictions of shoreline positions for the portion of the GENESIS grid that is south of the existing seawall, a distance of about 3.2 km (2 mi). Each shoreline is an average of the results of 20 model runs that were driven with the 20 different 4-year wave blocks discussed in Chapter 3. To minimize clutter, the 95 percent confidence interval shorelines are not included in these figures.



Source: USACE, 2010a

Figure 42: Shoreline Positions in Response to Seawall Extension without Beach Fill

During this interim period before the beach fill is completed (SRIPP Year 1 and part of Year 2), direct short-term adverse impacts on the Wallops Island and Assawoman Island shorelines would occur from construction of the seawall extension. Construction of the seawall extension would prevent erosion of sand on its landward side, thereby resulting in lower erosion volumes when compared to the No Action Alternative (Table 30). However, the seawall extension would reduce the amount of sand eroding from Wallops Island and thereby added into the longshore sediment transport system.

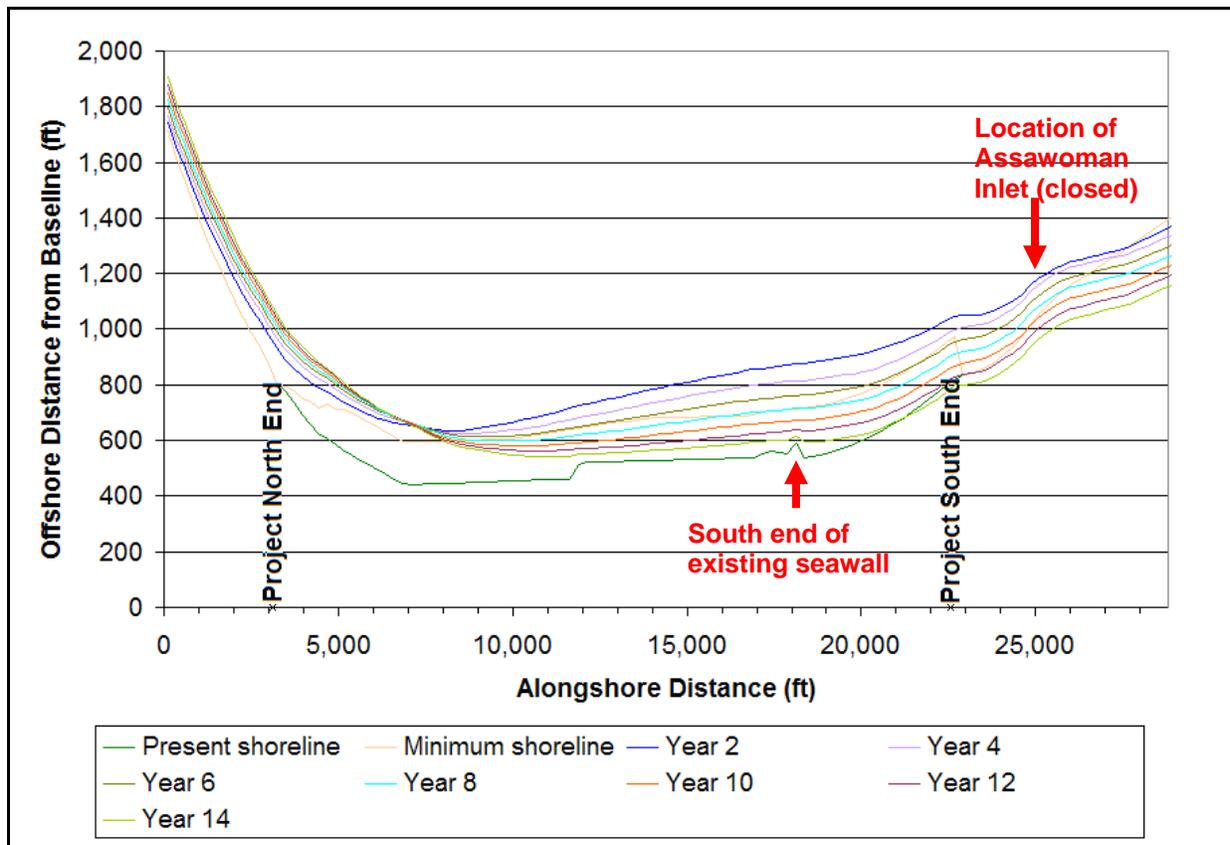
Once the beach fill is completed, some of the beach fill material would pass to the south, which would help alleviate the erosion problem on Assawoman Island. The majority is expected to pass to the north and accumulate on the north end of Wallops Island.

Therefore, the short-term adverse impacts during Year 1 would be mitigated in the long-term and beneficial impacts on Wallops Island, Assawoman Island, and potentially other islands to the south would occur from the addition of sand to the longshore sediment transport system.

Impacts on the Shoreline from Beach Fill

Figure 43 shows the estimated shoreline positions from at Year 2 to Year 14. Though it is intended that renourishment should occur at the end of Year 5, the USACE analysis was carried out to Year 14 without renourishment to help determine if adverse impacts occur to adjacent beaches if renourishment intervals are postponed or cancelled. Figure 43 shows that by Year 4,

in many places the shoreline has retreated to near the minimum shoreline for storm damage protection, and thus, this is intended to be shortly before renourishment. By Year 12, the entire initial fill has been removed from the south end of the project; however, by Year 14, there is still fill in front of the seawall.



Source: USACE, 2010a

Figure 43: Shoreline Positions over Time for Alternative One

In summary, under Alternative One, the rate of erosion on the southern end of Wallops Island and the northern end of Assawoman Island would be reduced due to additional sand available for transport after beach fill is completed. Because the nodal zone of longshore sediment transport is located in the vicinity of the southern end of Wallops Island, in any given year, sediment that is placed on the beach would be dislodged and transported south, potentially being deposited on Assawoman Island and other barrier islands to the south. However, due to the uncertainty of the nodal zone, the sediment that is placed on the beach could also be transported primarily north in any given year.

Over the lifetime of the SRIPP, the seawall extension and beach fill would have long-term direct beneficial impacts on geology and the Wallops Island shoreline by mitigating the current rate of shoreline retreat. Continued beach nourishment would add to this benefit by providing ongoing mitigation of shoreline retreat.

Growth of the Southern Tip of Fishing Point

The SRIPP would not affect the sediment transport processes that will continue to cause changes at Fishing Point. The influx of sediment supply from beach fill operations may affect inlet

Environmental Consequences

dynamics, which in turn may affect sediment transport processes along the westward tip of Fishing Point. The growth of the southern tip of Fishing Point would be the same as predicted for existing conditions (discussed under Section 3.1.4.3).

Narrowing of the Tom's Cove Isthmus

The SRIPP would not affect the sediment transport processes that will continue to create the changes at Tom's Cove Isthmus. The isthmus separating Tom's Cove from the Atlantic Ocean is narrowing primarily because the Atlantic Ocean shoreline is eroding. This is expected to continue whether offshore shoals proposed under the SRIPP are dredged or not. The USACE modeling results indicated that mining either Unnamed Shoal A or B would not produce significant changes compared with the current conditions. Furthermore, dredging Unnamed Shoal A (the preferred source for the initial fill) would produce the fewest changes in the Tom's Cove area. The changes and impacts on Tom's Cove Isthmus would be the same as those predicted for the existing conditions (discussed under Section 3.1.4.3).

Changes in Wallops Island Shoreline Orientation and Chincoteague Inlet Migration

The northern end of Wallops Island is currently accreting rapidly due to sediment being delivered there from two directions: 1) north along the Wallops Island shoreline, and 2) by the westward drift of Chincoteague Inlet ebb shoals. Over the short term, sediment may be stored in swash bars, the ebb tidal delta, or the ebb/flood tidal ramp. Over the long term, it is probable that the sediment will be carried into Chincoteague Inlet by tidal currents and sequestered in flood shoals. This mechanism will act to slow down the rate of sediment accumulation that would otherwise occur on northern Wallops Island.

With implementation of the SRIPP, the northern end of Wallops Island would continue to accrete, and would likely accrete at a faster rate than under existing conditions due to the presence of additional sand in the longshore sediment transport system from the beach fill.

The sediment accumulation on north Wallops Island may tend to push Chincoteague Inlet to the east, which appears to already be occurring as documented on recent aerial photographs of the western tip of Assateague Island. However, future Chincoteague Inlet locations can be strongly affected by USACE dredging decisions, and whether attempts are made to maintain the inlet channel in a fixed location or to dredge whatever is found to be the current channel location. The sediment accumulation on north Wallops Island is changing the current north-south shoreline orientation to one that is much more east-west. The amount of material proposed to be mined from the north end of Wallops Island is intended to be equal to the excess that is being deposited there. This is expected to help stabilize the location of Chincoteague Inlet and is not expected to provide a force that helps shift the inlet to the west. While it is recognized that inlets are dynamic features, removal of this sand is expected to (if anything) help stabilize the inlet.

Effects of Sea-Level Rise

Impacts on Fishing Point and the accretion on the north end of Wallops Island and the Tom's Cove area due to sea-level rise would be the same as those described under the No Action Alternative. The SRIPP would help to protect Wallops Island infrastructure from the effects of sea-level rise by providing additional shoreline and a newly constructed 4.3-m-high (14-ft-high) dune along the proposed beach fill. The USACE accounted for sea-level rise in this project by including an additional amount of material at each renourishment event that would raise the entire fill profile by an amount equal to the projected amount of sea-level rise (USACE, 2010a). This additional volume is shown on Figure 16 in blue. See the discussion under the No Action

Alternative within this section [Section 4.2.2.1] for more information on the methodology and predicted rates used by USACE for the characterization of sea-level rise.

Dredging Offshore Borrow Sites

Impacts on the Proposed Shoals

Impacts on Unnamed Shoal A and Unnamed Shoal B are discussed in Section 4.2.2.2, Offshore Sand Shoals, below.

Impacts on Assateague Island

As material is removed from a shoal and the water depth changes, the resulting change in wave refraction can significantly affect the longshore sediment transport on adjacent beaches. The USACE followed MMS (2001) guidelines to model the potential impacts on the Assateague Island shoreline through the use of STWAVE (STeady-state spectral WAVE model) and the CERC (Coastal Engineering Research Center) sediment transport formula (USACE, 2010a). STWAVE is a wave refraction model used to transform representative offshore waves to a near-breaking depth. The refracted wave data were then used in the CERC formula to calculate sediment transport rates along the shoreline (within individual grid points). Bathymetry data used in the STWAVE model were obtained from the National Ocean Survey hydrographic surveys that are available in electronic format from the Geophysical Data System (version 4.0) developed by the National Geophysical Data Center. Bathymetric surveys collected in the 1960s through the 1990s were used where available, with earlier survey data used to fill gaps in the more recent bathymetry coverage.

The results of the modeling effort were used to compare existing conditions to post-dredging conditions and determine if a significant change in longshore sediment transport rates, and thus potential impacts on the Assateague Island shoreline, would occur. A summary of the USACE modeling effort and results are discussed below.

The borrow sites would be dredged several times to supply material for the initial beach nourishment and each of the renourishment cycles. The greatest potential for change in wave refraction would occur once the entire volume was removed; therefore, wave refraction using the existing bathymetry was modeled and then wave refraction with the entire volume removed from the shoal was modeled.

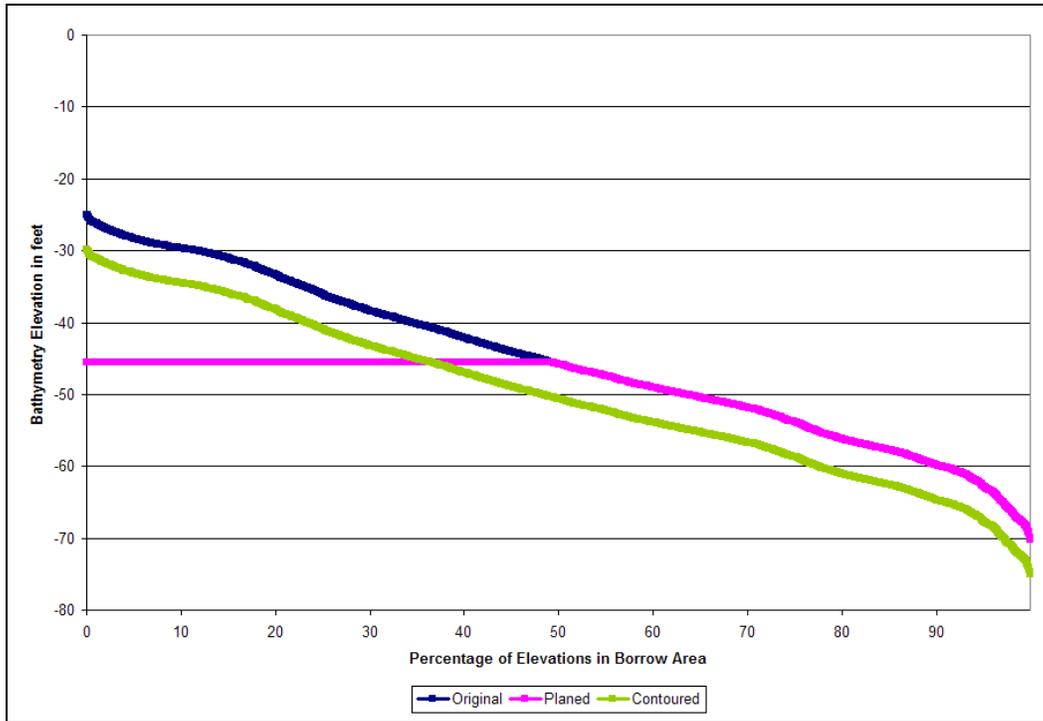
Material can be removed from the borrow site in variety of ways. For STWAVE modeling, two material removal techniques were chosen:

1. The “Plane Method” involving removal of the highest points within a borrow site down to an elevation that provided an adequate volume of material. This method would have the effect of turning a rounded mound of sediment into one or more flat areas.
2. The “Contour Method,” in which the same depth of material would be removed from all points within the borrow site. This would have the effect of dropping the contour everywhere within the borrow site by a constant amount.

The Plane Method is assumed to be the one that would have the greatest shoreline impacts, and the Contour Method is assumed to be moderately close to what might reasonably be used by a dredging contractor. Although the quantity of sand proposed for removal at one time (initial fill or renourishment fill) would not likely exceed 2.4 million m³ (3.2 million yd³), the modeling was performed for removal of the entire 50-year SRIPP lifespan sand placement volume (i.e.,

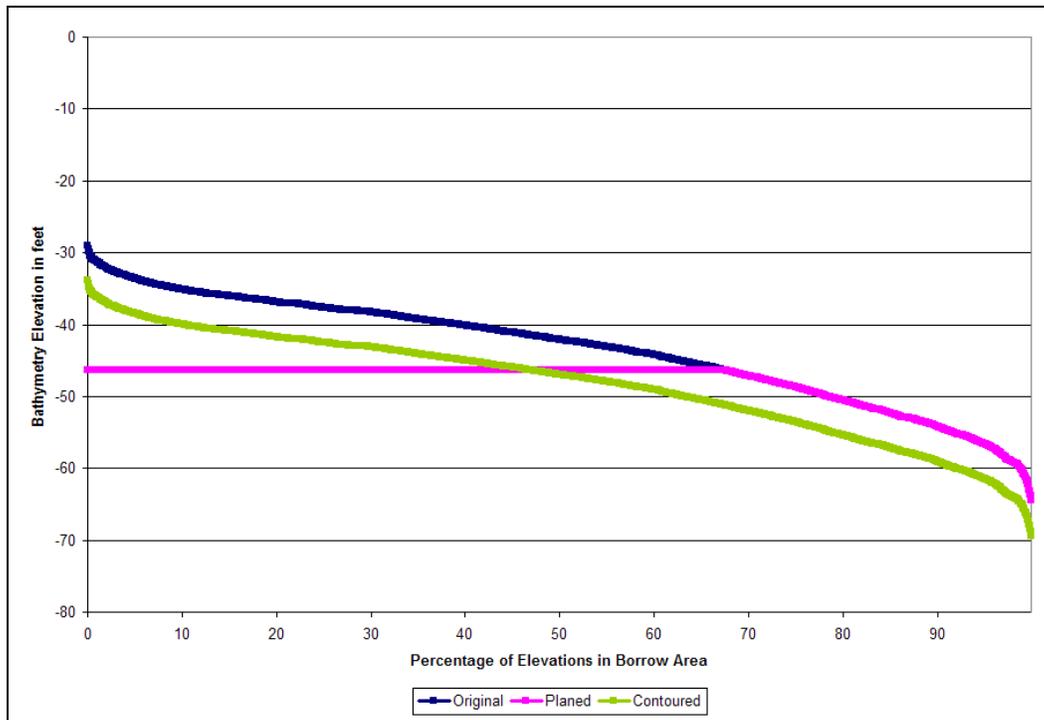
Environmental Consequences

7,646,000 m³ [10,000,000 yd³] for Alternative One) from the 5.2 km² (2 mi²) study area as a conservative approach. The effects of these two methods on Unnamed Shoal A and Unnamed Shoal B are shown on Figures 44 and 45.



Source: USACE, 2010a

Figure 44: Unnamed Shoal A: Plane and Contour Dredge Method Profiles



Source: USACE, 2010a

Figure 45: Unnamed Shoal B: Plane and Contour Dredge Method Profiles

The USACE modeling was based on site-specific wave characteristics by considering temporal (inter-annual) and spatial variability in wave conditions. According to MMS (2001), “the methodology used to evaluate borrow site impacts provides a reliable quantitative technique for developing acceptable site-specific limits associated with changes in sediment transport potential.”

The results of the USACE modeling effort are presented as numerical values that correspond to the change in sediment transport potential in response to dredging (see Appendix A [USACE, 2010a] for modeling results). The results are compared with a pre-determined threshold value to determine whether or not the difference in longshore sediment transport along the Assateague shoreline would be directly attributable to dredging. If model results are larger than the pre-determined threshold value, then shoreline change directly attributable to the SRIPP would likely occur, and would therefore be considered a significant impact (MMS, 2001). Values less than the threshold only indicate that dredging for the SRIPP cannot be distinguished from naturally occurring longshore sediment transport, and therefore the SRIPP would not result in significant impacts on the Assateague Island shoreline.

The results of the sediment transport modeling under the Plane Methods and Contour Methods for dredging of both Unnamed Shoal A and Unnamed Shoal B showed that the pre-determined threshold value is not crossed anywhere along the Assateague shoreline. Therefore, the proposed excavation depths (which correlate with sediment volumes) under both dredging scenarios would be acceptable.

Because the natural variability in shoreline changes along the coast, certain portions of the Assateague Island shoreline will be more tolerant of alterations to the wave climate and

Environmental Consequences

associated sediment transport patterns. Because the Tom's Cove Isthmus is a naturally vulnerable area to changes in longshore sediment transport (as described under shoreline change of the No Action Alternative), if any minor shoreline changes were to occur, they would likely be seen in this area of Assateague Island. Because Chincoteague Shoal is large and shallow, it greatly modifies the nearshore wave climate, and helps to reduce the shoreline impacts of dredging activities that would occur farther seaward of Chincoteague Shoal on either of the two shoals proposed as SRIPP borrow sites. The modeling results showed that when comparing Unnamed Shoal A with Unnamed Shoal B, no significant difference in the shoreline impacts from the dredging of either site exist.

Use of North Wallops Island as Borrow Site

The removal of sand from the north end of Wallops Island would lower topography within the footprint of the excavated areas. Because the accretion area on the north end of Wallops Island is expected to grow in response to the initial and renourishment beach fills, the impacts from sediment removal at the north end of Wallops Island would be mitigated by the re-deposition of sediment that would come from the addition of new sand on the beach. Therefore, while the use of the north Wallops Island beach as a sand source would result in direct, short-term adverse impacts on the shoreline in the period of a few months to years after excavation activities, in the long-term (i.e., lifetime of the SRIPP), use of this area is not anticipated to result in significant changes to the shoreline. Disturbance to surface sediments outside of the excavation areas would also result from activities associated with the movement and transfer of excavated sediments from the north end of Wallops Island to the areas designated for sand placement.

The accumulation of material at the north end of Wallops Island from both the south (northward transport along Wallops Island) and east (westward transport across Chincoteague ebb shoal) is causing Chincoteague Inlet to migrate to the east. The amount of material proposed for removal from the north end of Wallops Island would be similar to the excess that is being deposited, which is expected to help stabilize the location of Chincoteague Inlet and is not expected to provide a force that helps shift the inlet to the west. While it is recognized that inlets are dynamic features, removal of this sand is expected to, if anything, help stabilize the inlet.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

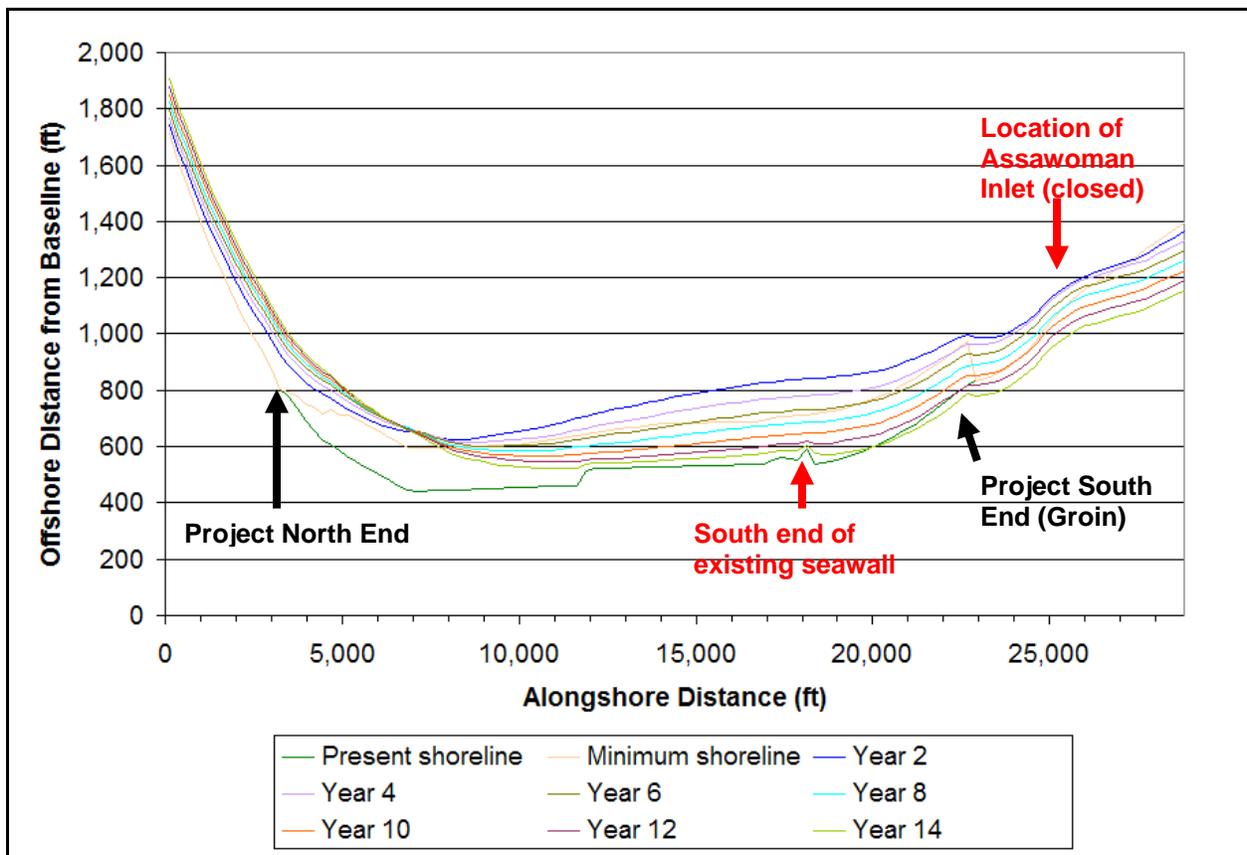
Under Alternative Two, seawall construction, initial beach fill, and renourishment activities would be the same as Alternative One; however, a slightly smaller volume of fill would be placed on the beach during both initial fill and renourishment cycles (see Table 7). The USACE accounted for sea-level rise under Alternative Two by including an additional amount of material at each renourishment event that would raise the entire fill profile by an amount equal to the projected amount of sea-level rise (USACE, 2010a). The effects of sea-level rise on Wallops Island would be the same as described under Alternative One.

Approximately 2/3 of the proposed groin structure (80 m [265 ft]) would be installed within the beach once the fill has been placed. The groin would be specifically designed to let some sand pass through the structure and was modeled as such. If there were no beach fill, the groin would exacerbate the downdrift erosion on Assawoman Island; however, because the SRIPP includes a beach fill component, overall, more sand would be moving onto the north end of Assawoman Island than is occurring at present. According to the modeling results, the combination of the groin with beach fill would result in accretion of sand on the north end of Assawoman Island.

The greatest amount of erosion and accretion would occur immediately adjacent to the groin and would exponentially decrease with distance from the groin.

Activities related to groin construction would disturb surface sediments on the beach, but these impacts would be temporary and minor. In the long-term, the groin would help to retain sand on the Wallops Island shoreline so that erosion and sediment transport from Wallops Island would be reduced and the beach created by the SRIPP would stay in place longer than under Alternative One. NASA would implement the same types of mitigation measures as described for seawall construction under Alternative One.

Figure 46 shows the estimated shoreline positions from Year 2 to Year 14. Though it is intended that renourishment should occur at the end of Year 5, the USACE analysis was carried out to Year 14 without renourishment to help determine if adverse impacts occur to adjacent beaches if the renourishment intervals are postponed or cancelled. Figure 46 shows that by Year 4, in many places the shoreline has retreated to near the minimum shoreline for storm damage protection, and thus, this is intended to be shortly before renourishment. By Year 12, the entire initial fill has been removed from the south end of the project; however, by Year 14, there is still sediment in front of the seawall.



Source: USACE, 2010a

Figure 46: Shoreline Positions over Time for Alternative Two

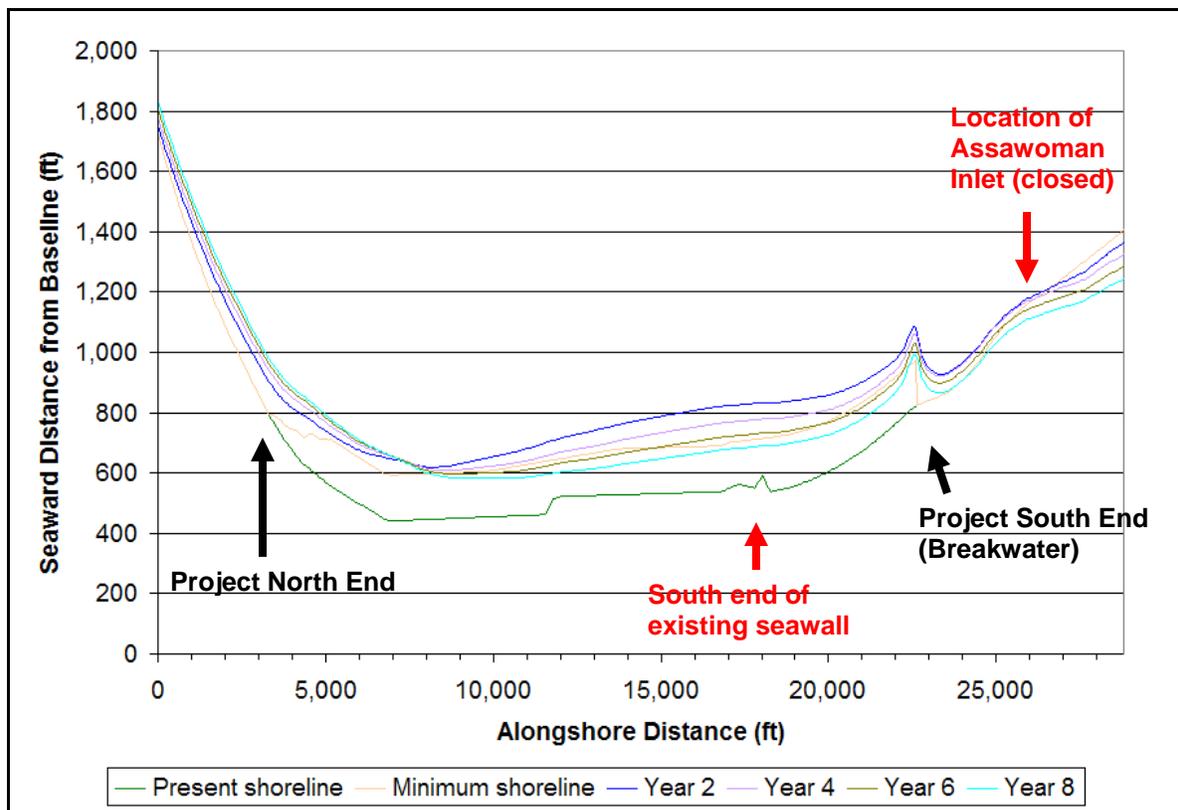
Environmental Consequences

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

Under Alternative Three, seawall construction, initial beach fill and renourishment activities would be the same as Alternative One; however, a slightly smaller volume of fill would be placed on the beach during both initial fill and the renourishment cycles (see Table 7). The USACE accounted for sea-level rise under Alternative Three by including an additional amount of material at each renourishment event that would raise the entire fill profile by an amount equal to the projected amount of sea-level rise (USACE, 2010a). The effects of sea-level rise on Wallops Island would be the same as described under Alternative One.

The construction of a nearshore breakwater structure would result in a build-up of sediment along the shoreline perpendicular to the breakwater (Figure 47). Temporary and minor adverse effects on sediments are anticipated in the immediate vicinity of the breakwater during the construction period.

The breakwater would be specifically designed to let some sand pass through the structure and was modeled as such. If there were no beach fill, the breakwater would exacerbate the downdrift erosion on Assawoman Island; however, because the SRIPP includes a beach fill component, overall, more sand would be moving onto the north end of Assawoman Island than is occurring at present. According to the modeling results, the combination of the breakwater with beach fill would result in accretion of sand on the north end of Assawoman Island. The greatest amount of erosion and accretion would occur immediately adjacent to the breakwater and would exponentially decrease with distance from the breakwater.



Source: USACE, 2010a

Figure 47: Shoreline Positions over Time for Alternative Three

4.2.2.2 Offshore Sand Shoals

No Action Alternative

Under the No Action Alternative, the SRIPP would not be implemented. Maintenance and emergency repairs to structures and the seawall would continue as necessary, but those activities would not involve work in open water. Therefore, no impacts on the geology or sediments of the offshore sand shoals would occur.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

Under Alternative One, dredging activities would result in changes to the volume, shape, and elevation of the sediments at the proposed borrow sites. Dredging at the proposed borrow sites would be conducted in a manner that is generally consistent with the recommendations made in two recent MMS publications examining the dredging of offshore shoals in the mid-Atlantic (CSA International, Inc. et al., 2009; Dibajnia and Nairn, *in press*). These recommendations include; targeting depocenters for extraction, avoiding active erosional areas, shallow dredging over large areas rather than deep pits, dredging shoals in less than 30 m of water, and avoiding longitudinal dredging over entire length of shoal. NASA’s EFH consultation with NMFS contains more detail about proposed dredging methods (Appendix J).

As described in Section 2.5.7.2, NASA would target specific zones of the shoals for dredging to the extent practicable. NASA estimates that the 5.2 km² (2 mi²) study area covers approximately 70 percent of the total surface area of Unnamed Shoal A. The 5.2 km² (2 mi²) study area covers approximately 33 percent of Shoal B. Shoal volumes are shown in Table 31. For the initial fill volume Zone A-1 (Figure 18) would be targeted and would comprise approximately 2.1 km² (0.8 mi²) or 30 percent of Shoal A. Zone A-2, which would only be utilized in an off-nominal condition for initial fill, covers approximately 1.6 km² (0.6 mi²), or approximately 22 percent of Shoal A. Zones B-1 and B-2, which would be considered for use during renourishment, are approximately 2.2 km² (0.9 mi²) and 1.8 km² (0.7 mi²), respectively.

Roughly 20 percent of the Shoal A’s total volume would be removed if only Shoal A was used to obtain fill material over the lifetime of the SRIPP. Because Unnamed Shoal A would be used for the initial fill, Unnamed Shoal B would have less total volume removed over the SRIPP lifetime. Therefore, roughly 7 percent of Shoal B’s volume would be removed if it was used to obtain the entire SRIPP renourishment volumes. Therefore, the SRIPP would result in direct, long-term adverse impacts on the volumes of sand at either of the proposed shoals. Removal of shoal sediments would result in long-term adverse impacts on site-specific and regional geology.

Table 31: Offshore Borrow Site Impacts

Borrow Area	Area Impacted by Initial Fill Only ¹	Area Impacted over Lifetime of SRIPP ²	Estimated Total Shoal Volume	Maximum Volume That Could Be Removed Over SRIPP Lifetime
Unnamed Shoal A	210 ha (515 ac)	520 ha (1,280 ac)	52 million m ³ (68 million yd ³)	9,990,000 m ³ (13,066,250 yd ³)
Unnamed Shoal B ³	0 ha (0 ac)	520 ha (1,280 ac)	100 million m ³ (132 million yd ³)	6,933,000 m ³ (9,067,500 yd ³)

¹Dredging for initial fill is targeting a 0.8 mi² area of Shoal A, but may extend over a greater area of shoal. See Figure 18 or Appendix J for more detail.

²The total area that may be dredged over the lifetime of the SRIPP.

³Because Unnamed Shoal A would be used for the initial fill (dredge volume is 3,057,500 m³ [3,998,750 yd³]), the maximum volume represents the amount of sand required for the nine renourishment cycles.

Environmental Consequences

In addition, the bottom substrate at and near either of the borrow sites may be modified in several ways. A change in the hydrological regime as a consequence of altered bathymetry may result in a change of depositional patterns at the site, and therefore a change in sediment grain size. Exposure of the underlying sedimentary units may also change the depositional patterns by exposing material that has different textural and compositional properties than the existing bottom substrate.

Bottom substrate at a distance from the borrow site may also be modified by the deposition of fine-grained sediments in benthic and surface plumes generated by dredging activities. Sediments contained within plumes produced from the disturbance and resuspension of bottom sediments (benthic plume), and from discharges of the dredging vessel and equipment (surface plume), would settle out from the water column and be deposited at a distance from the dredge site. The deposition of resuspended sediments may result in a layer of sediment that differs from the existing substrate.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

For the seawall construction, initial sand placement, and renourishment activities, impacts would be the same as those described under Alternative One. However, the volume of sand needed for renourishment activities would be less, because construction of a groin would reduce shoreline erosion rates locally. Construction of a groin would result in site-specific changes to the geology of the nearshore environment immediately east of Wallops Island due to the potential changes in the shoreline and longshore sediment transport (discussed in Sections 4.2.2.1 and 4.2.3.4 respectively). The changes would be long-term, although they could be reversed if the groin was later removed.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

For the seawall construction, initial sand placement, and renourishment activities, impacts would be the same as those described under Alternative One. However, the volume of sand needed for renourishment activities would be less, because construction of a nearshore breakwater would reduce shoreline erosion rates locally. Construction of a breakwater would result in site-specific changes to the geology of the nearshore environment immediately east of Wallops Island due to the potential changes in the shoreline and longshore sediment transport (discussed in Sections 4.2.2.1 and 4.2.3.4 respectively). The changes would be long-term, although they could be reversed if the breakwater was later removed.

4.2.3 Physical Oceanography and Coastal Processes

4.2.3.1 Tides

No Action Alternative

Under the No Action Alternative, the SRIPP would not be implemented; however, maintenance activities and emergency repairs would occur at unknown locations on Wallops Island as necessary. The No Action Alternative would not result in any changes to tides in the project area.

Proposed Action Alternatives

The range of the tides would not be altered by SRIPP activities under any of the Proposed Action Alternatives.

4.2.3.2 Waves

No Action Alternative

Under the No Action Alternative, the SRIPP would not be implemented; however, maintenance activities and emergency repairs would occur at unknown locations on Wallops Island as necessary. Without the construction of the seawall extension and the placement of beach fill, the zone of breaking waves would encroach farther inland and closer to WFF infrastructure and assets over time.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

As waves move shoreward from deeper water and propagate over the offshore dredged area, the height, direction, and other characteristics of the waves would change. A reduction in wave height due to deeper water depths within the borrow area is expected, especially with larger, longer period waves. The changes in wave characteristics due to dredging can significantly increase or decrease the transport of sand along the shoreline, resulting in localized erosion and accretion. Because wave conditions and shoreline change are intricately linked, Section 4.2.2.1 describes the potential effects on the shorelines as a result of changing the wave conditions by dredging the entire volume of sand from either of the shoals. Modeling results showed that when comparing Unnamed Shoal A with Unnamed Shoal B, there would be no significant difference in the wave climatology from the dredging of either site.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

The types of impacts on waves from offshore dredging under Alternative Two would be the same for Alternative One. The construction of a groin would have localized impacts on the wave climate in the project area by reducing wave energy on the opposite side of where the waves strike the groin. The groin would trap sand being transported along the shoreline as shown in Figure 7.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

The types of impacts on waves from offshore dredging under Alternative Three would be the same for Alternative One. The construction of an offshore detached breakwater would reduce wave energy in the area between the breakwater and the shoreline resulting in sediment deposition on the beach as shown in Figure 8.

4.2.3.3 Currents

No Action Alternative

Under the No Action Alternative the SRIPP would not be implemented; however, maintenance activities and emergency repairs would occur at unknown locations on Wallops Island as necessary. With the absence of in-water activity, there would be no impact on currents in the project area.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

Increasing the shoal depth with dredging would lead to decreased current velocity, sediment convergence, and infilling at the shoal. Although local current velocities immediately downstream of dredged areas may temporarily change, the magnitude of change and the size of the footprint are expected to be relatively small. Alterations of near-bed currents may result in

Environmental Consequences

local and short-lived changes in sediment transport pathways in the immediate vicinity of the borrow areas, but the pathways are expected to return to pre-dredging conditions following infilling (Byrnes et al., 2003). Infilling rates and sediment deposited in borrow depressions are expected to reflect natural variations, including storm characteristics and source material.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

The types of impacts on currents from offshore dredging as discussed under Alternative One would be the same for Alternative Two.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

The types of impacts on currents from offshore dredging as discussed under Alternative One would be the same for Alternative Three.

4.2.3.4 Longshore Sediment Transport

No Action Alternative

Under the No Action Alternative the SRIPP would not be implemented; however, maintenance activities and emergency repairs would occur at unknown locations on Wallops Island as necessary. With the absence of in-water activity, there would be no project related impacts to longshore sediment transport in the project area.

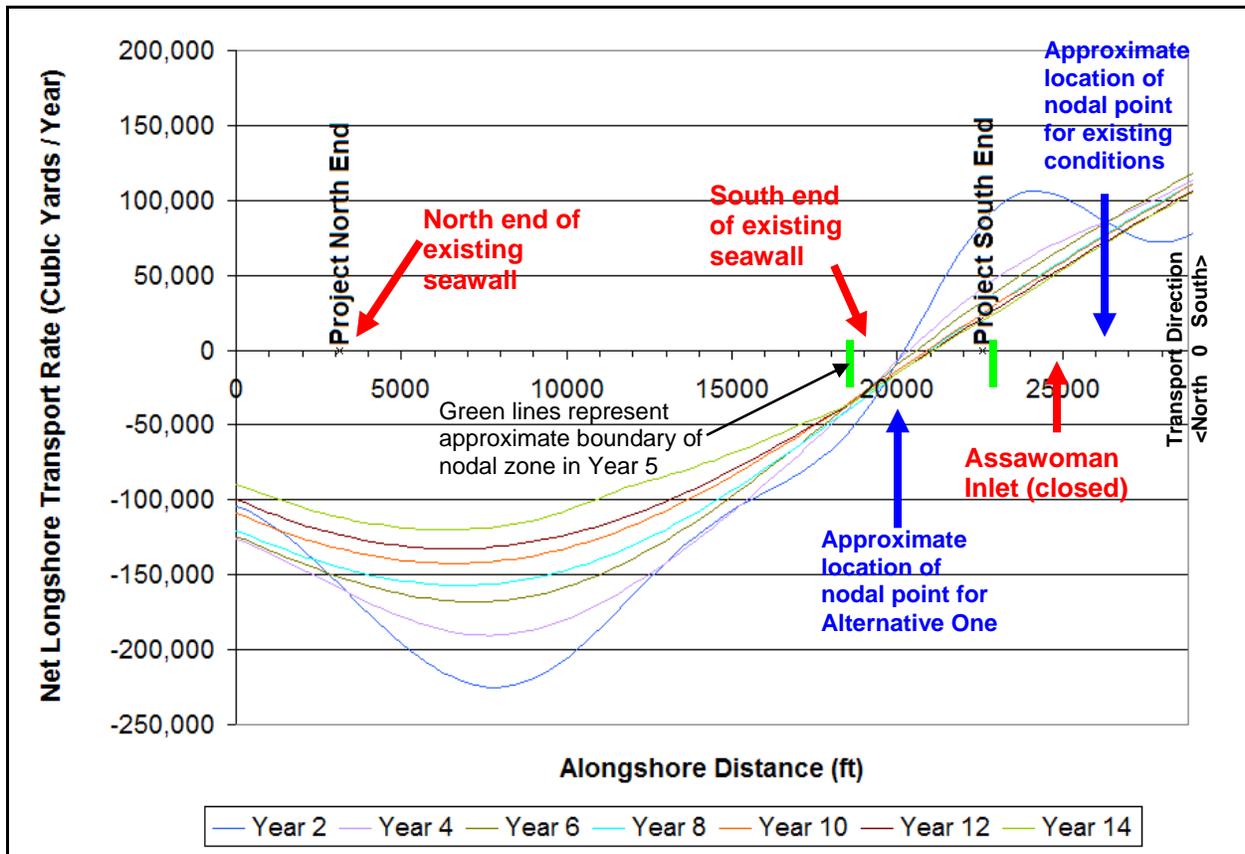
Nevertheless, as USACE (2010a) reported, the shoreline in the vicinity of Wallops Island is not in a state of static equilibrium, and it is not unreasonable to assume that substantial changes would continue to occur on decadal time scales, as compared with the slower time scales of more typical beaches. Fishing Point at the southern tip of Assateague Island is continuing to grow to the southwest at a rate of approximately 50 m (150 ft) per year. If this trend continues over the next 50 years, the tip will grow to the southwest by about 2.3 km (1.5 mi). This will more strongly shelter the Wallops Island shoreline from ocean waves approaching from the northeast, and will shift the transport divergent nodal zone which is currently on the north end of Assawoman Island to the south by roughly the same distance.

Longshore gross and net sediment transport rates for existing conditions are shown on Figures 28 and 29 in Section 3.1.5.4.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

Sand Placement and Seawall Extension

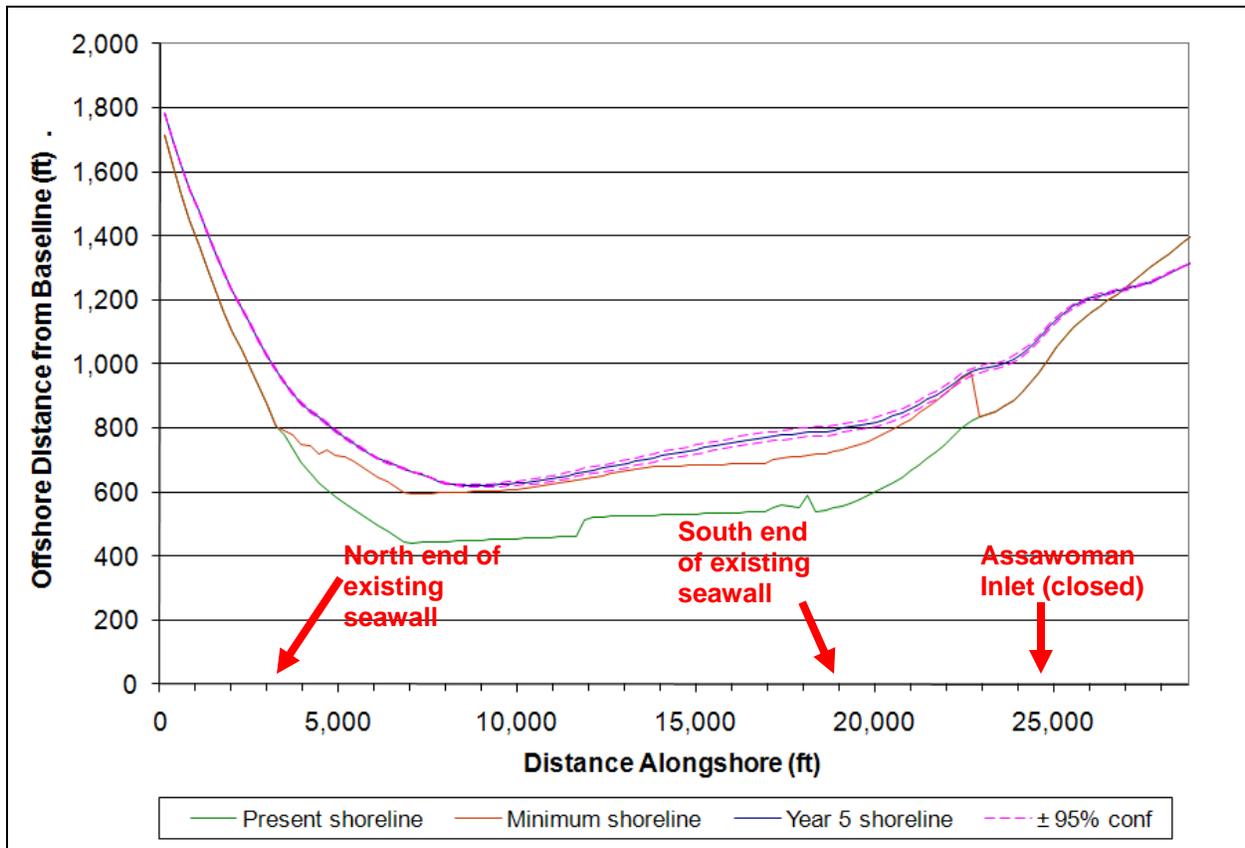
Placement of fill on the beach would add additional sand to the nearshore system. In comparing the net sediment transport rates modeled by the USACE (Appendix A) just prior to renourishment under Alternative One (Year 4 on Figure 48) to the No Action Alternative (existing conditions—see Figure 29), it is seen that the nodal point is shifted approximately 1.5 km (1 mi) to the north of its present estimated location and that maximum transport rates substantially exceed present conditions.



Source: USACE, 2010a

Figure 48: Net Sediment Transport Rates over Time for Alternative One

Figure 48 shows how net transport rates vary from SRIPP Year 2 (partial beach fill) through Year 14. Though it is intended that renourishment should occur at the end of Year 5, the USACE analysis was carried out to Year 14 without renourishment to help determine if adverse impacts would occur on adjacent beaches if renourishment intervals are postponed or cancelled. Figure 48 shows that substantial accretion would occur adjacent to both the north and south ends of the project through Year 2. Figure 49 shows the projected Year 5 shoreline positions with 95 percent confidence limits. At the south end of the project, over time, the net transport approaches a constant rate that is in excess of the current conditions. Accretion would occur at the north end of the project though the rate of accretion (without renourishment) decreases over time. Gross sediment transport rates were higher than for existing conditions, but after beach fill, varied little year to year (USACE, 2010a).



Source: USACE, 2010a

Figure 49: Shoreline Position in Year 5 for Alternative One

With implementation of the SRIPP, long-term beneficial direct impacts would occur on the longshore sediment transport system in the vicinity of Wallops Island due to the addition of sand from the beach fill.

Dredging Offshore Shoals

Longshore sediment transport within the project area is largely controlled by coastal geomorphology such as the current location and growth of Fishing Point and the overall wave climate of the region. As discussed in Section 4.2.2.1, no significant changes to the longshore sediment transport system are anticipated from dredging either of the two proposed SRIPP borrow sites; therefore, adverse impacts on Assateague Island are not anticipated. As indicated in Section 4.2.2.1, the results USACE (2009a) modeling showed that when comparing Unnamed Shoal A with Unnamed Shoal B, no significant difference in longshore sediment transport and shoreline impacts from the dredging exist between the two shoals. The SRIPP would not affect the sediment transport processes that will continue to create the changes at Fishing Point. In addition, the SRIPP would not affect the sediment transport processes that will continue to create the changes at Tom's Cove Isthmus.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

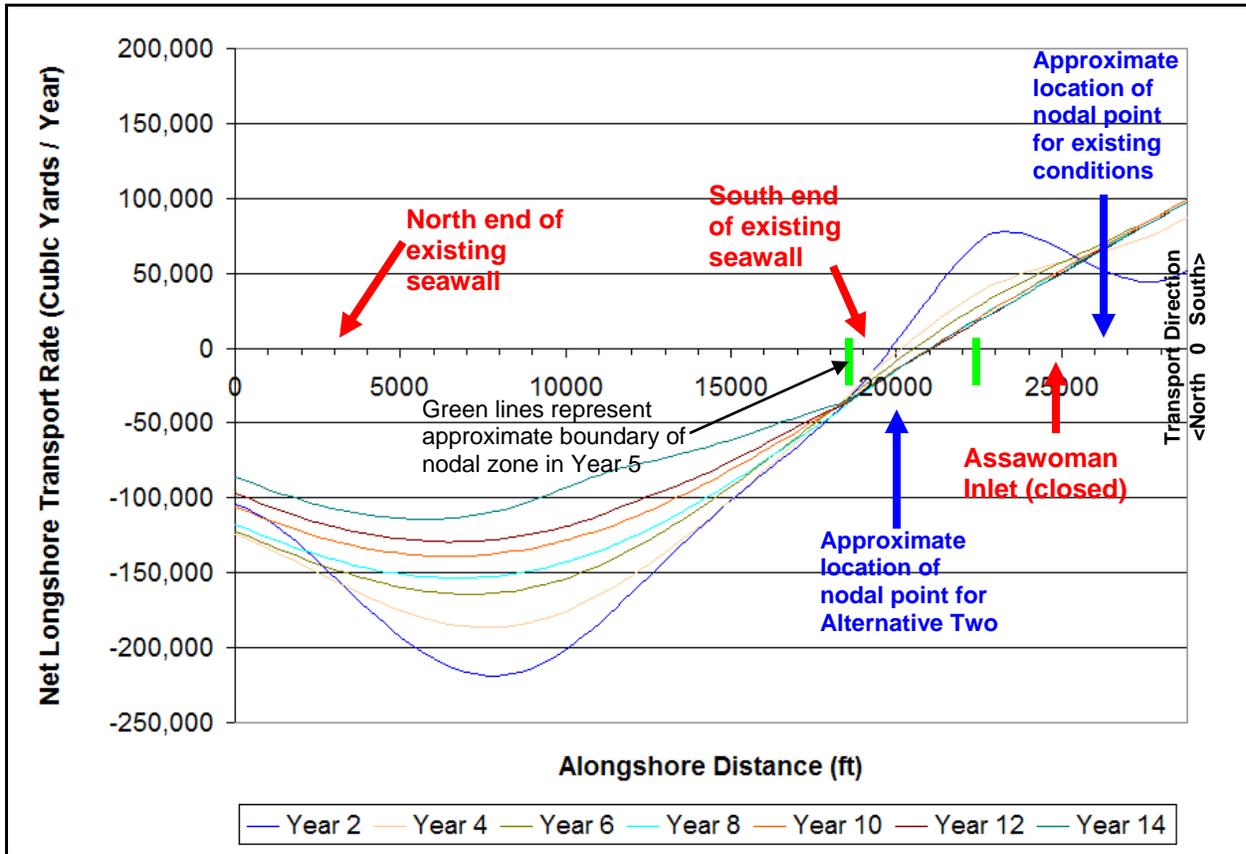
The types of impacts on longshore sediment transport from offshore dredging as discussed under Alternative One would be the same for Alternative Two. When comparing the net sediment transport rates just prior to renourishment under Alternative Two (Year 4 on Figure 50) to the No Action Alternative (existing conditions—see Figure 29), it is seen that the nodal point is shifted approximately 1.5 km (1 mile) to the north of its present estimated location and that maximum transport rates substantially exceed present conditions.

Figure 50 shows how net transport rates vary from SRIPP Year 2 (partial beach fill) through Year 14 with implementation of beach fill, seawall extension and a groin. Though it is intended that renourishment should occur at the end of Year 5, the USACE analysis was carried out to Year 14 without renourishment to help determine if adverse impacts would occur on adjacent beaches if renourishment intervals are postponed or cancelled. Figure 50 shows that substantial accretion would occur adjacent to both the north and south ends of the project through Year 2. Figure 51 shows the projected Year 5 shoreline positions with 95 percent confidence limits. At the south end of the project, over time, the transport rate approaches a constant rate that is in excess of the current conditions. Accretion would occur at the north end of the project though the rate of accretion (without renourishment) decreases over time.

While the transport rates would not be identical between Alternatives One and Two, and the groin would likely result in slightly lower rates of sediment transport within the local area around the groin, the modeling did not show a significant difference in the net sediment transport rates when comparing Alternative Two (groin) with Alternative One (no sand retention structure).

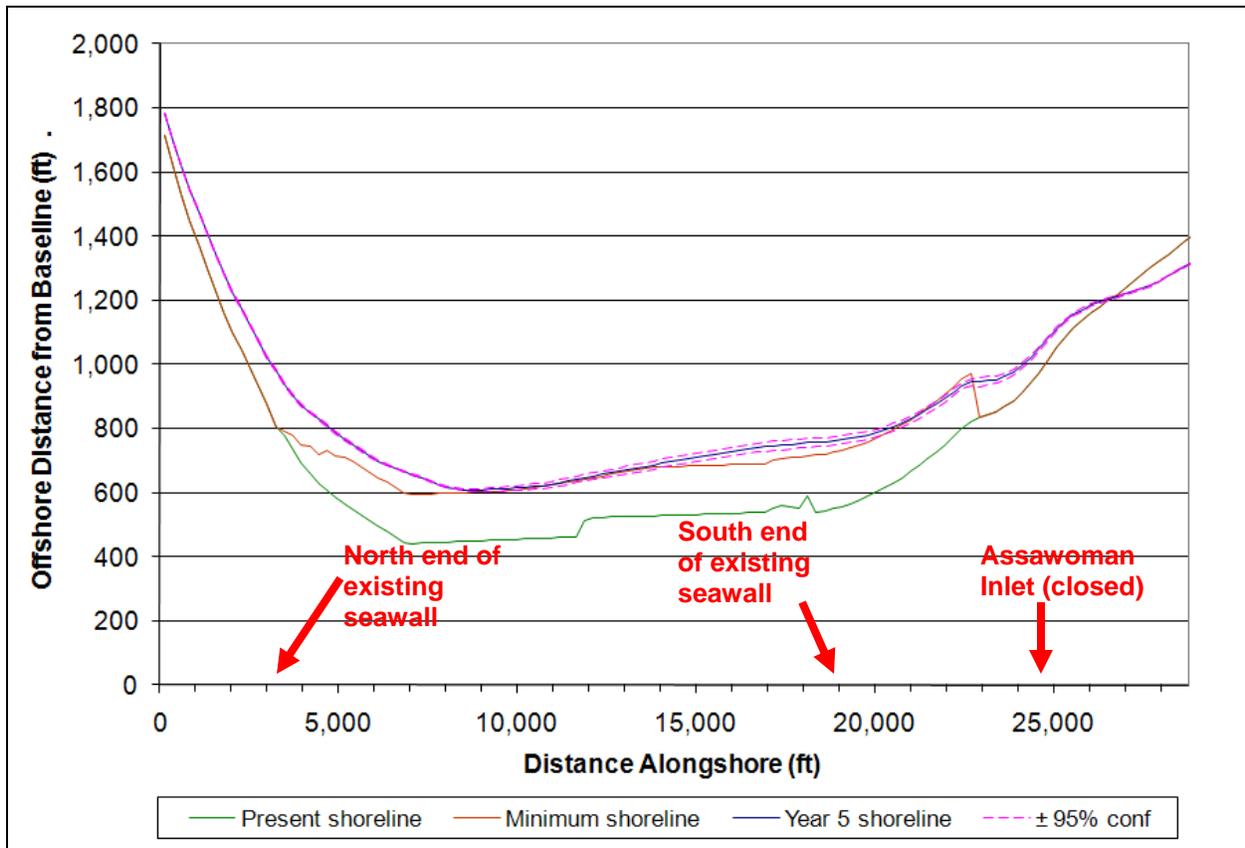
With implementation of the SRIPP, long-term beneficial direct impacts would occur on the longshore sediment transport system in the vicinity of Wallops Island due to the addition of sand from the beach fill and construction of a groin to help retain sediment on the Wallops Island shoreline.

Environmental Consequences



Source: USACE, 2010a

Figure 50: Net Sediment Transport Rates over Time for Alternative Two



Source: USACE, 2010a

Figure 51: Shoreline Position in Year 5 for Alternative Two

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

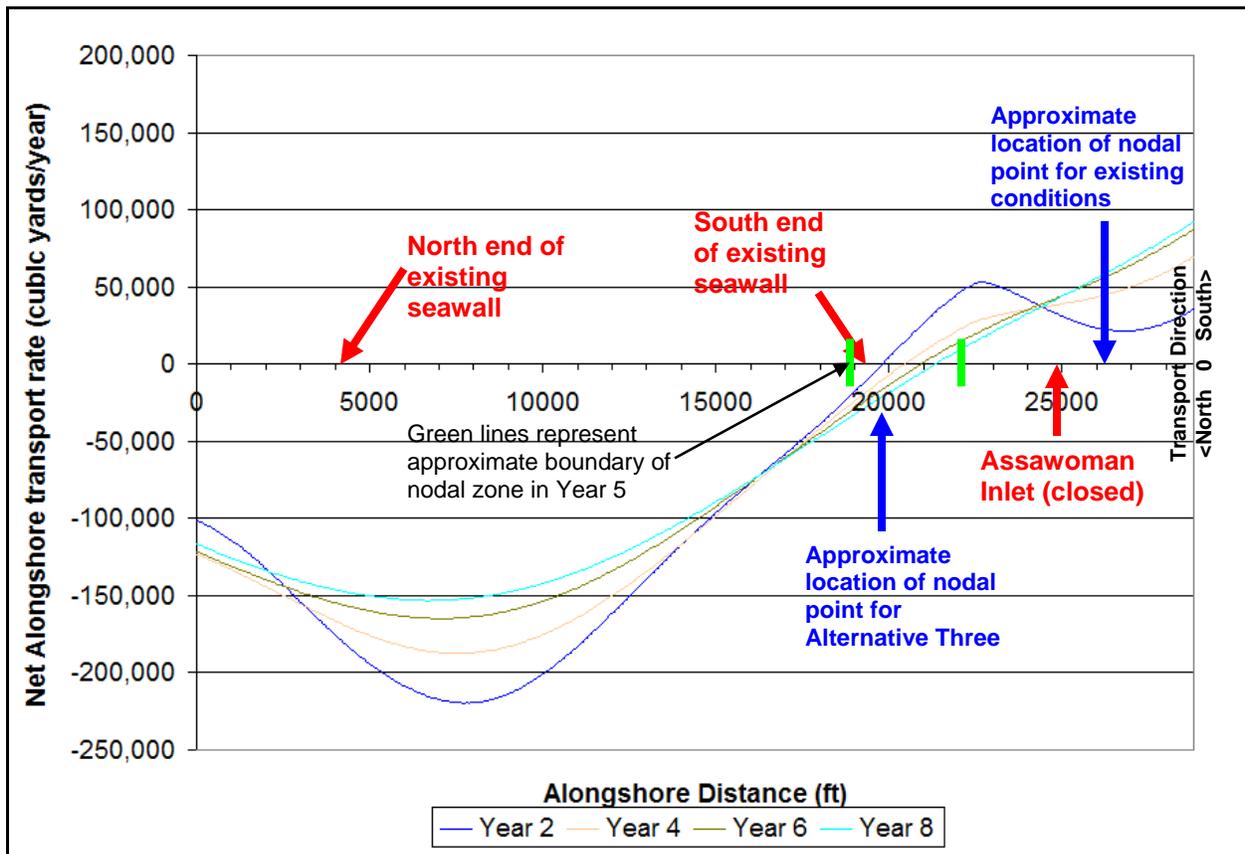
The types of impacts on currents from offshore dredging as discussed under Alternative One would be the same for Alternative Three. As for Alternative One, when comparing the net sediment transport rates just prior to renourishment under Alternative Three (Year 4 on Figure 52) to the No Action Alternative (existing conditions—see Figure 29), it is seen that the nodal point is shifted approximately 1.5 km (1 mi) to the north of its present estimated location and that maximum transport rates substantially exceed present conditions.

Figure 52 shows how net transport rates vary from SRIPP Year 2 (partial beach fill) through Year 8 with implementation of beach fill, seawall extension and a nearshore breakwater. Though it is intended that renourishment should occur at the end of Year 5, the USACE analysis was carried out to Year 8 without renourishment to help determine if adverse impacts would occur on adjacent beaches if renourishment intervals are postponed or cancelled. Figure 52 shows that substantial accretion would occur adjacent to both the north and south ends of the project through Year 2. Figure 53 shows the projected Year 5 shoreline positions with 95 percent confidence limits. At the south end of the project, over time, the transport rate approaches a constant rate that is in excess of the current conditions. Accretion would occur at the north end of the project though the rate of accretion (without renourishment) decreases over time.

Environmental Consequences

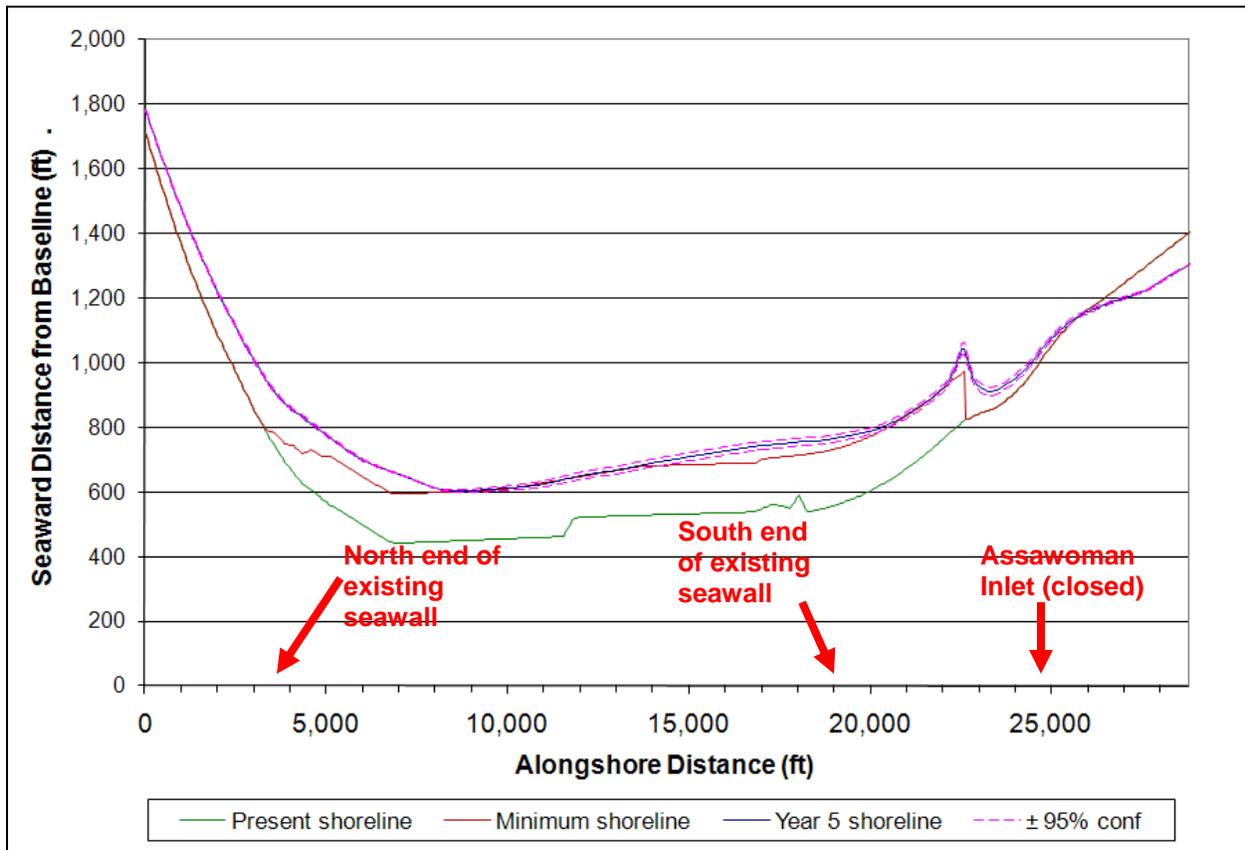
While the transport rates would not be identical between Alternatives One and Three, and the breakwater would likely result in slightly lower rates of sediment transport within the local area around the breakwater, the modeling did not show a significant difference in the net sediment transport rates when comparing Alternative Three (breakwater) with Alternative One (no sand retention structure). Net sediment transport rates with installation of a breakwater are very similar to the rates anticipated for construction of a groin under Alternative Two.

With implementation of the SRIPP, long-term beneficial direct impacts would occur on the longshore sediment transport system in the vicinity of Wallops Island due to the addition of sand from the beach fill and construction of a breakwater to help retain sediment on the Wallops Island shoreline.



Source: USACE, 2010a

Figure 52: Net Sediment Transport Rates over Time for Alternative Three



Source: USACE, 2010a

Figure 53: Shoreline Position in Year 5 for Alternative Three

4.2.3.5 *Cross-Shore Sediment Transport*

No Action Alternative

Under the No Action Alternative the SRIPP would not be implemented; however, maintenance activities and emergency repairs would occur at unknown locations on Wallops Island as necessary. With the absence of in-water activity, there would be no project related impacts to cross-shore sediment transport in the project area.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

The dredged areas on Shoal A and B would fill gradually over time; however, this would occur from local sediment transport and the deep troughs landward of Shoals A and B would isolate the Assateague Island shoreline and its nearshore profile from the dredging effects. Geological evidence supporting this includes a study by Field (1979) which showed that the linear sand ridges on the inner continental shelf off of the Maryland coast are formed from the reworking of ancient (inherited) geologic environments by modern marine processes and that they are mobile (southerly migration at variable rates). However, Field (1979) makes a case that these detached shoreface ridges, while once part of a barrier system, have become segmented and isolated on the

Environmental Consequences

inner continental shelf. As such, these sand bodies have a high preservation potential and consequently, a low cross-shore sediment transport potential.

Given the geometry of the shoals, their distances from shore and the sheltering/buffering action provided by Blackfish Bank Shoal, any effect that may occur on cross-shore transport would likely be small and indistinguishable from the natural variability in the system.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

The types of impacts on currents from offshore dredging as discussed under Alternative One would be the same for Alternative Two.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

The types of impacts on currents from offshore dredging as discussed under Alternative One would be the same for Alternative Three.

4.2.4 Water Resources

4.2.4.1 Surface Water and Water Quality on Wallops Island

No Action Alternative

Under the No Action Alternative, the SRIPP would not be implemented; however, maintenance activities and emergency repairs would occur. It is anticipated that the No Action Alternative would have temporary impacts on surface water resources from the use of construction vehicles and heavy machinery on the beach if a spill or leak occurred. The heavy equipment and construction activities may result in the introduction of petroleum products, heavy metals, or other contaminants to nearshore waters. Construction-related impacts would be temporary, and would not likely be adverse because any accidental release of contaminants or liquid fuels would be addressed in accordance with the existing WFF ICP emergency response and clean-up measures. Implementation of BMPs for vehicle and equipment fueling and maintenance, and spill prevention and control measures would reduce potential impacts on surface water during construction.

Saltwater intrusion into the marshes on Wallops Island resulting from storm surges may increase due to sea-level rise and climate change. Saltwater intrusion would result in effects on surface water quality on the northern and southern end of Wallops Island more immediately and directly than the more developed central portion of Wallops Island where there are fewer marshes and a seawall. Because saltwater intrusion is a natural process, it is difficult to classify the effects as beneficial or adverse; however, if storm surges become more frequent and larger, the effects of during- and post-storm saltwater intrusion may create long-term impacts on the marsh environment.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

No work would be done within surface waters on Wallops Island. However, Alternative One could have temporary impacts on the nearshore environment and surface water resources due to the presence of construction vehicles on existing roads and also during the use of heavy machinery on the beach or at the north end of Wallops Island. These construction activities may result in the introduction of petroleum products, heavy metals, or other contaminants to nearshore waters. Construction-related impacts would be temporary, and would not likely be adverse because any accidental release of contaminants or liquid fuels would be addressed in

accordance with the existing WFF ICP emergency response and clean-up measures. Implementation of BMPs for vehicle and equipment fueling and maintenance and spill prevention and control measures would reduce potential impacts on surface water during construction.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

The types of impacts on surface waters and the mitigation measures discussed under Alternative One would be the same for Alternative Two.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

The types of impacts on surface waters and the mitigation measures discussed under Alternative One would be the same for Alternative Three.

4.2.4.2 Wetlands

No Action Alternative

Under the No Action Alternative the SRIPP would not be implemented; however, maintenance activities and emergency repairs would occur at unknown locations on Wallops Island as necessary. Emergency repairs may result in adverse impacts on wetlands or Virginia-owned subaqueous bottom lands in the nearshore environment depending on the location and scope of the emergency action. If work is done within either of these areas, State and Federal permits would be required. The permit process for work proposed within wetlands or subaqueous bottom land requires the submission of a JPA to the VMRC under regulation authority contained in §§28.2-103 and 28.2-1307 of the Code of Virginia. The review process takes into account various local, State and Federal statutes governing the disturbance or alteration of environmental resources. The VMRC acts as an information clearinghouse and provides the application to local wetland boards, VDEQ, and the USACE for independent yet concurrent reviews. Based on the comments received from the concurrent reviews, the VMRC determines the type of permit(s) required to proceed with the project. In cases where a permit for emergency actions is required, the VMRC can issue a general wetlands permit to address catastrophic erosion situations that are attributable to specific storm events or natural calamity and thus streamline the permit process. Any necessary permits required for work involving maintenance, repair, or emergency actions in wetlands or subaqueous bottom land would be obtained by NASA prior to implementation. Long term adverse indirect impacts on wetlands could occur from the prevention of island overwash. Through overwash, sediments would be pushed to the west side of Wallops Island, acting to build marsh on the west side over time. Structural emergency actions could prevent overwash and reduce the amount of sediment that would be otherwise available on the west side of the island, potentially leading to a long-term loss of salt marsh.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

Under Alternative One, there would be no impacts on wetlands because no wetlands are located within the construction footprint for any project activities, including the northern part of Wallops Island and the southern portion of Wallops Island in the vicinity of the proposed seawall extension. Long term adverse indirect impacts on wetlands could occur from the prevention of island overwash. Through overwash, sediments would be pushed to the west side of Wallops Island, acting to build marsh on the west side over time. The construction of an elevated sand berm and dune would prevent overwash and reduce the amount of sediment that would be

Environmental Consequences

otherwise available on the west side of the island, potentially leading to a long-term loss of salt marsh.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

Under Alternative Two, there would be no impacts on wetlands because no wetlands are located within the construction footprint for any project activities, including the northern part of Wallops Island and the southern portion of Wallops Island in the vicinity of the proposed seawall extension. Long term adverse indirect impacts on wetlands could occur from the prevention of island overwash. Through overwash, sediments would be pushed to the west side of Wallops Island, acting to build marsh on the west side over time. The construction of an elevated sand berm and dune would prevent overwash and reduce the amount of sediment that would be otherwise available on the west side of the island, potentially leading to a long-term loss of salt marsh.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

Under Alternative Three, there would be no impacts on wetlands because no wetlands are located within the construction footprint for any project activities, including the northern part of Wallops Island and the southern portion of Wallops Island in the vicinity of the proposed seawall extension. Long term adverse indirect impacts on wetlands could occur from the prevention of island overwash. Through overwash, sediments would be pushed to the west side of Wallops Island, acting to build marsh on the west side over time. The construction of an elevated sand berm and dune would prevent overwash and reduce the amount of sediment that would be otherwise available on the west side of the island, potentially leading to a long-term loss of salt marsh.

4.2.4.3 Marine Waters

No Action Alternative

Under the No Action Alternative, the SRIPP would not be implemented; however, maintenance activities and emergency repairs would occur. It is anticipated that the No Action Alternative could have temporary impacts on nearshore marine water resources from the use of construction vehicles and heavy machinery on the beach if a spill or leak occurred. The heavy equipment and construction activities may result in the introduction of petroleum products, heavy metals, or other contaminants to nearshore waters. Construction-related impacts would be temporary, and would not likely be adverse because any accidental release of contaminants or liquid fuels would be addressed in accordance with the existing WFF ICP emergency response and clean-up measures. Implementation of BMPs for vehicle and equipment fueling and maintenance, and spill prevention and control measures would reduce potential impacts on surface water during construction. Therefore, the No Action Alternative is not anticipated to significantly impact marine water quality.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

Sand Placement

There would be increased, localized turbidity associated with the beach nourishment operations in the nearshore environment from placement of the fill and from anchoring of the dredge and

pump-out station. Nearshore turbidity impacts from fill placement are directly related to the quantity of fines (silt and clay) in the nourishment material.

The medium sized sand grains of the offshore borrow sites should allow for a short suspension time and containment of sediment during and after placement activities. The beach fill consists of beach quality sand of similar grain size and composition as indigenous beach sands. Turbidity impacts would be short-term and spatially limited to the vicinity of the dredge outfall pipe, the pump-out station, and dredge anchor points. No other water quality parameters are anticipated to be substantially impacted during beach fill operations. NASA would obtain all necessary permits for sediment placement in the nearshore environment, which may include a VMRC permit, a Virginia Water Protection Permit/401 certification from the VDEQ, and USACE Section 404 permit. An evaluation report based on Section 404(b)(1) of the CWA, Guidelines for Specification of Disposal Sites for Dredged or Fill Material, would be submitted to permitting agencies to address impacts associated with Alternative One. Under these guidelines, dredged or fill materials should not be discharged into the aquatic ecosystem unless it can be demonstrated that the discharge will not have an unacceptable impact from either individual or in combination with known and/or probable impacts from other activities affecting the ecosystem.

The contractor would be responsible for proper storage and disposal of any hazardous material such as oils and fuels used during the dredging and beach nourishment operations. The EPA and USCG regulations require the treatment of waste (e.g., sewage, graywater) from dredge plants and tender/service vessels and prohibit the disposal of debris into the marine environment. The dredge contractor would be required to implement a marine pollution control plan to minimize any direct impacts to water quality from construction activity. No accidental spills of diesel fuel from the dredge plant or tender vessels are expected. Personnel would implement USCG-approved safety response plans or procedures outlined in WFF's ICP to prevent and minimize any impacts associated with a spill.

Offshore Borrow Sites

Temporary impacts on marine waters would occur at the borrow site. Dredging in the borrow area would result in short-term adverse effects on marine water quality, including localized increases in turbidity and slight decreases in dissolved oxygen at the location of the drag head and in the surrounding sediment plume. Suspended sediment concentrations would be elevated during and for a period (several hours) after dredging operations.

Another source of suspended sediment is the hopper overflow. As dredged sediment settles on-board, water is released back to the ocean so that transported sediment contains less water. Suspended sediment at the drag head is generally localized and close to the bottom; however, the hopper overflow usually produces a "dynamic" plume (where highly turbid water forms a turbidity plume or current through the water column), a passive phase, and sometimes a near-bottom "pancaking" or laterally spreading turbidity current phase (W.F. Baird and Associates, 2004). Dredges are often equipped with under-hull release of overflow sediment and anti-turbidity valves, which reduce the extent of suspended sediment plumes generated by the overflow process.

Operations using hopper dredges tend to be discontinuous and associated plumes would be dispersed over a larger area. Hopper dredges trigger a small plume at the seabed from the draghead and a larger surface plume from the discharge of overspill of water with suspended

Environmental Consequences

sediment from the hopper (MMS, 1999). The length and shape of the surface plume generated by the overspill depends on the hydrodynamics of the water and the sediment grain size.

Although the volume of discharged material is much higher during construction aggregate dredging, findings from studies of these operations from overseas provide information on the potential behavior of turbidity plumes from dredging for beach restoration material (MMS, 1999). Detailed investigation of these types of operations off the coast of the United Kingdom found that most sediments in the plume settle out within 300 to 500 m (984 to 1,640 ft) from the dredge over a period of roughly 20 to 30 minutes and that suspended sediment concentrations returned to concentrations close to background level within an hour after completion of dredging (Hitchcock et al., 1999). The distance and time increased with decreasing sediment size. Because the sediment on Shoals A and B is well-sorted medium sand with low silt and clay content, turbidity plumes would be localized and short-lived. Hitchcock et al. (1999) reported that far field (i.e., > 500 m [1,640 ft]) visible plumes that extend beyond the boundaries of suspended sediment are comprised of organic compounds such as fats, lipids, and carbohydrates agitated by the dredging process. Because the size of far field plume would depend on weather and tidal currents, the exact extent cannot be estimated; however, impacts on water quality are not expected to be substantial.

Since the dominant substrate at the borrow site is sand, it is expected to settle rapidly and cause less turbidity and oxygen demand than finer-grained sediments. No appreciable effects on dissolved oxygen, pH, or temperature are anticipated because the dredged material (sand) has low levels of organics and low biological oxygen demand. Additionally, dredging activities would occur within the open ocean where the hydrodynamics of the water column are subject to mixing and exchange with oxygen rich surface waters. Ripple marks seen on the surface of both Unnamed Shoals A and B during the 2009 benthic video survey are evidence that wave energy reaches the seafloor and mixing of the water column occurs there. It is anticipated that Alternative One would have minor, short-term impacts on marine waters at either offshore borrow site.

North Wallops Island Borrow Site

Although no work would be done within surface waters during excavation activities at the north Wallops Island borrow site, the nearshore marine environment could be affected if a spill or leak from construction vehicles or heavy machinery occurred. Construction-related impacts would be temporary, and would not likely be adverse because any accidental release of contaminants or liquid fuels would be addressed in accordance with the existing WFF ICP emergency response and clean-up measures. Implementation of BMPs for vehicle and equipment fueling and maintenance, and spill prevention and control measures would reduce potential impacts on surface water during construction. Therefore, excavation activities are not anticipated to significantly impact marine water quality.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

The types of impacts on marine waters and the mitigation measures discussed under Alternative One for dredging of either offshore shoal, or for use of the north Wallops Island borrow site, would be the same for Alternative Two, however the extent of impacts would be slightly less due to the need for less fill material. In addition, there is potential for short-term adverse water quality impacts in the nearshore and beach environment during construction of the groin if a

vessel or construction equipment were to spill its fuels or other substances that could contaminate the ocean environment. The WFF ICP emergency response and clean-up measures would be implemented in the event of a spill. Toxic concentrations would be localized and temporary due to the mixing and dilution associated with wave movement. Short-term increases in turbidity during construction of the groin would occur.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

The types of impacts on marine waters and the mitigation measures discussed under Alternative One for dredging of either offshore shoal, or for use of the north Wallops Island borrow site, would be the same for Alternative Three, however to a lesser degree due to a smaller amount of material needed for beach fill. In addition, there is potential for short-term adverse water quality impacts in the nearshore environment during construction of the breakwater if a vessel were to spill its fuels or other substances that could contaminate the ocean environment. The WFF ICP emergency response and clean-up measures would be implemented in the event of a spill. Toxic concentrations would be localized and temporary due to the mixing and dilution associated with wave movement. Short-term increases in turbidity during construction of the breakwater would occur.

4.2.5 Floodplains

No Action Alternative

Under the No Action Alternative, the SRIPP would not be implemented; however, maintenance and emergency repair activities would occur. Because the entire island is within the 100-year floodplain, there are no practicable alternatives to conducting maintenance and repair activities within the floodplain. It is anticipated that the No Action Alternative would have no impact on floodplains.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

Wallops Island is located entirely within the floodplain; therefore, all SRIPP activities on land would take place within the 100-year and 500-year floodplains. No practicable alternatives to work in the floodplain exist. The functionality of the floodplain on Wallops Island, provided both by the wetlands on the island and the area of the island itself, would not be reduced by the SRIPP. NASA would ensure that its actions comply with EO 11988, *Floodplain Management*, and 14 CFR 1216.2 (NASA Regulations on Floodplain and Wetland Management) to the maximum extent possible. Since the Proposed Action would involve federally funded and authorized construction in the 100-year floodplain, this PEIS also serves as NASA's means for facilitating public review as required by EO 11988.

The 1.8-m-high (6-ft-high) berm, the 4.3-m-high (14-ft-high) dune at the seawall (shown conceptually on Figures 15 and 16), the seawall extension, and the new beach itself would provide some flooding reduction from ocean waters for Wallops Island facilities (USACE, 2010a). The approach of the SRIPP design is that the beach fill alone would provide storm damage reduction against smaller, more frequent storms, leaving the seawall intact to protect against the largest storms expected over the lifetime of the project. The SRIPP would not include storm damage reduction as a result of flooding from the back bays and waterways on the north, west, and south sides of Wallops Island. Substantial, long-term direct impacts on the floodplain as a result of the beach fill and seawall extension would occur under Alternative One.

Environmental Consequences

Alternative Two: Full Beach Fill, Groin, Seawall Extension

Under Alternative Two, the impacts on floodplains would be the same as those described for Alternative One.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

Under Alternative Three, the impacts on floodplains would be the same as those described for Alternative One.

4.2.6 Coastal Zone Management

No Action Alternative

Under the No Action Alternative, the SRIPP would not be implemented; however, maintenance and emergency repair activities would occur. Maintenance activities may require a permit from VMRC for work within the coastal zone. Wallops Island is exempt from CBRA. It is anticipated that the No Action Alternative would have minimal impact on the coastal zone because NASA would ensure that any project activities comply with the enforceable policies of the Virginia's Coastal Resources Management Program.

Proposed Action Alternatives

SRIPP activities within the coastal zone would have reasonably foreseeable effects on coastal resources. Based upon the information and analysis in this PEIS and the Federal Consistency Determination (Appendix H), NASA determined that the proposed SRIPP activities are consistent to the maximum extent practicable with the enforceable policies of the Virginia Coastal Resources Management Program (Table 32). VDEQ concurred with NASA's determination in its April 14, 2010 letter (Appendix H).

Table 32: Federal Consistency Determination

Virginia Policy	Consistent?	Analysis
Fisheries Management	Yes	There would be short-term site-specific adverse effects on fish habitat within the fill placement area due to temporary burial of existing benthic habitat and increased levels of turbidity during and immediately after sand placement. Benthic habitats would recover post-project. No impacts on commercial or recreational fishing are anticipated. The proposed action would not violate the provisions outlined in Code of Virginia § 28.2-200 through 28.2-713 and Code of Virginia § 29.1-100 through 29.1-570.
Subaqueous Lands Management	Yes	The creation of a beach along Wallops Island would affect existing subaqueous areas in the nearshore ocean environment. Elevated turbidity in marine waters would occur during and immediately after beach fill. The newly created beach profile would extend approximately 21 meters (70 feet) above water from the existing shoreline and continue for a maximum of 52 meters (170 feet) underwater, resulting in a new bathymetric profile in the subaqueous lands immediately east of Wallops Island. Permits would be obtained from VMRC to ensure compliance with CZM policies.

Virginia Policy	Consistent?	Analysis
Wetlands Management	Yes	Project activities would not directly impact wetlands.
Dunes Management	Yes	Project activities would involve the creation of a beach and dunes along 6 kilometers (3 miles) of the Wallops Island shoreline over the top of the existing seawall. No destruction of existing dunes would occur. Permits would be obtained from VMRC to ensure compliance with CZM policies.
Non-point Source Pollution Control	Yes	Construction activities could temporarily increase non-point source runoff to the Atlantic Ocean during the duration of the project. NASA would implement appropriate BMPs to minimize the impact. All land-disturbing activities would be conducted on the existing beach (seawall construction and use of north Wallops Island for beach renourishment) and newly created beach.
Point Source Pollution Control	Yes	The project would not involve a new point source discharge to Virginia waters.
Shoreline Sanitation	Yes	The project would not involve the construction of septic tanks.
Air Pollution Control	Yes	Use of equipment for construction of the seawall extension, movement of sand placed on the newly created beach, and excavation of sand at the north end of Wallops Island along with barge operations for dredging and transport of sand would result in emissions. NASA would minimize adverse impacts to air quality by implementing BMPs. The project would not violate Federal or Virginia air quality standards.
Coastal Lands Management	Yes	The proposed project would not include land development activities that would impact the Chesapeake Bay or its tributaries.

4.2.7 Air Quality

All of the activities associated with the Proposed Action Alternatives would occur in an attainment area for all criteria pollutants; therefore, there is no requirement to perform a General Conformity evaluation, which is applicable only to areas designated as non-attainment or maintenance areas. Additionally, it is not necessary to conduct a PSD Applicability Analysis, as there are no stationary emission sources associated with any of the Proposed Action Alternatives. Subsequently, the WFF State operating permit would not be affected or need to be modified.

No Action Alternative

Under the No Action Alternative, activities would remain at present levels as described in Section 3.1.9 (calendar year 2008 WFF GHG emissions tables) and there would be no additional impacts to air quality and no increase in GHG emissions.

Environmental Consequences

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

Seawall Extension

Prior to the construction of the seawall extension, the rock material would need to be brought onto WFF, transported from a specified location (i.e., the New Church, VA, railhead, as the material would initially be transported by train) and stockpiled on the beach near the barge loading area. Emission calculations include those associated with the transport of rock by heavy-duty diesel trucks to an unloading site on the beach. Depending on weather conditions and road conditions/type, these trucks may generate fugitive particulates (i.e., dust) while traveling on roads from the railhead to Wallops Island. However, these emissions would be minimized by implementing BMPs such as lower speed limits for construction-related equipment and the implementation of dust suppression procedures (e.g., application of water) when necessary.

During the construction phase of this additional seawall, diesel emissions would be generated mostly from large construction equipment (i.e., heavy lifting equipment such as a crane and dozer) and a marine vessel (i.e., barge). In addition, it was assumed that the construction crew would drive to the work site every day in their personally owned vehicles (POVs, e.g., light-duty trucks), conservatively assuming that each person would drive their own vehicle.

Calculations were performed using approved emission factors and conservative assumptions. To help minimize emissions under this alternative, vehicles and equipment used for all of the proposed construction would be maintained in good working order. Additionally, the non-road diesel engines are required by law to utilize low-sulfur diesel, which must meet a 500 ppm sulfur maximum. Idling of construction equipment would be prohibited where feasible, except for certain equipment (i.e., barge, crane, and loaders) for which idling is necessary and would be unavoidable. Virginia regulations do not impose any idling restrictions on this type of construction equipment. Based on the quantification of criteria emissions (Table 33) and the short duration of time (approximately 3 months) of operating fossil-fuel burning equipment, it is unlikely that these emissions would have an impact on the area's compliance with the NAAQS.

Table 33: Emissions from Construction Activities Associated with Seawall Extension

Emission Sources	Emissions in tons per year					Emissions in metric tonnes per year			
	CO	NO _x	VOC	PM	SO _x	CO ₂	N ₂ O	CH ₄	CO ₂ e
Personal Vehicles (Light-Duty Diesel Trucks)	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	<0.1	<0.1	0.3
Heavy-Duty Diesel Trucks	0.1	<0.1	<0.1	<0.1	<0.1	1.4	<0.1	<0.1	1.4
Tugboat/Barge	5.3	23.0	0.6	0.4	0.4	0.3	<0.1	<0.1	0.3
Construction Equipment	1.4	4.6	0.5	0.3	<0.1	508.6	<0.1	<0.1	513.7
TOTAL	6.9	27.7	1.1	0.7	0.50	510.5	<0.1	<0.1	515.7

Beach Fill – Sand Placement and Dredging Operations

Initial Beach Fill

During the initial beach fill, air emissions would result from propulsion of the barge when in transit between the borrow site and the mooring buoy, dredging, pumping of sand to the beach, placement and relocation of mooring buoys, and the placement of beach fill material. It is assumed that two hopper dredges would operate simultaneously. Each vessel would be equipped with propulsion engines totaling 8,000 horsepower (hp) and pumping/jetting engines totaling 5,000 hp, and would carry an average of 2,300 m³ (3,000 yd³) per trip. Allowance was made for 10 percent downtime for equipment operation due to refueling, weather, or mechanical problems. For Unnamed Shoal A, the one-way travel distance from the shoal site to the mooring buoy would be 27 km (17 mi), and the barge would make an average of 3.1 round trips per day. For Unnamed Shoal B, the travel distance would be 35 km (22 mi) and the barge would make an average of 2.6 round trips per day. The duration of dredging would be 216 days for Shoal A and 257 days for Shoal B.

The initial placement and relocations of the mooring buoys would be accomplished using a 5,000-hp derrick barge, two 2,000-hp work barges, and two 1,000-hp tender tugs. Placement and removal would take a total of 12 hours per buoy. It was assumed that there would be 10 separate placements and removals over the duration of the project. Beach fill activities would require four 215-hp bulldozers operating 24 hours per day at each of two sites where sand would be pumped to shore. In addition, a light all terrain vehicle (ATV) or light truck would be needed.

Emissions for barge propulsion and tug boats were based on the EPA report entitled *Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories* (EPA, 2009c). Emissions from the pumps and generators were based on AP-42 (EPA, 2009b). The total estimated emissions are presented in Table 34. To help minimize emissions under this alternative, vehicles and equipment used for all of the proposed activities would be maintained in good working order. Additionally, the ATV would be subject to the non-road diesel engines requirements to utilize low-sulfur diesel, which must meet a 500-ppm sulfur maximum. Idling of equipment would be prohibited where feasible, except for the barge, for which idling is necessary and would be unavoidable. The Commonwealth of Virginia regulations do not impose any idling restrictions on this type of equipment. There would be temporary, localized increases in the concentration of these pollutants in the ambient air. Most of the area affected would be over water. Based on the quantification of criteria emissions (see Table 34) and the short duration of time (approximately 7 months) of operating fossil-fuel-burning equipment, it is unlikely that these emissions would have an impact on the area's compliance with the NAAQS.

Environmental Consequences

Table 34: Alternative One Emissions from Dredging and Initial Beach Fill

Unnamed Shoal A	Tons per year					Metric tonnes per year			
	CO	NO _x	VOC	PM	SO _x	CO ₂	N ₂ O	CH ₄	CO ₂ e
Dredging and Transport	84.0	664.7	22.9	20.0	9.8	27,886	0.9	0.5	28,178
Relocate Mooring Buoys	0.9	7.6	0.3	0.2	0.1	339	<0.1	<0.1	344
Beach Fill Placement	14.9	51.3	3.9	3.5	8.0	29	<0.1	<0.1	30
TOTAL	99.7	723.6	27.1	23.8	18.0	28,255	0.9	0.5	28,552
Unnamed Shoal B	CO	NO _x	VOC	PM	SO _x	CO ₂	N ₂ O	CH ₄	CO ₂ e
Dredging and Transport	95.6	785.9	27.5	24.0	11.6	33,057	1.1	0.6	33,416
Relocate Mooring Buoys	0.9	7.6	0.3	0.2	0.1	339	<0.1	<0.1	334
Beach Fill Placement	17.6	61.1	4.6	4.3	9.6	35	<0.1	<0.1	35
TOTAL	114.1	854.6	32.2	28.6	21.3	33,432	1.1	0.6	33,796

Renourishment from Offshore Borrow Sites

In each of the nine renourishment cycles, a total of 616,000 m³ (806,000 yd³) of sand would be placed on the beach. With dredging operations occurring at both shoals, the duration of the project would be 56 days for Shoal A, and 65 days for Shoal B. The total emissions are provided in Table 35. Air quality impacts would be the same as for the initial beach fill, but would occur over a shorter duration. To minimize downtime due to weather, NASA would conduct renourishment activities in the more favorable summer season when possible.

Table 35: Alternative One Emissions from Dredging and Renourishment Fill

Unnamed Shoal A	Tons per year					Metric tonnes per year			
	CO	NO _x	VOC	PM	SO _x	CO ₂	N ₂ O	CH ₄	CO ₂ e
Dredging and Transport	19.2	151.9	5.2	4.6	2.2	7,025	0.2	0.1	7,098
Relocate Mooring Buoys	0.8	6.9	0.3	0.2	0.1	339	<0.1	<0.1	344
Beach Fill Placement	3.4	11.7	0.9	0.8	1.8	7	<0.1	<0.1	7
TOTAL	23.4	170.6	6.4	5.6	4.2	7,731	0.2	0.1	7,449
Unnamed Shoal B	CO	NO _x	VOC	PM	SO _x	CO ₂	N ₂ O	CH ₄	CO ₂ e
Dredging and Transport	21.9	179.6	6.3	5.5	2.6	8,327	0.3	0.1	8,417
Relocate Mooring Buoys	0.8	6.9	0.3	0.2	0.1	339	<0.1	<0.1	344
Beach Fill Placement	4.0	14.0	1.1	1.0	2.2	9	<0.1	<0.1	9
TOTAL	26.7	200.5	7.6	6.7	4.9	8,675	0.3	0.1	8,770

North Wallops Island Borrow Site

The collection of accumulated sand from the northern end of Wallops Island every 5 years for renourishment of the Wallops Island shoreline would result in emissions from construction crew POVs traveling to and from the work site. In addition, emissions from non-road construction equipment (e.g., excavators, bulldozers) used to collect, transport, and distribute the sand on the beach would occur. It is anticipated that the equipment used for the borrow site activity would include excavators, bulldozers, loaders, and specialized beach-going dump trucks. The excavator would transport the sand to a stockpile, assumed to be at the southern point of the borrow site. At the stockpile, the loaders would move the sand into the bed of each dump truck. Thus, the loaders would need to be stationary and idling continuously during this operation. The internal combustion engines powering all of the construction equipment and vehicles would burn diesel fuel.

Borrow-site-related impacts are expected to be limited to the renourishment activity duration (two months) and area of the activity. Calculations were performed using approved emission factors and conservative assumptions. Based on the quantification of criteria emissions (Table 36), it is unlikely that these emissions would have an impact on the area’s compliance with the NAAQS.

Table 36: Emissions from North Wallops Island Renourishment Activities

Emission Sources	Emissions in tons per year					Emissions in metric tonnes per year			
	CO	NO _x	VOC	PM	SO _x	CO ₂	N ₂ O	CH ₄	CO ₂ e
Pan Excavator	0.2	0.7	<0.1	0.1	<0.1	3.6	<0.1	<0.1	3.6
Bulldozer	1.0	3.5	0.3	0.3	0.3	1.9	<0.1	<0.1	1.9
Dump Truck	1.3	0.8	0.2	0.2	<0.1	12.6	<0.1	<0.1	12.7
Light Duty Trucks (POVs)	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	<0.1	<0.1	0.3
Loader	1.9	4.1	0.5	0.3	0.3	20.1	<0.1	<0.1	20.3
TOTAL	4.5	9.1	1.1	0.9	0.8	38.4	<0.1	<0.1	38.8

Summary of Alternative One Emissions

The No Action Alternative is the baseline for comparison of air quality impacts. Depending on which borrow sites would be utilized for the renourishment cycles, the emissions from each element within this alternative (seawall construction and beach fill) are combined into different scenarios to help demonstrate the estimated emissions (Table 37 and Table 38). Based on the quantification of criteria pollutants for all elements of Alternative One, it is reasonable to conclude that these activities would not have a long-term adverse impact on air quality in the project area.

Environmental Consequences

Table 37: Alternative One Emissions Summary for Initial Beach Fill

Shoal	Emissions in tons per year					Emissions in metric tonnes per year			
	CO	NO _x	VOC	PM	SO _x	CO ₂	N ₂ O	CH ₄	CO ₂ e
A ¹	106.6	756.1	28.2	24.5	18.4	36,930	1.0	0.6	37,257
B ²	121.0	887.1	33.4	29.3	21.8	43,638	1.3	0.6	41,078

¹ Assuming seawall construction and initial beach fill utilizing Shoal A only.

² Assuming seawall construction and initial beach fill utilizing Shoal B only.

Table 38: Alternative One Emissions Summary for Renourishment Beach Fill

Borrow Site	Emissions in tons per year					Emissions in metric tonnes per year			
	CO	NO _x	VOC	PM	SO _x	CO ₂	N ₂ O	CH ₄	CO ₂ e
A ¹	25.8	188.1	7.1	6.2	4.6	9,464	0.1	0.3	9,513
B ²	29.4	221.0	8.4	7.4	5.5	11,154	0.3	0.2	11,259
A-W.I. ³	20.5	132.1	5.4	5.0	3.7	6,341	0.1	0.2	6,374
B-W.I. ⁴	22.9	154.1	6.3	5.8	4.2	7,468	0.2	0.1	7,538

¹ Assuming renourishment utilizing Shoal A only.

² Assuming renourishment utilizing Shoal B only.

³ Assuming half of renourishment is obtained from Shoal A and half from the north Wallops Island borrow site.

⁴ Assuming half of renourishment is obtained from Shoal B and half from the north Wallops Island borrow site.

W.I. = Wallops Island

Although there are no formally adopted NEPA thresholds of significance for GHG emissions, there are a multitude of State and regional regulatory programs requiring GHG emissions reductions. The Governor of Virginia issued EO 59 in 2007, which established the “Governor’s Commission on Climate Change” (Bryant, 2008). However, due to the absence of such thresholds, it is challenging to determine the level of proposed emissions that would substantially contribute to global climate change.

Given the absence of science-based or adopted NEPA significance thresholds for GHGs, the CO₂e emissions from Alternative One are compared to the EPA GHG baseline inventory of 2007 to determine the relative increase in proposed GHG emissions.

Table 39 summarizes the annual GHG emissions from Alternative One and the most recent U.S. annual baseline GHG emissions. These data show the ratio of CO₂e emissions resulting from Alternative 1 to all sources in the United States is approximately 0.047/7,150 million metric tonnes. CO₂e emissions from this alternative would amount to approximately 6.62x10⁻⁴ percent of the total GHG emissions generated by the United States. GHG emissions from Alternative One are the highest of all proposed alternatives; therefore, it can be assumed that under any of the other alternatives, the cumulative impacts of GHG emissions would not be substantial.

Table 39: Alternative One Construction Emissions for Wallops Mainland/Island

Scenario/Activity	Emissions
Alternative One ¹ (metric tonnes per year)	47,325
U.S. 2007 Baseline Emissions ² (10 ⁶ metric tonnes per year)	7,150
Proposed Emissions as a % of U.S. Emissions	6.62x10 ⁻⁴

Source: EPA, 2009b

¹Total emissions for Alternative One assume of use of Shoal A only for initial and renourishment fills, and Wallops Island construction emissions

²Baseline emissions include all rocket launches from WFF during 2007

Alternative Two: Full Beach Fill, Groin, Seawall Extension

Seawall Extension

The construction activities and emissions associated with the seawall extension would be the same as outlined under Alternative One.

Groin

Similar to construction of the seawall extension, the groin construction would require similar-sized rocks, which would also be transported by heavy-duty trucks from the same train depot location. However, the number of vehicle trips would be less due to the smaller size of the groin compared to the seawall extension.

Similar to Alternative One, calculations were performed using approved emission factors and conservative assumptions. Construction activities for this alternative include those associated with the seawall extension and groin. Mitigation of emissions would be similar to Alternative One. Based on the quantification of criteria (Table 40) and the short duration (approximately 1 month) of operating fossil-fuel burning equipment for the groin construction, it is unlikely that these emissions would have an impact on the area’s compliance with the NAAQS.

Table 40: Emissions from Groin Construction Activities

Emission Sources	Emissions in tons per year					Emissions in metric tonnes per year			
	CO	NO _x	VOC	PM	SO _x	CO ₂	N ₂ O	CH ₄	CO ₂ e
Personal Vehicles (Light-Duty Diesel Trucks)	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Heavy-Duty Diesel Trucks	0.2	0.1	<0.1	<0.1	<0.1	0.2	<0.1	<0.1	0.2
Tugboat/Barge	7.4	29.4	1.2	0.9	1.0	1,049.2	<0.1	<0.1	1078.6
Construction Vehicles	1.9	6.3	0.6	0.5	0.6	1,048.7	<0.1	<0.1	1078.0
TOTAL	9.5	35.8	1.9	1.4	1.6	2,098.1	0.2	<0.1	2,156.8

Beach Fill

Initial Beach Fill

With dredging operations occurring at both shoals, the duration of the project would be 197 days for Shoal A and 234 days for Shoal B. The total emissions are provided in Table 41. Air quality impacts would be the same as for the Alternative One initial beach fill.

Environmental Consequences

Table 41: Alternative Two Emissions from Dredging and Initial Beach Fill

Unnamed Shoal A	Tons per year					Metric tonnes per year			
	CO	NO _x	VOC	PM	SO _x	CO ₂	N ₂ O	CH ₄	CO ₂ e
Dredging and Transport	76.6	606.0	20.9	18.2	8.9	25,414	0.8	0.5	25,679
Relocate Mooring Buoys	0.9	7.6	0.3	0.2	0.1	339	<0.1	<0.1	344
Beach Fill Placement	13.6	46.7	3.5	3.2	7.4	27	<0.1	<0.1	27
TOTAL	91.0	660.3	24.8	21.7	16.4	25,780	0.8	0.5	26,051
Unnamed Shoal B	CO	NO _x	VOC	PM	SO _x	CO ₂	N ₂ O	CH ₄	CO ₂ e
Dredging and Transport	87.2	716.3	25.0	21.9	10.5	30,126	1.0	0.5	30,453
Relocate Mooring Buoys	0.9	7.6	0.3	0.2	0.1	339	<0.1	<0.1	344
Beach Fill Placement	16.1	55.7	4.2	3.9	8.7	32	<0.1	<0.1	32
TOTAL	104.1	779.6	29.5	26.1	19.4	30,498	1.0	0.5	30,830

Renourishment from Offshore Borrow Sites

With dredging operations occurring at both shoals, the duration of the project would be 49 days for Shoal A and 58 days for Shoal B. The total emissions are given in Table 42. The air quality impacts would be the same as for the initial beach fill, but would occur over a shorter duration. Renourishment activities would be carried out in the more favorable summer season when possible, thus avoiding downtime due to weather.

Table 42: Alternative Two Emissions from Dredging and Renourishment Fill

Unnamed Shoal A	Tons per year					Metric tonnes per year			
	CO	NO _x	VOC	PM	SO _x	CO ₂	N ₂ O	CH ₄	CO ₂ e
Dredging and Transport	17.2	136.1	4.7	4.1	2.0	6,292	0.2	0.1	6,358
Relocate Mooring Buoys	0.8	6.9	0.3	0.2	0.1	339	<0.1	<0.1	344
Beach Fill Placement	3.0	10.5	0.8	0.7	1.6	7	<0.1	<0.1	7
TOTAL	21.0	153.5	5.8	5.1	3.8	6,638	0.2	0.1	6,709
Unnamed Shoal B	CO	NO _x	VOC	PM	SO _x	CO ₂	N ₂ O	CH ₄	CO ₂ e
Dredging and Transport	19.6	160.9	5.6	4.9	2.4	7,459	0.3	0.1	7,540
Relocate Mooring Buoys	0.8	6.9	0.3	0.2	0.1	339	<0.1	<0.1	344
Beach Fill Placement	3.6	12.5	0.9	0.9	2.0	8	<0.1	<0.1	8
TOTAL	24.0	180.3	6.8	6.0	4.4	7,806	0.3	0.1	7,892

North Wallops Island Borrow Site

Impacts from borrow site activities associated with sand removal from north Wallops Island would be slightly less than those described under Alternative One.

Summary of Alternative Two Emissions

The No Action Alternative is the baseline for comparison of air quality impacts. Depending on what sources would be utilized for one of the renourishment activities, the emissions from each element within this alternative are combined into different scenarios to help demonstrate the estimated emissions (Table 43 and Table 44). Based on the quantification of criteria pollutants for all elements of Alternative Two, it is reasonable to conclude that these activities would not have a long-term adverse impact on air quality in the project area. It is not possible to address the significance of potential impacts from GHG emissions, and therefore no significance conclusion or mitigation can be made or adopted due to the lack of regulatory guidance for that determination to be sound (Jones and Stokes, 2007).

Table 43: Alternative Two Emissions Summary for Initial Beach Fill

Shoal	Emissions in tons per year					Emissions in metric tonnes per year			
	CO	NO _x	VOC	PM	SO _x	CO ₂	N ₂ O	CH ₄	CO ₂ e
A ¹	100.4	696.1	26.7	23.1	18.1	35,329	1.1	0.5	35,678
B ²	113.6	815.4	31.4	37.5	21.0	41,444	0.3	0.6	41,547

¹Assuming groin, seawall extension, and initial beach fill utilizing Shoal A only.

²Assuming groin, seawall extension, and initial beach fill utilizing Shoal B only.

Environmental Consequences

Table 44: Alternative Two Emissions Summary for Renourishment Beach Fill

Borrow Site	Emissions in tons per year					Emissions in metric tonnes per year			
	CO	NO _x	VOC	PM	SO _x	CO ₂	N ₂ O	CH ₄	CO ₂ e
A ¹	23.2	169.2	6.4	5.6	4.2	8,517	0.2	0.1	8,581
B ²	26.5	198.8	7.5	6.6	4.9	10,031	0.3	0.1	10,126
A-W.I. ³	18.3	118.7	4.9	4.5	3.3	5,7051	<0.1	<0.1	5,749
B-W.I. ⁴	20.5	138.4	5.6	5.2	3.8	6,716	<0.1	<0.1	6,779

¹Assuming renourishment utilizing Shoal A only.

²Assuming renourishment utilizing Shoal B only.

³Assuming half of renourishment is obtained from Shoal A and half from the north Wallops Island borrow site.

⁴Assuming half of renourishment is obtained from Shoal B and half from the north Wallops Island borrow site.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

Seawall Extension

The construction activities, and subsequent emissions, associated with the seawall extension would be the same as outlined under Alternative One.

Breakwater

Similar to construction of the seawall extension, the breakwater construction would require similar-sized rocks, which would also be transported by heavy-duty trucks from the same train depot location. However, the number of vehicle trips would be less due to the smaller size of the breakwater compared to the seawall extension. Although the breakwater could be constructed entirely from land or from barges in the ocean, the ocean-construction scenario was used in the emissions analysis. Equipment that would likely be used for the breakwater construction from the ocean is anticipated to include dump trucks, a tugboat and barge, and a crane. The internal combustion engines powering the construction equipment and vehicles would burn diesel fuel.

Similar to Alternative One, calculations were performed using approved emission factors and conservative assumptions. The construction activities for this alternative include those associated with the seawall extension and breakwater. The mitigation of emissions would be similar to Alternative One. Based on the quantification of criteria emissions (Table 45) and the short duration (approximately 1 month) of operating fossil-fuel burning equipment for this construction, it is unlikely that these emissions would have an impact on the area's compliance with the NAAQS.

Table 45: Emissions from Breakwater Construction Activities

Emission Sources	Emissions in tons per year					Emissions in metric tonnes per year			
	CO	NO _x	VOC	PM	SO _x	CO ₂	N ₂ O	CH ₄	CO ₂ e
Personal Vehicles (Light-Duty Diesel Trucks)	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	<0.1	<0.1	0.4
Heavy-Duty Diesel Trucks	0.2	0.10	<0.1	<0.1	<0.1	1.5	<0.1	<0.1	1.6
Tugboat/Barge	6.6	28.8	0.8	0.5	0.5	0.4	<0.1	<0.1	0.4
Construction Vehicles	1.7	5.5	0.5	0.4	0.5	752.2	<0.1	<0.1	758.5
TOTAL	8.5	34.4	1.3	0.9	1.0	754.5	<0.1	<0.1	760.8

Beach Fill

Initial Beach Fill

With dredging operations at both shoals, the duration of the project would be 192 days for Shoal A and 228 days for Shoal B. The total emissions are given in Table 46. The air quality impacts and mitigation strategies would be the same as for the Alternative One beach fill.

Table 46: Alternative Three Emissions from Dredging and Initial Beach Fill

Unnamed Shoal A	Tons per year					Metric tonnes per year			
	CO	NO _x	VOC	PM	SO _x	CO ₂	N ₂ O	CH ₄	CO ₂ e
Dredging and Transport	74.5	590.0	20.4	17.8	8.7	24,743	0.8	0.4	25,001
Relocate Mooring Buoys	0.9	7.6	0.3	0.2	0.1	339	<0.1	<0.1	344
Beach Fill Placement	13.1	45.5	3.4	3.2	7.2	26	<0.1	<0.1	26
TOTAL	88.5	643.1	24.1	21.2	16.0	25,108	0.8	0.5	25,372
Unnamed Shoal B	CO	NO _x	VOC	PM	SO _x	CO ₂	N ₂ O	CH ₄	CO ₂ e
Dredging and Transport	84.9	697.5	24.4	21.4	10.3	29,331	1.0	0.5	29,649
Relocate Mooring Buoys	0.9	7.6	0.3	0.2	0.1	339	<0.1	<0.1	344
Beach Fill Placement	15.7	54.1	4.1	3.7	8.5	31	<0.1	<0.1	31
TOTAL	101.4	759.2	28.8	25.4	18.9	29,701	1.0	0.5	30,023

Renourishment from Offshore Borrow Sites

With dredging operations occurring at both shoals, the duration of the project would be 47 days for Shoal A and 57 days for Shoal B. The total emissions are given in Table 47. The air quality impacts would be the same as for the initial beach fill, but would occur over a shorter duration.

Environmental Consequences

Table 47: Alternative Three Emissions from Dredging and Renourishment Fill

Unnamed Shoal A	Tons per year					Metric tonnes per year			
	CO	NO _x	VOC	PM	SO _x	CO ₂	N ₂ O	CH ₄	CO ₂ e
Dredging and Transport	16.7	132.5	4.6	4.0	2.0	6,127	0.2	0.1	6,191
Relocate Mooring Buoys	0.8	6.9	0.3	0.2	0.1	339	<0.1	<0.1	344
Beach Fill Placement	3.0	10.2	0.8	0.7	1.6	6	<0.1	<0.1	7
TOTAL	20.5	149.7	5.6	4.9	3.7	6,473	0.2	0.1	6,541
Unnamed Shoal B	CO	NO _x	VOC	PM	SO _x	CO ₂	N ₂ O	CH ₄	CO ₂ e
Dredging and Transport	19.1	156.6	5.5	4.8	2.3	7,459	0.2	0.1	7,342
Relocate Mooring Buoys	0.8	6.9	0.3	0.2	0.1	339	<0.1	<0.1	344
Beach Fill Placement	3.5	12.2	0.9	0.8	1.9	8	<0.1	<0.1	8
TOTAL	23.3	175.7	6.6	5.9	4.3	7,806	0.3	0.1	7,694

North Wallops Island Borrow Site

The impacts from borrow-site activities associated with sand removal from north Wallops Island would be slightly less than those described under Alternative One.

Summary of Alternative Three Emissions

The No Action Alternative is the baseline for comparison of air quality impacts. Depending on what sources would be utilized for one of the renourishment activities, the emissions from each element within this alternative are combined into different scenarios to help demonstrate the estimated emissions (see Table 48 and Table 49). Based on the quantification of criteria pollutants for all elements of Alternative Three, it is reasonable to conclude that these activities would not have a long-term adverse impact on air quality in the project area. It is not possible to address the significance of potential impacts from GHG emissions, and therefore no significance conclusion or mitigation can be made or adopted due to the lack of regulatory guidance for that determination to be sound (Jones and Stokes, 2007).

Table 48: Alternative Three Emissions Summary for Initial Beach Fill

Shoal	Emissions in tons per year					Emissions in metric tonnes per year			
	CO	NO _x	VOC	PM	SO _x	CO ₂	N ₂ O	CH ₄	CO ₂ e
A ¹	97.0	677.5	25.5	22.1	17.0	33,119	0.9	0.8	33,421
B ²	109.9	793.6	30.1	26.3	19.9	39,072	1.1	0.5	39,430

¹Assuming groin, seawall extension, and initial beach fill utilizing Shoal A only.

²Assuming groin, seawall extension, and initial beach fill utilizing Shoal B only.

Table 49: Alternative Three Emissions Summary for Renourishment Beach Fill

Borrow Site	Emissions in tons per year					Emissions in metric tonnes per year			
	CO	NO _x	VOC	PM	SO _x	CO ₂	N ₂ O	CH ₄	CO ₂ e
A ¹	22.6	165.1	6.2	5.4	4.1	8,303	0.2	0.1	8,367
B ²	25.7	193.7	7.3	6.5	4.7	9,778	0.3	0.1	9,873
A-W.I. ³	18.0	116.1	4.8	4.4	3.4	5,564	0.1	<0.1	5,607
B-W.I. ⁴	20.1	135.2	5.5	5.1	3.9	6,547	0.2	<0.1	6,611

¹Assuming renourishment utilizing Shoal A only.

²Assuming renourishment utilizing Shoal B only.

³Assuming half of renourishment is obtained from Shoal A and half from the north Wallops Island borrow site.

⁴Assuming half of renourishment is obtained from Shoal B and half from the north Wallops Island borrow site.

4.2.8 Noise

The following text describes potential impacts on the airborne noise environment. Potential underwater noise impacts on marine mammals are described in Section 4.3.10.

No Action Alternative

Under the No Action Alternative, project-specific short-term impacts on noise would occur during maintenance and emergency repair activities. Impacts on noise would be dependent on the type, length, and frequency of the activities, but are not anticipated to be significant.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

There are no adjacent sensitive noise receptors, such as residential areas, churches, schools, and recreation areas close enough to Wallops Island to be affected by noise generated from SRIPP activities.

Under Alternative One, there would be temporary increases in noise levels from the operation of heavy equipment on Wallops Island, especially in the beach area during construction of the seawall, moving the beach fill into place, or during sediment removal at the north Wallops Island borrow site. However, none of the project activities would occur near occupied facilities, so noise impacts on WFF employees and tenants would be minimal. Additionally, SRIPP activities, including haul trucks traveling on Wallops Island roads, are not anticipated to be outside the range of existing noise levels from vehicles, airplanes, and barges at WFF. NASA would comply with local noise ordinances and State and Federal standards and guidelines for potential impacts on humans caused by construction activities in order to mitigate potential impacts on NASA personnel.

OSHA limits noise exposure for workers to 115 dB for a period of no longer than 15 minutes in an 8-hour work shift, and to 90 dB for an entire 8-hour shift. Workers near activities producing unsafe noise levels, both on land and water, would be required to wear hearing protection equipment. Therefore, impacts on the occupational health of construction workers as a result of construction noise are not expected.

Ambient underwater sound levels at the offshore borrow sites would increase during dredge operations. Much of the sound produced during filling of the hopper is associated with propeller and engine noise with additional sounds emitted by pumps and generators.

Environmental Consequences

Alternative Two: Full Beach Fill, Groin, Seawall Extension

Under Alternative Two, the types of impacts and mitigation measures would be the same as described under Alternative One; however increased noise levels at the south end of Wallops Island would continue for a longer period of time compared to Alternative One due to construction of the groin in that area.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

Under Alternative Three, the types of impacts and mitigation measures would be the same as described under Alternative One; however, increased noise levels at the south end of Wallops Island would continue for a longer period of time compared to Alternative One due to construction of the breakwater in that area.

4.2.9 Hazardous Materials and Hazardous Waste Management

No Action Alternative

Under the No Action Alternative, impacts from hazardous materials and hazardous waste are possible because existing infrastructure containing storage areas or accumulation points would continually be at risk from wave overtopping and flooding (especially during severe storm events), as well as continued shoreline retreat. NASA would likely remove hazardous materials and hazardous wastes from Wallops Island more frequently and prior to threatening weather to lessen potential impacts from hazardous materials and hazardous waste.

Maintenance or emergency repair activities may include the use of hazardous materials and hazardous waste generation (i.e., solvents, hydraulic fluid, oil, and antifreeze). With implementation of safety measures and proper procedures for the handling, storage, and disposal of hazardous materials and wastes during construction activities, no adverse impacts are anticipated during construction.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

Construction activities would include the use of hazardous materials and hazardous waste generation (i.e., solvents, hydraulic fluid, oil, and antifreeze). With implementation of safety measures and proper procedures for the handling, storage, and disposal of hazardous materials and wastes during construction activities, no adverse impacts are anticipated during construction.

The short- and long-term effects of an accident on the environment would vary greatly depending upon the type of accident and the substances involved. NASA has implemented various controls to prevent or minimize the effects of an accident involving hazardous materials on NASA property, including the following:

- Preparation of an ICP
- Preparation of emergency plans and procedures designed to minimize the effect an accident has on the environment
- Maintenance of an online database of hazardous materials and the associated buildings where they are stored or used, which would be updated to include the new facilities
- Annual training for all users of hazardous materials

Implementation of Alternative One would have a beneficial impact by restoring the shoreline and increasing the distance between breaking waves and hazardous materials critical storage areas and accumulation points. No impacts on ASTs or USTs are anticipated under Alternative One because the tanks are not located within the project area. In the event of a petroleum or chemical release during construction activities, or the disturbance or movement of an AST or UST, NASA would notify VDEQ. Section 62.1-44.34:19.1 of the Code of Virginia requires an operator of a facility with a total aboveground storage capacity of more than 4,997 liters (1,320 gallons) of oil, or an operator of an individual AST with a storage capacity of more than 2,498 liters (660 gallons) of oil to register the facility or AST. ASTs with a storage capacity of 2,498 liters (660 gallons) of oil or less are exempt from registration. NASA would ensure that contractors providing ASTs to the work site have registered the ASTs as necessary to comply with Section 62.1-44.34:19.1 of the Code of Virginia.

When barge operators and any SRIPP contractors are operating vessels that are carrying hazardous waste materials, NASA would ensure that the contractors are in compliance with 49 CFR Part 176 – Carriage by Vessel.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

The types of hazardous materials and hazardous waste management impacts, minimization and mitigation measures, and regulations for Alternative Two are the same types as those described under Alternative One.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

The types of hazardous materials and hazardous waste management impacts, minimization and mitigation measures, and regulations for Alternative Three are the same types as those described under Alternative One.

4.2.10 Munitions and Explosives of Concern

No Action Alternative

Under the No Action Alternative the SRIPP would not be implemented but emergency measures may still be implemented to protect at-risk infrastructure. It is not anticipated that MEC would constitute a safety hazard in the areas near the shoreline where maintenance or emergency repair activities would occur. However, MEC (both UXO and DMM) from the former National Advisory Committee for Aeronautics (NACA)/NASA EOD Area (Figure 34) may migrate to the Atlantic Ocean if further beach erosion occurs in the project area (USACE, 2007). Therefore, the No Action Alternative would result in potentially adverse impacts as it relates to MEC.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

MEC are not anticipated to be encountered on the Wallops Island shoreline in the area of seawall construction or beach fill. It is anticipated that shoreline erosion would increase to the south of the seawall extension, which includes the area known as the former NACA/NASA EOD Area. MEC (both UXO and DMM) may migrate to the ocean if further beach erosion occurs in this area (USACE, 2007). The SRIPP beach fill would reduce the potential of MEC migration into the ocean.

During offshore dredging activities, MEC are not anticipated to be encountered on Unnamed Shoal A or B. If MEC is inadvertently encountered during dredging and accidentally placed on

Environmental Consequences

the Wallops Island shoreline, NASA personnel would notify the WFF Security office, who would arrange to have them properly removed.

There is a potential that MEC would be encountered during excavation of the north Wallops Island borrow site. As described in Chapter 3, historic military activities in that area have resulted in a high probability of encountering MEC in the nearshore environment and on the northern end of Wallops Island. As seen on Figure 34, the sea target impact and the small arms range safety fan overlap the accreting shoreline of north Wallops Island.

To minimize the risk of adverse impacts from UXO in this area, an MEC Avoidance Plan that addresses the potential hazards would be prepared. A visual and magnetic survey of the area to locate MEC would be completed and potential hazards removed prior to excavation.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

Impacts related to MEC would be the same as described under Alternative One. No MEC is anticipated to be encountered in the area of the groin. Construction of a groin would reduce the rate of shoreline erosion, minimizing the possibility of MEC migration into the ocean via beach erosion.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

Impacts related to MEC would be the same as described under Alternative One. No MEC is anticipated to be encountered in the area of the breakwater. Construction of a breakwater would reduce the rate of shoreline erosion, minimizing the possibility of MEC migration into the ocean via beach erosion.

4.3 BIOLOGICAL ENVIRONMENT

4.3.1 Vegetation

No Action Alternative

Under the No Action Alternative, the SRIPP would not be implemented; however, maintenance and emergency repair activities would occur. Vegetation associated with the dune and swale zones and the shrub, thicket, and maritime forest areas located at the southern end of the island would continue to be at-risk as the shoreline continues to retreat. The ongoing accretion at the northern end of Wallops Island would continue to provide substrate for the establishment and development of vegetative communities.

Increased overwash events would impact coastal vegetation on Wallops Island. Apart from the physical destruction of plants by overwash processes, fluctuations in the elevation of the water table and variations in groundwater salinity, both spatially and temporally, would have an adverse impact on vegetation patterns. Overwash events would erode and strip vegetation in some areas and deposit sediment on other areas, burying vegetation.

The No Action Alternative could result in temporary adverse impacts on vegetation due to disturbance and removal for emergency repairs and maintenance activities. Impacts would be minimized by avoiding naturally vegetated areas and re-vegetating after construction. Over time, because this alternative would not prevent shoreline retreat, vegetation in the dune and shore environments may be adversely affected.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

Alternative One would reduce the factors currently contributing to the loss of vegetative beach habitat on Wallops Island: inundation from storms, wave energy, and loss of sand. The high energy environment of the beach and surf zone cannot be tolerated by the majority of vegetation, except for a few plants which exist in the subtidal zone, phytoplankton, macroalgae, and some algae attached to substructure.

It is anticipated that under Alternative One there would be some temporary impacts on vegetation during the construction of the seawall and placement of beach fill for initial and renourishment cycles. The movement of dump trucks carrying the seawall components would likely disturb some vegetation in the upper beach zone, as would any equipment used during sand placement activities.

Addition of sand to the shoreline would result in long-term beneficial impacts on existing vegetation. The presence of a beach is an important buffer for other vegetative zones on Wallops Island. The SRIPP would create beach and dune habitat along approximately 6.0 km (3.7 mi) of shoreline where none currently exists. In addition, NASA would plant the dune with American beachgrass and install sand fencing as a dune profile stabilization measure. Naturally occurring grasses would also likely repopulate the upper dune areas. Vegetative species associated with dune and swale systems would benefit from the expanded beach habitat that would be created under Alternative One. Shrub, thicket, and marine forest systems on the island would have additional storm damage reduction from erosion and wave action.

During renourishment cycles from the northern part of Wallops Island, vegetation is not expected to be disturbed because the pan excavator and other equipment would travel along the unvegetated beach to reach the upland borrow site. NASA would avoid removing sand from vegetated areas to the extent practicable. However, minor adverse impacts may occur (e.g., uprooting, crushing).

Overall, it is anticipated that Alternative One would result in beneficial impacts on Wallops Island vegetation by creation of new habitat where none currently exists.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

Under Alternative Two, the types of impacts on vegetation would be the same as those discussed under Alternative One; however, less beach fill volume (initial and renourishment volumes) would be required compared to Alternative One. Although there would be a slightly smaller amount of vegetative beach habitat created initially, the groin would further reduce the amount of wave energy reaching the beach and would reduce longshore sediment transfer from Wallops Island shoreline. This would help maintain the beach as both a vegetative habitat for beach grasses and a buffer for other vegetative zones present on Wallops Island.

The groin would be constructed partially on land, partially in the ocean. It is anticipated that there would be temporary impacts on vegetation during the portion of the construction on land. The movement of dump trucks carrying the groin components would likely tread on vegetation in the upper beach zone; however, adverse effects are anticipated to be temporary and minor.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

Under Alternative Three, the types of impacts on vegetation would be the same as those discussed under Alternative One; however, less beach fill volume (initial and renourishment

Environmental Consequences

volumes) would be required compared to Alternative One. Although there would be a slightly smaller amount of vegetative beach habitat created initially, the breakwater would further reduce the amount of wave energy reaching the beach and would reduce longshore sediment transfer from Wallops Island shoreline. This would help maintain the beach as both a vegetative habitat for beach grasses and a buffer for other vegetative zones present on Wallops Island. The breakwater would be constructed entirely in the ocean, so there would be no construction impacts on vegetation.

4.3.2 Wildlife

4.3.2.1 *Invertebrates, Amphibians, Reptiles, and Mammals*

No Action Alternative

Under the No Action Alternative, the SRIPP would not be implemented; however, maintenance and emergency repair activities would occur. Based on past trends of sediment transport and erosion in the region, it is reasonable to assume that under the No Action Alternative substantial changes to Wallops Island shoreline would continue to occur. Over time, this could alter the type and magnitude of terrestrial wildlife habitats present on Wallops Island.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

The majority of terrestrial wildlife is found in the northern dune and swale zone and the western freshwater and brackish marshes of Wallops Island. Reptiles and amphibians are found among the vegetation of the dune and swale zone, so it is unlikely that they would be adversely affected by beach fill and seawall construction activities since these would not occur in the dune and swale environment. Mammals inhabit the dune and swale zone, as well as the maritime forest in the center of the island. It is unlikely that there would be any concentration of mammals in either the seawall construction area, or in the beach nourishment area of the Wallops Island shoreline. Although they may occasionally venture into the upper beach zone, they would become startled by SRIPP-related noises and activity, and would quickly vacate the area.

Temporary adverse impacts on upper beach invertebrates, such as ghost crabs, on existing portions of the beach may occur during implementation of Alternative One. Bulldozing to shape the beach has been shown to reduce the populations of ghost crabs by over 50 percent up to three months after construction activities have ended (Peterson et al., 2000). After the initial construction of the new beach, ghost crabs would be expected to recolonize the area. The length of time it would take for reestablishment of background densities would be dependent on a number of factors such as the time of year construction activity ends and weather events. Ghost crabs spawn from April through July in the mid-Atlantic. From roughly October through April, they “hibernate” in their burrows (Leber 1982). Hobbs et al. (2008) reported that high-energy weather events reset ghost crab populations that had been reduced by off-road vehicle traffic. As a result, storm events after beach fill events may facilitate recolonization of the beach from spring through fall. Regardless, as a relatively small area of existing beach would be affected by the initial beach construction, effects would not be substantial.

Renourishment and dune maintenance would likely be more disruptive to upper beach invertebrates as they would be expected to inhabit the newly created beach and would then be subject to effects such as displacement, disruption of feeding, reduction in prey base, crushing, or burial. Given their seasonal distribution, greater impacts may be realized from spring through

fall. In addition, ghost crabs are primarily nocturnal and feed on the foreshore and therefore may be more susceptible the effects of construction activities at night. If renourishment and maintenance activities were conducted at a frequency that would allow for species recovery, effects would be short-term (on the order of several months). However, a persistent need to renourish or mechanically maintain the upper beach or dune could counteract recovery, with the geographic extent of effects based upon how much of the beach must be re-worked.

Reptiles, amphibians, and invertebrates would also experience adverse impacts to their habitat during future renourishment cycles if sand is borrowed from the unvegetated beach of north Wallops Island. However, these adverse impacts would be temporary and highly localized.

Terrestrial species found inland in vegetated areas may become startled by construction-related noises, but this would be temporary and would only last the duration of the construction.

Excavation of the north Wallops Island borrow site could also potentially result in the loss of nesting habitat for the diamondback terrapin. Although the impact would likely be temporary due to accretion on the north end of Wallops Island, the area may remain unsuitable as habitat until more natural elevations are re-established by shoreline processes. If more frequent renourishment cycles are needed than currently planned, the beach area may not fully recover as a viable nesting area for terrapins. However, because there are other known nesting habitats for terrapins on Wallops Island, impacts are not expected to be substantial.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

The types of impacts on terrestrial wildlife discussed under Alternative One would be the same for Alternative Two. However, because less beach fill volume (initial and renourishment volumes) would be required compared to Alternative One, there would be fewer barge trips, less material obtained from north Wallops Island and less potential for disturbance to invertebrates through smothering or habitat loss.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

The types of impacts on terrestrial wildlife discussed under Alternative One would be the same for Alternative Three. However, because less beach fill volume (initial and renourishment volumes) would be required compared to Alternative One, there would be fewer barge trips, less material obtained from north Wallops Island and, therefore, less potential for disturbance to invertebrates through smothering or habitat loss.

4.3.2.2 Birds

Impacts on shorebirds, seabirds and other migratory birds known to breed, nest, and forage along the shoreline of Wallops Island are discussed in this section. Impacts on threatened and endangered bird species are addressed in Section 4.3.10.

No Action Alternative

Under the No Action Alternative, the SRIPP would not be implemented; however, maintenance and emergency repair activities would occur. Based on past trends of sediment transport and erosion in the region, it is reasonable to assume that under the No Action Alternative substantial changes to the Wallops Island shoreline would continue to occur. This would adversely affect shorebirds, seabirds, and migratory birds by decreasing the amount of beach habitat.

Environmental Consequences

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

Nearshore and On-shore Impacts

Impacts on shorebirds, seabirds and migratory birds known to breed, nest, and forage along the shoreline of Wallops Island are anticipated. Temporary noise disturbances from both the construction machinery used for seawall extension, movement of beach sand, excavation of the north Wallops Island borrow site, and the dredges are expected to adversely affect birds; however, these noise levels would be similar to existing noise from daily operations, including occasional flights and rocket launches on Wallops Island. Birds which are startled by construction and dredge noise are likely to temporarily leave the immediate area, which could disrupt nesting and foraging activities, and lead to nest predation. The continued presence of birds at WFF, even with the noise from flight and launch operations over the past few decades, suggests that short-term noises have not significantly disturbed birds on the island.

Another potential adverse impact to birds is the disturbance of beach habitat during the placement of sand on Wallops Island shoreline. The placement of sediment on the shoreline may temporarily disturb the breeding, nesting, and feeding activities of seabirds. During beach nourishment, the large amount of sand placed on the beach is anticipated to smother some prey species such as crabs and worms, which inhabit the surface layer of sand. Additionally, the surf zone serves as a nursery and feeding grounds for several species of surf fishes (including pompano, kingfish, spot, and juvenile flounders) that prey upon these benthic invertebrates, and in turn are preyed upon by seabirds. A reduction in the availability of surf zone fishes would adversely affect foraging seabirds. However, studies by Nelson (1985, 1993) and Hackney et al., (1996) report an infaunal recovery time ranging from 2 to 7 months following beach nourishment. Therefore, no long-term adverse affects to seabird foraging capabilities are anticipated.

Studies of the effects of beach nourishment on shorebird populations have reported variable results. For example, Peterson et al. (2006) reported that shorebird (primarily sanderling) use of a filled beach at Bogue Banks, North Carolina was reduced by 70 percent on filled beaches for several months after project completion. They postulated that reduction in shorebird use was in response to a decrease in prey (primarily coquina clam, *Donax* spp.) abundance and possibly much coarser than native sediment that was placed on the beach. Grippo et al. (2007) examined the effects of beach renourishment projects over a two-year study on waterbird and shorebird communities in Brunswick County, North Carolina. No significant effect on total waterbird and shorebird abundance was found, and waterbirds actually increased in number due to the creation of additional beach habitat. Although fewer food resources were present while the benthic communities recovered, no significant differences in feeding activity were observed, although this could have been due to the highly transient nature of the birds.

A beneficial effect of the project would be that the newly constructed beach could potentially create suitable shorebird nesting habitat. Because the created beach would have a sand dune behind it, washover events (that typically create preferred shorebird nesting, feeding, and roosting habitat) would be less frequent than on a natural beach. However, despite a lack of washover, the elevated, sparsely vegetated beach on Wallops Island could be beneficial to beach nesting species during times when other barrier island beaches in the area would be more subject to nest inundation and storm washout.

Currently there is no beach along the existing seawall. As such, there is no beach habitat for birds. Initial placement of beach fill would have little or no impact on birds within the areas where beach does not exist at the present time.

There would be potential impacts on birds during the renourishment phases of the project after the initial beach fill has been placed and habitat and benthic prey populations have had time to develop. The time of year that renourishment is conducted would play a role in dictating the intensity of potential adverse effects. For example, conducting renourishment during the spring could adversely affect the settlement (transition from living in the water column to living on the bottom) of coquina clams that are important prey items for shorebirds; along North Carolina beaches, the first recruits (young individuals that recently transitioned from larvae to juveniles) of the year have been observed during this time frame (Reilly and Bellis, 1983). Coquina clams are an important food source to a number of shorebirds, including Sanderlings, Red Knots, and Willets. Renourishment activities during the summer months would likely be the most disturbing to nesting and foraging shorebirds and could result in inadvertent crushing or burial of nests, startling, and burial of food sources. Both coquina clams and mole crabs (*Emerita* spp.) reach peak larval abundance in the summer (Diaz, 1980). Conducting work in the fall would not have the same potential direct impacts to nesting shorebirds, however it could have a pronounced effect on mole crabs, which experience a fall (in addition to spring) recruitment (settling of larvae on the beach). Diminished fall recruitment could have effects lasting into the following season as fewer females would be available to produce eggs the following spring, indirectly affecting the numerous waterbirds (including Least Terns, Laughing Gulls, and Willets) that feed upon them (Dolan et al., 2004). As nesting birds would no longer be present within the project area and as it is hypothesized that both coquina clams and mole crabs migrate offshore with the movement of sand during the winter (Edwards and Irving, 1943), conducting renourishment work in winter months (November – March) would have the fewest adverse effects on shorebirds. At this time, NASA has not decided the time of year that renourishment would occur; however to minimize impacts on shorebirds it would continue to monitor the Wallops Island beach in accordance with its Protected Species Monitoring Plan (NASA, 2010c) to establish shorebird use trends on the new beach during the times of peak activity (spring – fall). During the planning phase for future renourishment cycles, a variety of factors would be considered, including shorebird use of the beach (temporal and geographic) and magnitude of the required renourishment event. NASA would consult with USFWS and VDGIF in planning all future renourishment cycles to minimize impacts on shorebirds.

Removal of sand from north Wallops Island would likely have the most detrimental long-term effects on shorebird foraging and nesting. In recent years, north Wallops Island has supported a large shorebird population likely due to its gently sloped sand flats, tidal pools, and distance from WFF mission operations. Excavation and movement of sand from this area could result in mortality or burial of food sources (discussed above), thereby reducing the value of the area to feeding shorebirds until infaunal recovery, which could take several months. If the need is identified for renourishment at a greater frequency than the project design of 5 years, infaunal recovery could be interrupted, further impacting the birds' ability to obtain necessary food on north Wallops Island. Coupled with the newly replenished beach large areas of shoreline could be devoid of an adequate prey base for extended periods of time. This impact could lead to shorebirds needing to fly elsewhere to find food. Uniform grading of the area could also remove ephemeral tidal pools, which are highly attractive foraging areas for a number of shorebird species, including Piping Plovers (discussed in Section 4.3.10) and Red Knots. According to

Environmental Consequences

VDGIF, up to 25 percent of Virginia's weekly Red Knot population occurred on Wallops Island during spring migration in recent years (Watts and Truitt, unpubl. data), demonstrating the importance of this area to migrating shorebirds. As such, continued use of the north borrow site without adequate recovery time could present adverse impacts to Red Knots in particular. Impacts on nesting shorebird species could include reduced nest viability from flooding and washout due to the resulting lower beach elevations. The habitat value of north Wallops Island to shorebird species is high, and as such, NASA would only excavate sand for future renourishment outside of plover and sea turtle nesting season (March 15 through November 30 or the last date of potential sea turtle hatchling emergence based on when the last eggs were laid). Additionally, during planning for this component of the SRIPP, NASA would consult with USFWS and VDGIF to identify more site-specific means (targeting certain areas over others) for mitigating impacts.

In conclusion, although Alternative One would have direct and indirect adverse effects on shorebirds that inhabit the areas within and adjacent to Wallops Island, it is reasonable to expect that the newly created beach would offer a substantial amount of habitat for foraging and nesting. As such, the benefits of having 6.0 km (3.7 mi) of beach where there is currently none would outweigh the shorter-term adverse effects, thus presenting a net positive benefit to those species.

Offshore Borrow Sites

Aerial seabird surveys conducted by USFWS in 2001 and 2003 (Forsell, 2003) identified northern gannets, common and red-throated loons, gulls, and scoters within or adjacent to the offshore portion of the project area. These species of birds could be affected by dredging operations. Seabirds target offshore shoals as a source of prey because fish tend to school around shoals. During dredging operations at Unnamed Shoals A or B, noise disturbances from the hopper dredge are expected. These noises may cause seabirds to divert flight patterns or vacate the shoal area, where they sometimes feed on schooling fish and benthos. This impact could lead to seabirds needing to feed on other shoals in the area, which would cause them to expend more energy along their migratory path.

Direct site-specific adverse effects on diving, bottom-feeding seabird species may also occur within the dredged area due to removal of benthic habitat and changes in shoal bathymetry. Dredging different shoal areas could have different effects on species that use the area for feeding. Removing the entire crest of the shoals could reduce upwelling (i.e., upward motion of sub-surface waters and benthic nutrients to surface waters) that could potentially impact foraging quality for gannets, gulls, and pelicans, and would increase the diving depth for many seaducks. Dredging the flanks of the shoals would maintain upwelling, but would reduce shallow water areas of the shoals, lowering the benthic foraging area available to scoters. Dredging into the center of the crest could maintain the upwelling, but could potentially affect sedimentation patterns, resulting in change of substrate and benthic food availability, and it could also increase the diving depth for seaducks (Forsell and Watson, 2006). Over the lifetime of the SRIPP, the dredging plan may involve sand removal from these general areas on Shoals A and B; therefore, a combination of these effects could occur.

There would also be minor direct impacts to seabirds outside the dredging and fill footprints due to turbidity as a result of the dredging and fill placement operations. Seabirds use their sight to locate fish over the shoals, and the increased turbidity caused by dredging may temporarily

impair their feeding ability. However, the sediment is expected to quickly settle from the water column.

Removal of sand from the shoal(s) would lower the topography of the shoal and, as described in Section 4.3.7 (Finfish), may adversely affect fish populations in the area. As a result, dredging may indirectly affect seabird populations that prey on fish present at the shoal by altering fish distribution and populations.

In conclusion, the impacts are not anticipated to be significant within a regional context given the hundreds of shoals and potential forage areas available to the birds within the mid-Atlantic region. The dredging would be shallow and limited to the top several meters of sediment on each shoal and would only affect a portion of each shoal's total surface area. In addition, as described in Section 4.3.5, the benthic organisms within the areas affected by dredging would be expected to recover to pre-dredge levels within a few years.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

The types of impacts on seabirds discussed under Alternative One would be similar to those for Alternative Two. However, because less beach fill volume (initial and renourishment volumes) would be required compared to Alternative One, there would be less sand removed from the offshore shoals, fewer barge trips, and therefore a reduced potential for disturbance of seabird breeding, nesting, and feeding activities.

Noise generated during groin construction could cause temporary disturbance of shorebird nesting and foraging. The groin would provide benefits to fish-eating avifauna by introducing habitat for fish that would be attracted to the structure. In addition, the above water portion of the groin would provide potential roosting and resting area for birds. Construction of a groin may lead to some habitat loss due to erosion within a groin "shadow" approximately 300 m (1,000 ft) downdrift of the structure (see Section 4.2.2.1 for details); however, renourishing the beach would reduce the potential for downdrift erosion by providing continual sand on the Wallops Island shoreline.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

The types of impacts on seabirds discussed under Alternative One would be similar to those for Alternative Three. However, because less beach fill volume (initial and renourishment volumes) would be required compared to Alternative One, there would be less sand removed from the shoals, fewer barge trips, and therefore a reduced potential for disturbance of seabird breeding, nesting, and feeding activities.

Noise generated during breakwater construction could cause temporary disturbance of shorebird nesting and foraging, however it would likely to a lesser degree than the groin due to its location several hundred meters offshore. The breakwater would provide benefits to fish-eating avifauna by introducing habitat for fish that would be attracted to the structure. In addition, the above water portion of the breakwater would provide potential roosting and resting area for birds. Construction of a breakwater may lead to some habitat loss within a 2.5-km (1.5-mi) area downdrift of the structure (see Section 4.2.2.1 for details); however, renourishing the beach would reduce the potential for downdrift erosion by providing continual sand on the Wallops Island shoreline.

Environmental Consequences

4.3.3 Submerged Aquatic Vegetation

No Action Alternative

Under the No Action Alternative, the SRIPP would not be implemented; however, maintenance and emergency repair activities would occur. Maintenance and repair activities may result in very localized and minor increases in turbidity. These increases in turbidity may affect SAV that were found during an October 2009 survey of the north end of Wallops Island.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

As discussed in Chapter 3, SAV is present in small amounts in the coastal bays of Wallops, Assawoman, and Chincoteague Islands. Widgeon grass that was observed during the October 2009 vegetation survey of north Wallops Island would be directly affected if removed during excavation, or indirectly affected by changes in water quality. Although localized increases in turbidity are anticipated during implementation of Alternative One in the nearshore area of Wallops Island, turbidity would not reach the SAV beds that are mapped approximately 11 km (7 mi) and 8 km (5 mi) from Wallops Island. NASA would conduct vegetation surveys prior to excavation activities on the north end of Wallops Island and if SAV is observed would coordinate with appropriate agencies to ensure adequate protection.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

The types of impacts on SAV discussed under Alternative Two would be the same for Alternative One. The minor additional turbidity associated with the construction of a groin in the southern portion of the project area would not adversely impact SAV beds located in the coastal bays of the region.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

The types of impacts on SAV discussed under Alternative Three would be the same for Alternative One. The minor additional turbidity associated with the construction of a breakwater in the southern portion of the project area would not adversely impact SAV beds in the coastal bays of the region.

4.3.4 Plankton

No Action Alternative

Under the No Action Alternative, there would be no dredging or in-water construction activities; therefore, there would be no impacts on plankton.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

Sand Placement Site

Placement of sand in the surf zone would result in only minor temporary impacts on phytoplankton or zooplankton because this area is already subject to dynamic wave activity and mixing of the water column. Sand placement would result in an increase in turbidity from the resuspension of sediment at the discharge pipe along the beach. This turbidity would be carried along the shoreline and seaward. The resuspended sediment may temporarily reduce sunlight penetration that would adversely impact phytoplankton productivity. The resuspended sediment may also release organic matter that zooplankton can feed up. Burlas et al. (2001) conducted

biological monitoring of a beach restoration project on the New Jersey coast and concluded that there was no obvious difference in the surf zone ichthyoplankton at the nourished beaches and nearby natural beaches.

Offshore Borrow Sites

Plankton are widely dispersed throughout the project area. Because phytoplankton and zooplankton distributions are concentrated in the upper portions of the water column and dredging would occur at the sediment surface, there should be only minor entrainment of plankton in the dredge. In addition, water release and water quality changes, such as increased turbidity and localized decreases in DO, may result in localized adverse impacts to plankton communities. Although ichthyoplankton may be entrained in the suction dredge during dredging operations, ichthyoplankton are not concentrated on sand shoals; therefore, no significant impacts on ichthyoplankton are expected under Alternative One on the two offshore sand shoals.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

The impacts on the plankton from dredging of offshore shoals and placement of the sand under Alternative Two would be the same as those under Alternative One. The groin would occupy a portion of the water column in the surf zone and nearshore but would not cause a negative impact to the plankton.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

The impacts on the plankton from dredging of offshore shoals and placement of the sand under Alternative Three would be the same as those under Alternative One. The breakwater would occupy a portion of the water column but would not cause a negative impact to the plankton.

4.3.5 Benthos

No Action Alternative

Under the No Action Alternative, beach habitat for benthos would continue to erode along the southern portion of Wallops Island and accrete on the northern portion. Benthic communities would continue to exist within the shifting beach landscape.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

Offshore Borrow Sites

Based on an initial beach fill target of approximately 2.4 million m³ (3.2 million yd³) and assuming a loss of 25 percent of the material during dredge and sand placement operations, a total of approximately 3.1 million m³ (4 million yd³) of sand would be dredged from Shoal A. To be conservative, it is assumed that the entire 210 ha (515 ac) sub-area A-1 on Shoal A would be dredged for the initial beach fill requirements at a dredging depth of approximately 2-3 m (7-10 ft). Shoal A covers approximately 700 ha (1,800 ac), and Shoal B covers approximately 1,600 ha (3,900 ac). Therefore, during the dredging for the initial beach placement approximately 30 percent of the surface area of Shoal A would be affected. For renourishment cycles, either Shoal A or Shoal B would be used. Under Alternative One, each renourishment cycle would require the dredging of approximately 770,000 m³ (1,007,500 yd³) of sand. Assuming a conservative uniform dredging depth of 2 m (7 ft), approximately 39 ha (95 ac) or approximately 6 percent of

Environmental Consequences

the total area of Shoal A or 3 percent of the total area of Shoal B would be dredged under each renourishment cycle.

Dredging sand from either offshore shoal would have a significant and immediate adverse impact on the local benthic community of the shoal. The primary direct effect would be the removal of sand and entrainment of the infauna and epifauna that reside within and on the sediment. Because the majority of the benthos live in the upper 15 cm (6 in) of sediment, a single pass of the dredge would remove approximately 0.3 m (1 ft) of sediment and would result in a significant decrease in the abundance, biomass, and number of species of benthic organisms in the immediate area of the dredge cut. However, it is expected that there would be a negligible impact on the regional benthic ecosystem because: (1) the benthic assemblages on the sand shoals are not unique but are similar to assemblages in adjacent areas, and (2) the spatial extent of the dredged area is small compared to the broad area of the nearshore continental shelf. Diaz et al. (2006) reported on the results of biological monitoring on Sandbridge Shoal located off the southern Virginia coast that has been dredged four times from 1996 to 2003. Their results showed no negative impacts on macrobenthos.

In addition to the direct impacts on the benthos from the dredging operations, there may be indirect impacts as a result of changes to the sedimentary environment. Dredging causes the suspension of sediment, which increases turbidity over the bottom as a benthic plume. The deposition of this suspended sediment in adjacent areas can indirectly affect the benthos by covering the sediment surface and changing the physical characteristics of the sediment. However, benthos living on the nearshore continental shelf are adapted to sediment movements as a result of storm activity. As is evident from the ripple marks and bedforms in the video survey of the proposed SRIPP shoals, surficial sediment is frequently moved around on the shoals to create these features. Most macrobenthic organisms can burrow and move through a few centimeters of deposited sediment. Changes to the grain size of the sediment surface may affect larval settlement patterns as benthic larvae preferentially settle on particular sized sediment.

Dredging also changes the local sediment topography by creating furrows and depressions and lowering the overall topography of the shoal. The changes in bottom topography result in changes to local hydrodynamics which in turn may affect the distribution of both larval and adult benthic organisms. Changes in the local hydrodynamics may also affect the distribution of food resources for the benthos.

Through the physical removal of the surficial sediment, dredging exposes sediment that has different physical and geochemical properties than the pre-dredged sediment. The changes to the surficial sediment characteristics may change its suitability for burrowing, feeding, and larval settlement for the benthos. Dredging exposes anaerobic sediment that may affect the benthic recolonization of the dredged area and changes the rate of nutrient exchange between the sediment and water column.

Because of the dynamic nature of benthic communities on the nearshore continental shelf and their variability over time, the recolonization and recovery of the dredged area can proceed at various rates. Depending on the time of year, benthos can recolonize the dredged area in varying degrees via larval recruitment as well as from immigration of adults from adjacent, undisturbed areas. Benthic abundances and total species numbers may reach pre-dredge amounts relatively quickly dependent upon the time of year dredging occurs (e.g., within a year) (Burlas et al.,

2001; Posey and Alphin, 2002; Byrnes et al., 2004). However, it may take several years before the benthic community recovers to its pre-dredge levels of community composition and biomass (Wilber and Stern 1992; Newell et al., 1998).

In the early stages of recovery of the benthic community, there may be shifts in the dominant species in the dredged areas. There are several benthic species in this region of the Mid-Atlantic such as oligochaetes, the bivalve *Tellina* spp. and polychaete worm *Asabellides* that would likely recruit into the dredged area in any season (Diaz et al., 2004). There are species with life history characteristics, such as multiple reproductive events per year, which allow them to rapidly recolonize unoccupied space. These opportunistic species are adapted to exploit suitable habitat when it becomes available.

The timing of dredging would be an important factor in determining the eventual recovery of the dredged area because many benthic species have distinct reproductive and recruitment periods (Diaz et al., 2004). Recovery would be primarily from larval recruitment and adult immigration. As a result, recovery should be most rapid if dredging is completed before seasonal increases in larval abundance and adult activity in the spring and early summer (Herbich, 2000).

Pump-Out Station

As described in Section 2.5.7.3, a pump-out station may be located offshore. It would be used to deliver the sand and water slurry contained in the hopper dredge to the beach. It would be anchored temporarily offshore of the beach and would likely have multiple anchor sites. The placement of the anchors and anchor sweeps would impact benthic habitat. However, the impact would be temporary and last several months during the placement of the beach fill. In addition, the anchors for the pump-out station would rest on and periodically move along the sediment surface. There would be a negligible impact on the regional benthic ecosystem because; (1) the benthic assemblages on the relatively uniformly flat bottom offshore of the beach are not unique and are similar to assemblages in adjacent areas and (2) the spatial extent of the disturbed area is small compared to the broad area of the nearshore continental shelf.

Placement Site

Unlike many beach restoration projects, the initial sand placement would occur to a large extent in an area where a beach does not currently exist. Of the approximate 6.0-km (3.7-mi) length of the project, there is no beach for a length of approximately 4,250 m (14,000 ft). Placement of the dredged sand along the Wallops shoreline would bury existing subtidal benthic organisms seaward of the seawall, as well as intertidal organisms living on and within the interstitial areas of the rock seawall. Placement of the initial fill would bury the existing intertidal benthic community along an approximate 4,300-m (14,000-ft) length of the seawall. The mean tidal range is approximately 1.1 m (3.6 ft); therefore approximately 0.5 ha (1.2 ac) of hard-bottom, intertidal habitat would be permanently buried. In addition, approximately 91 ha (225 ac) of the subtidal benthic community along the existing seawall would be buried during the initial fill placement.

A new beach would be formed in front of the seawall and a beach benthic community would become established. With the placement of fill and restoration of the beach, the composition of the benthic community along the seawall would fundamentally change. The community would change from one characterized by (1) sessile and mobile epifaunal organisms present throughout

Environmental Consequences

an intertidal zone on the hard substrate of the seawall, and (2) an adjacent subtidal sand bottom, to an exposed beach with a swash and surf zone. The presence of the seawall, and the hard habitat it currently provides to intertidal organisms, is an artificial condition that has developed from the erosion of the pre-existing beach.

Due to the handling and pumping activities, the dredged sand itself would also be devoid of live benthos. As a result, the recovery of benthos at the placement area would rely on immigration of adult organisms from adjacent undisturbed areas, as well as larval colonization from the water column. Recovery time of the benthos within the seaward surf zone is expected to be relatively rapid, even more rapid than the offshore borrow sites given the dynamic conditions within the nearshore and surf zones.

Because of the absence of a beach seaward of the existing seawall, the placement of sand in this location would have a beneficial effect on benthic organisms by restoring beach habitat that does not currently exist. It is expected that the beach would repopulate with benthic organisms relatively quickly. Burlas et al. (2001) estimated that the recovery time for benthos in their New Jersey study ranged from approximately 2 to 6 months when there is a good match between the fill material and the natural beach sediment.

Several environmental studies of beach nourishment indicate that there are no detrimental long-term changes in the beach fauna as a result of beach nourishment (USACE, 1992; Burlas et al., 2001). The greatest influencing factor on beach fauna populations appears to be the composition of the placed material – not the introduction of additional material onto the beach. The deposited sediments, when similar in composition (grain size and other physical characteristics) to existing beach material (whether indigenous or introduced by an earlier nourishment or construction event), do not appear to have the potential to result in long term impacts on the numbers of species or community composition of beach infauna (USACE, 1994; Burlas et al., 2001). The proposed beach fill for the SRIPP is similar in composition and grain-size to the native beach material; therefore, there would be no long-term impacts to benthic community composition.

During placement of sand on the existing beach during renourishment cycles, there would be impacts to the established beach and nearshore benthos. In the subtidal area that would be filled, impacts would tend to be most severe to small, relatively immobile species such as oligochaetes and polychaetes that are unable to burrow through the overburden of new sand. Larger, more mobile taxa such as mole crabs (*Emerita*) which can burrow through the placed sediment or other species that avoid the disturbance by migrating out of the area are generally less impacted by the sediment deposition (Burlas et al., 2001). Peterson et al. (2000) reported that *Emerita* and *Donax* densities were lower by 86 - 99 percent on nourished beaches 5 – 10 weeks after construction in North Carolina. The slow recovery rates may have been a consequence of a poor match in grain size and a high shell content.

Grain size compatibility is important to the establishment of a healthy native beach benthic community. Peterson et al. (2006) reported that cold-season filling using much coarser sand than native caused dramatic suppression of the beach community and degrading the habitat value and benthic prey base for foraging shorebirds on a beach in North Carolina. Alternatively, sediment that is too fine may have a negative effect on the establishment of beach benthos. Peterson et al. (2000) noted that mole crab abundance was greatly reduced in nourished beaches in North Carolina that used much finer grained sediment (mean 0.08 mm) than the native beaches (mean grain size of 0.20 mm). They speculated that the reduced abundance were due to negative effects

on burrowing or the effects of turbidity on feeding. The proposed SRIPP beach fill has a median grain size of approximately 0.29 mm compared to 0.20 mm for the native beach. Therefore, negative impacts to the beach benthic community due to widely different grain sizes would not be expected.

As discussed above in this section, the timing and extent of renourishment can affect the ability of benthos to recover following sand placement. Spring, summer, and fall would be expected to produce the greatest effects, with winter likely having the least.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

The impacts on the benthos from dredging the offshore shoals and the placement of the sand under Alternative Two would be very similar to those under Alternative One. However, because the amount of dredged material required under Alternative Two is less than Alternative One, the impacts on benthic habitat would be less. Based on an initial beach fill target of approximately 2.30 million m³ (2.92 million yd³) and assuming a loss of 25 percent of the material during dredge and placement operations, a total of approximately 2.8 million m³ (3.65 million yd³) of sand would be dredged from Shoal A.

To be conservative, it is assumed that the entire 210 ha (515 ac) sub-area A-1 on Shoal A would be dredged for the initial beach fill requirements at a dredging depth of approximately 2-3 m (7-10 ft). Shoal A covers approximately 700 ha (1,800 ac), and Shoal B covers approximately 1,600 ha (3,900 ac). Therefore, during the dredging for the initial beach placement approximately 30 percent of the surface area of Shoal A would be affected. For renourishment cycles, either Shoal A or Shoal B would be used. Under Alternative Two, each renourishment cycle would require the dredging of approximately 690,000 m³ (915,000 yd³) of sand. Assuming a conservative uniform dredging depth of 2 m (7 ft), approximately 35 ha (86 ac) or approximately 5 percent of the total area of Shoal A or 2 percent of the total area of Shoal B would be dredged under each renourishment cycle.

Construction and placement of a groin would result in a direct and permanent adverse impact on the local benthic community within the immediate footprint of the groin. The construction of the groin would bury 0.08 ha (0.19 ac) of sandy, subtidal benthic habitat and replace it with hard substrate. The benthos within the construction limits of the groin would be covered with rock. However, the groin would not have a minor impact on the benthic community within the region as the footprint of the structure is small compared to the overall available area of similar unconsolidated sediment throughout the nearshore shelf. Alternatively, a groin would provide approximately hard substrate and habitat heterogeneity in an otherwise featureless area. It would provide approximately 0.02 ha (0.05 ac) of hard, intertidal benthic habitat. The hard surface of the rock would offer attachment surface for a variety of sessile organisms and the spaces between the rocks would provide habitat for mobile species such as crabs.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

The impacts on the benthos from dredging the offshore shoals and the placement of the sand under Alternative Three would be similar to those under Alternatives One and Two. Because the amount of dredged material required under Alternative Three is less than Alternatives One or Two, the impacts on benthic habitat would be less significant. Based on an initial beach fill target of approximately 2.17 million m³ (2.84 million yd³) and assuming a loss of 25 percent of the

Environmental Consequences

material during dredge and placement operations, a total of approximately 2.71 million m³ (3.55 million yd³) of sand would be dredged from Shoal A.

To be conservative, it is assumed that the entire 210 ha (515 ac) sub-area A-1 on Shoal A would be dredged for the initial beach fill requirements at a dredging depth of approximately 2-3 m (7-10 ft). Shoal A covers approximately 700 ha (1,800 ac) and Shoal B covers approximately 1,600 ha (3,900 ac). Therefore, during the dredging for the initial beach placement approximately 30 percent of Shoal A would be affected. For renourishment cycles, either Shoal A or Shoal B would be used. Under Alternative Three, each renourishment cycle would require the dredging of approximately 671,250 m³ (878,750 yd³) of sand. Assuming a conservative uniform dredging depth of 2 m (7 ft), approximately 34 ha (84 ac) or approximately 5 percent of the total area of Shoal A or 2 percent of the total area of Shoal B would be dredged under each renourishment cycle.

Construction and placement of a breakwater would result in a direct and permanent adverse impact on the local benthic community within the immediate footprint of the breakwater. The construction of the breakwater would bury 0.31 ha (0.76 ac) of sandy, subtidal benthic habitat and replace it with hard substrate. The benthos within the construction limits of the breakwater would be covered with rock. However, the breakwater would have a minor impact on the benthic community within the region as the footprint of the structure is small compared to the overall available area of similar unconsolidated sediment throughout the nearshore shelf. Alternatively, a breakwater would provide hard substrate and habitat heterogeneity on an otherwise featureless bottom. It would function similar to an artificial reef, only in relatively shallow water compared to deeper water where artificial reefs typically are created, and having a portion exposed above the water. It would provide approximately 0.11 ha (0.28 ac) of hard, subtidal benthic habitat as well as 0.04 ha (0.11 ac) of hard, intertidal benthic habitat. The hard surface of the rock would offer attachment surface for a variety of sessile organisms and the spaces between the rocks would provide habitat for mobile species such as crabs.

4.3.6 Invertebrate Nekton

No Action Alternative

Under the No Action Alternative, there would be no in-water activity for emergency repairs and maintenance to protect at-risk infrastructure; therefore, there would be no impacts on invertebrate nekton.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

Borrow Sites

No significant impacts on invertebrate nekton such as squid, ctenophores (comb jellies), and jellyfish would occur under Alternative One. Pelagic invertebrates are widely dispersed throughout the inner continental shelf offshore of the MAB and not concentrated on shoal features (Slacum et al., 2006). In addition, water quality changes resulting from the hopper dredges should not result in a significant impact to pelagic invertebrates. Individuals may be entrained in the suction dredge during dredging operations, but this level of mortality would not be significant to the regional population of pelagic invertebrates.

Placement Site

Placement of sand in the surf zone is not expected to result in significant impacts on invertebrate nekton because this area is already exposed to dynamic wave activity and mixing of the water column. Burlas et al. (2001) conducted biological monitoring of a beach restoration project on the New Jersey coast and concluded that there were no obvious differences in the surf zone invertebrate nekton at the nourished beaches compared to the nearby natural beaches.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

The impacts on invertebrate nekton from dredging the offshore shoals and from placement of the sand under Alternative Two would be the same as those under Alternative One. The groin would occupy a portion of the water column in the surf zone and nearshore but would not cause an adverse impact on these pelagic invertebrates.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

The impacts on invertebrate nekton from dredging the offshore shoals and from placement of the sand under Alternative Three would be the same as those under Alternative One. The breakwater would occupy a small portion of the water column but would not cause an adverse impact on these pelagic invertebrates.

4.3.7 Finfish

No Action Alternative

Under the No Action Alternative, there would be no in-water activity for emergency repairs and maintenance to protect at-risk infrastructure; therefore, there would be no impacts on finfish.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

Offshore Borrow Sites

Dredging the offshore shoals for beach fill material may affect finfish in a number of ways. Short-term impacts would consist of changes in water chemistry, habitat quality, or organism behavior as a result of the mechanical disturbance of the seafloor during dredging. Typically, these impacts are localized and dissipate rapidly once the dredging activity ceases. Long-term impacts typically consist of more permanent changes in the bottom substrate and local hydrodynamics or disruptions of vulnerable life history stages of fish. For example, as described in Section 3.2.7, several fish species in the project area, such as sand eel and winter flounder, have eggs that rest on the bottom. These species would be adversely impacted by dredging.

Fish are regularly entrained in dredges although in relatively low numbers (Reine et al., 1998). Larval and juvenile fish are often at greatest risk of entrainment due to their limited mobility and swimming strength. The distribution of individual fish species in the project area is largely determined by water depth, temperature, and salinity with most species ranging widely throughout the project area. Entrainment during offshore sand dredging, even if associated mortality is high, is likely to have minimal population level impacts for most taxa (Zarillo et al., 2008). Entrainment should be a localized, short-term concern for only a few families of demersal (bottom-dwelling) fish such as sea robins and flounder.

Fish use underwater sound pressure waves as well as sight to locate food and detect the presence of predators. While behavioral alterations of fish from human generated noise sources including

Environmental Consequences

dredging are poorly studied, it is possible that foraging, spawning, and recruitment success of fish would be impacted in the immediate vicinity of dredging operations, causing some organisms to relocate. In addition, the physical presence of the dredge and light produced during nighttime operations may attract other species to the vicinity. Behavioral alterations from sound, light, and structure would be localized and would end once dredging is completed. Dredging may also attract fish due to the suspension of benthic prey species in the water column along with the suspended sediment.

Dredging results in increased turbidity at the site of sediment excavation and as slurry overflow or dewatering from the hopper dredge. Wind, waves, and strong directional currents can also resuspend fine particles that accumulate in dredged areas. Turbidity may alter the trophic dynamics of an area by reducing the feeding efficiency of plankton-eating fish (Benfield and Minello, 1996) and reduce benthic prey species. Turbidity can also directly impact fish by irritating or clogging gill membranes and sediment deposition can impact demersal eggs, hindering egg respiration and increasing mortality.

The direct impact of turbidity on mortality, growth, and spawning behavior for continental shelf fish is largely unstudied but is likely a minimal concern since most adult fish are mobile enough to escape or avoid areas of highest turbidity. Furthermore, many shelf fish species are likely adapted to relatively high ambient turbidity levels.

Dredging would physically remove sediment from the shoals which, as described in Section 4.3.5, would result in an immediate reduction in the biomass, density, and diversity of benthic infauna and epifauna. These organisms serve as essential prey for many demersal fish. Loss of this forage base during dredging would have an adverse impact on the survival and growth rates of demersal fish in the immediate vicinity of the dredge operations. In addition, the borrow sites would be recolonized by different benthic communities until full recovery is realized which may result in a short-term change in the demersal fish population of the area.

Placement Site

Direct impacts of beach nourishment projects on surf zone fish are not well documented and largely inferred from changes to benthic prey resources (Burlas et al., 2001; Hackney et al., 1996). Given the highly dynamic nature of the surf zone, impacts to surf zone fish are not anticipated to be significant. Potential impacts to the fish community from the beach nourishment project could occur through several processes. The placement of sand on the beach buries, at least temporarily, existing benthic habitat, which may reduce the availability of infauna to benthic feeders. Additionally, the physical disturbance caused by dredging and the pumping of sand onto the beach may also affect fish distribution patterns. As described in the above Offshore Dredging subsection, elevated turbidity can negatively affect the physiology and feeding behavior of some fishes and presumably could make areas of shoreline that are being nourished unsuitable for some surf zone inhabitants.

Wilber et al. (2003) conducted a study of surf zone fish in response to beach nourishment in northern New Jersey. They reported that beach nourishment impacts on surf zone fish were restricted to localized attraction (northern kingfish) and avoidance (bluefish) responses to the beach nourishment operation. It is expected that beach fill operations at Wallops Island would result in a similar response; therefore, short-term and localized adverse impact on the surf zone fish population are anticipated.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

The impacts on finfish from dredging the offshore shoals and from placement of the sand under Alternative Two would be similar to those under Alternative One.

The construction of a groin would be a beneficial impact to local fish communities. A groin would function as fish habitat similar to a breakwater but to a lesser degree because it would be located in shallower water and have less submerged surface area and less of a submerged footprint. The groin would function as an artificial reef and provided structure and habitat in the otherwise featureless sand bottom that is characteristic of the nearshore environment offshore of Wallops.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

The impacts on finfish from dredging the offshore shoals and from placement of the sand under Alternative Three would be similar to those under Alternative One.

The construction of an offshore breakwater would be a beneficial impact to local fish communities. The breakwater would function as an artificial reef and provide structure and habitat in the otherwise featureless sand bottom that is characteristic of the nearshore environment offshore of Wallops. It is anticipated that the structure would attract a variety of fish species not regularly found on the sand bottom.

4.3.8 Essential Fish Habitat

An EFH Assessment was prepared for the SRIPP and is included as Appendix I. Pertinent correspondence regarding EFH consultation is provided in Appendix J. This section provides a summary of the EFH assessment and subsequent consultation with NMFS. The SRIPP dredging plan, a key factor dictating how the SRIPP would affect EFH, is summarized in this PEIS in Section 2.5.7.

No Action Alternative

Under the No Action Alternative, the SRIPP would not be implemented; however, maintenance activities and emergency repairs would occur. Temporary impacts on nearshore EFH from the use of construction vehicles and heavy machinery on the beach may occur through the introduction of petroleum products, heavy metals, or other contaminants due to a leak or spill. Construction-related impacts would be temporary, and would not likely impact EFH because any accidental release of contaminants or liquid fuels would be addressed in accordance with the existing WFF ICP emergency response and clean-up measures. Implementation of BMPs for vehicle and equipment fueling and maintenance, and spill prevention and control measures would reduce potential impacts on EFH during construction. Therefore, the No Action Alternative would not impact EFH.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

Wallops Island Nearshore Environment

The placement of sand on the Wallops Island beach would result in temporary adverse impacts on EFH due to turbidity and suspended solids concentrations that would be elevated above normal background levels in the surf zone in the immediate area of beach nourishment. Additionally, the beach nourishment would cause a smothering effect to benthos in the areas

Environmental Consequences

where sand is placed along the shoreline, likely resulting in the loss of immobile benthic species in the area. However, the population would have the ability to recolonize from adjacent undisturbed areas, and the overall population would not be adversely affected in the long-term. Therefore, beach nourishment on Wallops Island would result in a temporary, localized adverse impact to EFH in the nearshore area.

EFH may also be temporarily affected from the use of construction vehicles and heavy machinery on the beach for the movement of beach sand, construction of the seawall extension and excavation activities at the north Wallops Island borrow site. The heavy equipment and construction activities may result in the introduction of petroleum products, heavy metals, or other contaminants to nearshore waters due to a leak or spill. Construction-related impacts would be temporary, and would not likely be adverse because any accidental release of contaminants or liquid fuels would be addressed in accordance with the existing WFF ICP emergency response and clean-up measures. Implementation of BMPs for vehicle and equipment fueling and maintenance, and spill prevention and control measures would reduce potential impacts on nearshore waters and EFH during construction. Therefore, construction of the seawall may temporarily impact nearshore EFH.

Offshore Borrow Sites

Under Alternative One, the dredging of either offshore shoal is expected to cause direct temporary adverse effects to EFH habitat by removing benthic habitat and degrading water quality due to an increase in suspended sediment concentrations.

The EFH of non-motile benthic species which inhabit the offshore shoals, including the surf clam, would be adversely affected under Alternative One due to entrainment in the dredger. However, the adverse effects to the overall population are anticipated to be temporary as they would have the ability to recolonize from adjacent undisturbed areas. Studies conducted from 2002 to 2005 by the VIMS examined the effects of dredging to the benthic community in offshore sand shoals. The study found that benthic invertebrate communities destroyed by the dredger are able to rebound within a period of a few years (Diaz et al., 2004). Mitigation techniques such as maintaining the morphology of the shoals would be evaluated to preserve areas of benthic habitat and allow for quicker recruitment of benthic species to the dredged areas.

The loss of benthic organisms would create a loss of prey for some federally managed fish species, but the effect would be localized and temporary. The hopper dredge would also cause an increase in turbidity that could temporarily disturb the ability of fish, surf clams, and other mollusks to feed; however, this adverse effect would be temporary.

Dredging at the proposed borrow sites would be conducted in a manner that is generally consistent with the recommendations made in two recent MMS (now BOEMRE) publications examining the dredging of offshore shoals in the mid-Atlantic (CSA International, Inc. et al., 2009; Dibajnia and Nairn, *in press*). These recommendations include; targeting depocenters for extraction, avoiding active erosional areas, shallow dredging over large areas rather than deep pits, dredging shoals in less than 30 m of water, and avoiding longitudinal dredging over entire length of shoal. In addition, NASA would attempt to minimize the total amount of borrow removed from the offshore shoals over the 50-year life of the project. BMPs, such as planting the newly created dune with native beach grass and the installation of sand fencing would be implemented to reduce the amount of beach fill needed. Moreover, based on results of the

monitoring program and its adaptive management approach, NASA would examine measures to reduce shoreline erosion throughout the life of the project.

With implementation of mitigation measures and BMPs, Alternative One would result in localized and temporary adverse impacts on EFH. In the EFH assessment dated November 2009, NASA determined that there would be “site-specific adverse effects on EFH” but the impacts would not be significant in a regional context (Appendix I).

Pump-out Station

A pump-out station may be temporarily anchored in the nearshore environment to deliver the sand and water slurry contained in the hopper dredge to the beach. Benthic habitat would be adversely impacted by the placement of the anchors and anchor sweeps. Benthic organisms would be displaced within the footprint of the anchor and as the anchor chain moves along the bottom sediment. However, the impact would be temporary and last as long as the beach fill placement operations. There would be a negligible impact on the regional benthic ecosystem because; (1) the benthic assemblages on the relatively uniformly flat bottom offshore of the beach are not unique and are similar to assemblages in adjacent areas and (2) the spatial extent of the disturbed area is small compared to the broad area of the nearshore continental shelf.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

The types of impacts on EFH and the mitigation measures discussed under Alternative One would be similar to those for Alternative Two. As presented in Table 6, approximately ten percent less fill volume would be required during the project lifetime for Alternative Two when compared to Alternative One. Therefore, less turbidity and loss of benthic species by entrainment would occur compared to Alternative One. Also, less sand would be placed on the beach; therefore, there would be fewer impacts on nearshore and beach benthic communities from turbidity and burial.

During groin construction, adverse effects to surf clam EFH would occur. A number of the non-motile clams would be lost due to crushing during the groin placement. However, this adverse impact would be highly localized and the long-term effects of the groin would be beneficial to several federally managed species because it would provide additional habitat for fish and sessile benthos such as sponges that attach to hard substrates. The groin would permanently cover approximately 0.08 ha (0.19 ac) of benthic habitat.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

The types of impacts on EFH and the mitigation measures discussed under Alternative One would be similar to those for Alternative Three. As presented in Table 6, approximately twelve percent and three percent less fill volume would be required during the project lifetime for Alternative Three when compared to Alternatives One and Two, respectively. Therefore, less turbidity and loss of benthic species by entrainment would occur compared to Alternatives One and Two. Also, less sand would be placed on the beach; therefore, there would be fewer impacts on benthic communities and EFH would result from turbidity and burial.

During breakwater construction, adverse effects to surf clam EFH would occur. Construction barge anchoring would impact EFH and clams would be crushed during the breakwater placement. However, this adverse impact would be highly localized. The breakwater would permanently cover approximately 0.31 ha (0.76 ac) of benthic habitat and EFH. The long-term

Environmental Consequences

effects of the breakwater would be beneficial to EFH species because it would provide additional habitat for fish and sessile benthos that attach to hard substrates. The breakwater would provide approximately 0.04 ha (0.11 ac) of hard, intertidal benthic habitat as well as approximately 0.11 ha (0.28 ac) of hard, subtidal benthic habitat.

4.3.8.1 Agency Consultation

As required under Section 305(b) of the MSA, Federal agencies must consult with NMFS on all actions, or proposed actions, authorized, funded, or undertaken by the agency, that may adversely affect EFH. The Department of Commerce guidelines for implementing EFH coordination and consultation provisions of the MSA are contained in 50 CFR 600.905 – 930.

NMFS provided conservation recommendations to NASA in a letter dated April 19, 2010, (Appendix J). NASA was required to respond within 30 days as required by Section 305(b)(4)(B) of the MSA. NASA responded on May 17, 2010, stating that because not all the public comments were reviewed, it would provide a detailed response at a later date. On June 25, 2010, NASA transmitted a letter to NMFS responding in detail to the 11 conservation recommendations (Appendix J). NASA and its cooperating agencies (BOEMRE and USACE) were in agreement with seven of the 11 recommendations. For the remaining four recommendations, two of which assigned numerical thresholds for sand removal at each shoal, one of which was regarding avoidance of shoal crests, and the last of which was regarding the dredging contractor's means for sand placement on the beach, NASA provided detailed responses and scientific justification outlining why it did not agree with NMFS. Subsequent to the June 25, 2010, correspondence, NASA, BOEMRE, USACE, and NMFS held further discussions that resulted in a refinement of the proposed dredging plan for Shoal A as depicted in Figure 18. Because the focus of NASA's responses to the NMFS recommendations was dredging of Shoal A for initial fill, NASA would reinitiate consultation with NMFS prior to renourishment events.

4.3.9 Marine Mammals

No Action Alternative

Under the No Action Alternative, the SRIPP would not be implemented but emergency measures and maintenance would still take place as necessary. Because none of these measures would take place in marine waters, no impacts on marine mammals are anticipated under the No Action Alternative.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

The potential impacts associated with activities under Alternative One include physical disturbance to habitats (benthic or aquatic) during dredging and fill, vessel strike, and increased noise from vessel activities (dredging). No impacts are anticipated to marine mammals from the placement of sand on the beach, as all activities would occur from the beach.

Disturbance to Habitat

Dredging for sand can indirectly affect marine mammals by reducing their ability to obtain food in several ways. The most direct impact is a substantial initial reduction in the benthic invertebrate fauna in the dredged area (discussed in more detail in Section 4.3.5). Decreased feeding success and prey availability may occur in areas of increased turbidity. Turbidity plumes

caused by offshore dredging can lead to decreased visibility, which in turn can affect foraging ability by those species that use sight as a primary means to locate prey. These effects can also be expected outside the immediate vicinity of the dredging activity.

Operations using hopper dredges tend to be discontinuous and associated plumes would be dispersed over a larger area. Hopper dredges trigger a small plume at the seabed from the draghead and a larger surface plume from the discharge of overspill of water with suspended sediment from the hopper (MMS, 1999). The length and shape of the surface plume generated by the overspill depends on the hydrodynamics of the water and the sediment grain size.

Although the volume of discharged material is much higher during construction aggregate dredging, findings from studies of these operations from overseas provide information on the potential behavior of turbidity plumes from dredging for beach restoration material (MMS, 1999). Detailed investigation of these types of operations off the coast of the United Kingdom found that most sediments in the plume settle out within 300 to 500 m (984 to 1,640 ft) from the dredge over a period of roughly 20 to 30 minutes and that suspended sediment concentrations returned to concentrations close to background level within an hour after completion of dredging (Hitchcock et al., 1999). The distance and time increased with decreasing sediment size. Because the sediment on Shoals A and B is well-sorted medium sand with low silt and clay content, turbidity plumes would be localized and short-lived. Hitchcock et al. (1999) reported that far field (i.e., > 500m) visible plumes that extend beyond the boundaries of suspended sediment are comprised of organic compounds such as fats, lipids, and carbohydrates agitated by the dredging process. Because the size of far field plume would depend on weather and tidal currents, the exact extent cannot be estimated; however, impacts on water quality are not expected to be substantial.

Because the concentration of the suspended particles in the plume diminishes rapidly with time and distance from the source, the effects on fauna farther away from the activity are reduced.

In general, the effects of turbidity on phytoplankton due to light reduction or on pelagic fish and invertebrates, due to gill irritation and reduction of light levels for visual feeders, are considered small (MMS, 1999). A suction hopper dredge is usually on-site for 3 to 4 hours during a 24-hour period, with the remaining time spent in travelling and unloading sand. This discontinuous method of offshore dredging allows suspended sediments to dilute, dissipate, and settle. The SRIPP project area could be avoided by marine mammals, which could easily feed in adjacent areas until the disturbance ceased.

Vessel Strike

Vessel collisions are more likely to affect certain species that have surface feeding or resting habits, such as right and humpback whales. Threatened and endangered marine mammals are discussed in more detail in Section 4.3.10. According to the July 22, 2010, NMFS BO on the SRIPP, the potential of marine mammal strikes would be mitigated by operating the dredge at low speeds. A Final Rule was issued on October 10, 2008 restricting vessel speeds to 10 knots for all vessels 20 m (65 ft) or longer in Seasonal Management Areas (SMAs) along the east coast of the Atlantic (50 CFR 224.105, issued October 10, 2008). Although the project area is not in an SMA and therefore not subject to this rule, NASA expects the speed of the dredge to be approximately 3 knots while dredging and 10 knots while transiting between the borrow site and the nearshore pump-out buoy. Therefore, there would be a low risk of vessel strike to marine

Environmental Consequences

mammals. At this low speed, operators would be able to avoid large marine mammals by maneuvering the dredge vessel to avoid a whale strike. In addition, there is currently no available information to suggest that dredge vessels have ever collided with whales while operating in Atlantic waters.

Noise

There are three metrics commonly used in the evaluation of underwater sound impacts to marine mammals: peak pressure, root-mean-square (rms) or sound pressure level, and sound exposure level (SEL). Under the MMPA, the rms levels are used to determine harassment, and all underwater sound levels throughout the remainder of this PEIS will be reported in rms. The rms amplitude is a type of average that is determined by squaring all of the amplitudes over the period of interest, determining the mean of the squared values, and then taking the square root of the mean of the squared values.

Transmission loss (TL) underwater is the decrease in acoustic intensity as an acoustic pressure wave propagates out from a source. TL parameters vary with frequency, temperature, sea conditions, current, source and receiver depth, water chemistry, and bottom composition and topography. Because the temperature, sea conditions, water chemistry, and bottom composition are unknown, conservative estimates of TL for the underwater sources were performed based only on water depth and distance from source. Because the project activities occur in waters with depths less than 30 m, TL was calculated using a conservative 4.5-dB reduction per doubling of distance, using the formula:

$$TL = 15 * \text{Log}(R),$$

Where R = distance relative to the source to the received level of interest²

Under the MMPA, NMFS has defined levels of harassment for marine mammals. Level A harassment is defined as "...any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild." Level B harassment is defined as "...any act of pursuit, torment, or annoyance which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering."

Since 1997, NMFS has been using generic sound exposure thresholds to determine when an activity in the ocean that produces sound might result in impacts to a marine mammal such that a take by harassment might occur (NMFS, 2005). NMFS is developing new science-based thresholds to improve and replace the current generic exposure level thresholds, but the criteria have not been finalized (Southall et al., 2007). The current Level A (injury) threshold for impulse noise (e.g., impact pile driving) is 180 dB rms for cetaceans (whales, dolphins, and porpoises) and 190 dB rms for pinnipeds (seals, sea lions). The current Level B (disturbance) threshold for impulse noise is 160 dB rms for cetaceans and pinnipeds. The level B threshold for continuous noise is 120 dB rms for cetaceans and pinnipeds (NMFS, 2005).

Marine mammals use hearing and sound transmission for all aspects of their life, including reproduction, feeding, predator and hazard avoidance, communication, and navigation. The

² It should be noted that in the Draft PEIS NASA analyzed effects on marine mammals using $10 * \text{Log}(R)$; however, during consultation with NMFS, NMFS stated that use of $10 * \text{Log}(R)$ was overly conservative and recommended use of the more realistic $15 * \text{Log}(R)$ formula.

introduction of sound into the marine environment from anthropogenic sources has the potential to cause long-term or short-term effects. Short-term effects can include behavioral disruption or temporary habitat displacement; and long-term effects can include extended habitat displacement, physical injury to the auditory system, or in some cases mortality (Richardson et al., 1995). The behavioral responses of marine mammals to noise are highly variable and may depend upon individual hearing sensitivity (animals respond only to sounds they can directly detect), past exposure and habituation to noises, and demographic factors such as the age and sex of the animal. Other factors include the duration of the sound, whether the sound is moving, and environmental factors that affect the sound, including habitat characteristics (National Research Council [NRC], 2003).

To understand how anthropogenic noise may affect marine mammals, it is important to understand the hearing abilities of the marine mammals. A summary of the hearing sensitivities of marine mammals likely to occur within the project area are shown in Table 50. Southall et al. (2007) categorized cetaceans into three general hearing groups: low-frequency (7 Hz to 22 kHz), mid-frequency (150 Hz to 160 kHz), and high-frequency (200 Hz to 180 kHz). The majority of cetaceans, including beaked whales, toothed whales, pilot whales, and dolphins, fall into the mid-frequency hearing group. Baleen whales are in the low-frequency hearing group, and the dwarf sperm whale is in the high-frequency hearing group. All pinnipeds in the water are categorized into the same hearing group (75 Hz to 75 kHz). The Florida manatee has a hearing bandwidth of 400 Hz to 46 KHz (Gerstein, 2002).

Table 50: Marine Mammals Hearing Groups

Hearing Group	Estimated Auditory Bandwidth	Species
Low-frequency cetaceans	7 Hz to 22 kHz	Right whale Humpback whale Fin whale
Mid-frequency cetaceans	150 Hz to 160 kHz	True's Beaked Whale Blainville's Beaked Whale Sowerby's Beaked Whale Cuvier's Beaked Whale Melon-Headed Whale Short-Finned Pilot Whale Long-Finned Pilot Whale Rough-Toothed Dolphin Bottlenose Dolphin Atlantic Spotted Dolphin Common Dolphin Atlantic White-Sided Dolphin Risso's Dolphin Striped Dolphin Spinner Dolphin Clymene Dolphin
High-frequency cetaceans	200 Hz to 180 kHz	Dwarf Sperm Whale
Pinnipeds in Water	75 Hz to 75 kHz	Harbor Seal
Manatees	400 Hz to 46 KHz	Florida Manatee

Source: Southall et al., 2007; Gerstein, 2002

Environmental Consequences

A detailed description of marine mammal species is in Section 3.2.9. The marine mammals of primary concern for noise impacts are those that are likely to occur within the action area. These are bottlenose dolphins and possibly, right whales and humpback whales. The coastal morphotype of bottlenose dolphins may occur in the shallow waters off Wallops Island all year round, comprising either the northern or southern migratory stocks, though they are more likely to occur during summer months. The offshore morphotype is unlikely to occur within the project area, as they are primarily found along the OCS and continental slope. Right whales may occur in the area on occasion, especially when transiting between southeastern U.S. waters and New England. This is likely to occur between November and April. Humpback whales may occur in deeper water offshore of Wallops Island in fall, winter, and spring, as they migrate to feeding grounds off the New England coast. Although harbor seals may occur in the area, there are no known haulout sites in the project vicinity, so impacts to harbor seals are not addressed further. Although manatees are reported, it is highly unlikely they would be found in the project vicinity, and are not addressed further.

Under this alternative, underwater noise would be generated through the use of a hopper dredge. The primary noise from hopper dredging is created by the suction pipes used to remove the fill from the seabed. The noise generated by dredgers depends on their operational status: sea bed removal, transit, and dumping. In general the noisiest activity is associated with the seabed removal. Dredge noise is strongest at low frequencies (below 1,000 Hz). Clarke et al. (2002) reported received levels of approximately 140 dB at 40 m (130 ft) for a hopper dredge during loading operations (at frequencies below 1,000 Hz).

As discussed above, calculations were performed with these source levels assuming a transmission loss of 15 log to the NMFS Level A (180 dB for cetaceans and 190 dB for pinnipeds) and Level B thresholds (160 dB and 120 dB for impulse noise and continuous noise, respectively). Based on these assumptions, underwater noise from the hopper dredge would not reach the Level A threshold and would, therefore, not result in any injury or mortality. Dredge noise may exceed the Level B threshold for impulse noise at a distance of approximately 1.8 m (5.9 ft) from the dredge during loading. Dredge noise may exceed the Level B threshold for continuous noise at a distance of approximately 862 m (0.54 mi) from the dredge during loading.

Noise from dredging would be audible to the species known to occur in the area, and may result in some masking of vocal behavior of right whales, humpback whales, and non-echolocation calls of bottlenose dolphins. As discussed in the Marine Environment Protection Fund report (MALSF, 2009), there are only a few studies that have documented impacts of dredging on marine mammals. The only study that is well referenced was conducted by Richardson et al. (1990, 1995) and evaluated behavioral reactions of bowhead whales in the Beaufort Sea (north of Alaska). This study (Richardson et al., 1995) indicated that bowhead whales exhibited behavioral disturbance (i.e., avoidance of the area) at levels above 120 dB re 1 μ Pa in the 20 Hz to 1 kHz band. Additional studies (also summarized in Richardson et al., 1995) further indicated that bowheads avoid drilling sounds above 120 dB. These studies are the primary reason for use of a 120 dB threshold used by NMFS to determine behavioral harassment by continuous (non-pulsed) sounds. This level does not appear to result in a biologically significant impact on bowhead whales or other Arctic species, as evidenced in multiple Incidental Harassment Authorizations issued by NMFS for seismic activities in the Arctic (NMFS, 2010), which cannot be issued without determination that the activity would result in a negligible impact of marine mammal

species or stocks and that the activity does not result in an adverse unmitigable impact on the availability of those species for subsistence use.

Right whales have shown some evidence of tolerance to this type of noise along the southeast coast (Richardson et al., 1995). As summarized in Richardson et al. (1995), there are few studies documenting the responses of humpback whales to dredging, and other studies indicate the responses of humpbacks to a vessel depends heavily on their behavior (e.g., feeding humpbacks are less likely to react when actively feeding than when resting). Also summarized in Richardson et al. (1995), dolphins often tolerate or approach vessels, but the reactions are typically related to the behavioral activity similar to humpbacks (resting dolphins avoid, feeding dolphins ignore, and socializing dolphins approach).

Because the sounds of dredging are likely to be audible at distances of at least 862 m (0.54 mi) from the sound source and are within the audible range of the cetaceans likely to occur in the project vicinity, they may be affected by dredging noise. However, because dredging has occurred in the region before and is not a new sound source, there are many other sources of anthropogenic noise in the area (i.e., commercial and recreational vessels), the distance the dredging noise could be audible is unknown and variable (due to shallow water, shoals, etc.), the fact that the large cetaceans are likely to be migrating through (and are thus less likely to be disturbed), and the fact that this is a temporary noise source all indicate that SRIPP dredging activities would not result in significant adverse effects on marine mammals. A NMFS-approved observer would be present on board the dredging vessel for any dredging occurring between April 1 and November 30. The presence of an experienced endangered species observer who can advise the vessel operator to slow the vessel or maneuver safely when marine mammals are spotted would further reduce to a discountable level the potential for interaction with vessels.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

The potential impacts from activities under this alternative are the same as those identified under Alternative One. In particular, a discussion of potential impacts from dredging would be the same. However, under this alternative, one third of the groin (approximately 43 m [140 ft]) would be constructed in the water using a barge with heavy lifting equipment. The rock placement and barge operation would generate some underwater noise. As summarized in Nedwell and Edwards (2004), measurements of rock placement are scarce, and the one available study indicated that rock placement did not contribute to the overall noise level. Richardson et al. (1995) report barge noise levels ranging from 145 to 170 dB at 1 m (3.3 ft) at frequencies below 5 kHz.

As discussed above, calculations were performed with a maximum source level of 130 dB at 40 m (130 ft) assuming a transmission loss of 15 log to the NMFS Level A and Level B thresholds (190 dB and 160 dB, respectively). Based on these assumptions, underwater noise from the barge would not reach the Level A threshold and would, therefore, not result in any injury or mortality. Barge noise may exceed the Level B threshold at a distance of approximately 1.8 m (5.9 ft) from the barge for impulse noise and 862 m (0.54 mi) for continuous noise. The response of marine mammals to vessel noise is discussed for Alternative One and would be the same under this alternative.

Environmental Consequences

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

The potential impacts to marine mammals from dredging would be the same as those discussed under Alternative One. The potential impacts from rock placement and barging would be the same as those identified under Alternative Two.

4.3.10 Threatened and Endangered Species

The species listed in Table 51 are not likely to be affected by SRIPP actions due to lack of habitat or presence within the SRIPP action areas.

Table 51: Threatened and Endangered Species Not Affected by SRIPP

Common Name	Scientific Name	Reason for No Effect
Northeastern beach tiger beetle	<i>Cicindela dorsalis dorsalis</i>	Highly unlikely to occur in the project area
Delmarva peninsula fox squirrel	<i>Sciurus niger cinereus</i>	Project area not suitable habitat
Shortnose sturgeon	<i>Acipenser brevirostrum</i>	Project area not suitable habitat
Sperm Whale	<i>Physeter macrocephalus</i>	Project area not suitable habitat
Sei Whale	<i>Balaenoptera borealis</i>	Project area not suitable habitat
Blue Whale	<i>Balaenoptera musculus</i>	Project area not suitable habitat
Florida Manatee	<i>Trichechus manatus latirostrus</i>	Project area not suitable habitat

The species discussed in further detail below have either been documented in the SRIPP action area or have been identified by regulatory agencies as being potentially impacted by SRIPP activities.

No Action Alternative

Under the No Action Alternative, the SRIPP would not be implemented and beach habitat loss would continue due to shoreline erosion. Repairs and maintenance of the existing seawall and geotubes are likely to slow the rate of erosion over the central part of Wallops Island. However, erosion south of the seawall would continue. The dune and swale, shrub, thicket and maritime forest areas located at the northern and southern ends of Wallops Island would be at continued risk of loss. Under the No Action Alternative, negative impacts are anticipated to threatened and endangered bird species that rely on the beach for their habitat such as the Piping Plover, Wilson's plover, gull-billed terns, roseate tern, and Red Knot. The leatherback, Kemp's ridley, loggerhead, and Atlantic green sea turtles are known to migrate along East Coast beaches, but rarely nest in the area. It is not likely that repairs and maintenance activities would adversely affect sea turtles.

Under the No Action Alternative, no activities would occur in open water and, therefore, no impacts on marine threatened or endangered species would occur.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

Vegetation

Seabeach amaranth has not been documented on Wallops Island. No designated critical habitat is present in the SRIPP action areas. However, since there is potentially suitable habitat for this species on north Wallops Island, NASA has determined that the proposed action may result in adverse impacts on seabeach amaranth should it occur in the project area.

Initial beach construction would likely have limited impact on seabeach amaranth as there is currently little habitat where work would take place, and no seabeach amaranth plants were found during an August 2010 survey (NASA, 2010f). Potential effects could include burial of seeds and plants at the extreme north and south ends of the project site (where there is existing natural beach). After the initial construction of the new beach, there would be additional potential habitat area. Renourishment and dune maintenance could result in crushing or burial of plants. Excavation of the north Wallops Island borrow site could also potentially result in the loss of habitat or crushing or burial of plants. Offshore activities would not affect seabeach amaranth.

Protected Marine Mammals

No impacts on protected marine mammals from the construction of the seawall or the placement of sand on the beach are anticipated because the activities would occur in water depths too shallow for marine mammals to occur.

The potential impacts of offshore dredging activities are generally similar for all of the species of marine mammals that are described in Section 3.2.9. Potential impacts include collisions with equipment or transport vessels and noise disruption.

Vessel collisions are more likely to affect species that have surface feeding or resting habits, such as right, fin, and humpback whales.

A potential direct adverse effect on protected marine mammals is the noise associated with dredging operations. Noise from the dredge may have an effect on whale species that are sensitive to low frequency sound. The noise emitted by a dredge depends on the local environment, especially the sea-bed type. Variability in noise levels is also associated with the different parts of the dredging operations, such as the dredger dragging against the sea floor; the sound of suction through the pipe; noise from deposition of sand into the hopper; and the noise associated with the dredging ship itself. Meteorological conditions will also influence the noise emitted by the dredging operations (MALSF, 2009).

As discussed in Section 4.3.9, conservative calculations were performed with these source levels assuming a transmission loss of 15 log (cylindrical spreading) to the NMFS Level A and Level B thresholds. These conservative calculations do not take into account water temperature, chemistry, bottom composition, sea conditions, current conditions, or topography.

Marine mammals use hearing and sound transmission for all aspects of their life including reproduction, feeding, predator and hazard avoidance, communication and navigation. The introduction of sound into the marine environment from anthropogenic sources has the potential to cause long term or short term effects. Short term effects can include behavioral disruption or temporary habitat displacement; and long-term effects can include extended habitat displacement, physical injury to the auditory system, or in some cases mortality (Richardson et

Environmental Consequences

al., 1995). The behavioral responses of marine mammals to noise are highly variable and may depend upon individual hearing sensitivity (animals respond only to sounds they can directly detect), past exposure and habituation to noises, and demographic factors such as the age and sex of the animal. Other factors include the duration of the sound, whether the sound is moving, and environmental factors that affect the sound including habitat characteristics (National Research Council [NRC], 2003).

Under the MMPA, NMFS has defined levels of harassment for marine mammals. Level A harassment is defined as "...any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild." Level B harassment is defined as "...any act of pursuit, torment, or annoyance which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering."

Since 1997, NMFS has been using generic sound exposure thresholds to determine when an activity in the ocean that produces sound might result in impacts to a marine mammal such that a take by harassment might occur (NMFS, 2005). NMFS is developing new science-based thresholds to improve and replace the current generic exposure level thresholds, but the criteria have not been finalized (Southall et al., 2007). The current Level A (injury) threshold for impulse noise (e.g., impact pile driving) is 180 dB rms for cetaceans (whales, dolphins, and porpoises) and 190 dB rms for pinnipeds (seals, sea lions). The current Level B (disturbance) threshold for impulse noise is 160 dB rms for cetaceans and pinnipeds. The Level B threshold for continuous noise is 120 dB rms for cetaceans and pinnipeds (NMFS, 2005).

Under the Proposed Action, underwater noise would be generated through the use of a hopper dredge. The primary noise from hopper dredging is created by the suction pipes used to remove the fill from the seabed. The noise generated by dredgers depends on their operational status, sea bed removal, transit and dumping. In general the noisiest activity is associated with the seabed removal. Dredge noise is strongest at low frequencies (below 1,000 Hz). Clarke et al. (2002) reported received levels of approximately 130 dB at 40 km (130 ft) for a hopper dredge during loading operations while pumping (at frequencies below 1,000 Hz).

Based on these assumptions, underwater noise from the hopper dredge would not reach the Level A threshold and would, therefore, not result in any injury or mortality. Dredge noise may exceed the Level B threshold for impulse noise at a distance of approximately 1.8 m (5.9 ft) during loading. Dredge noise may exceed the Level B threshold for continuous noise at a distance of approximately 862 m (0.54 mi) from the dredge during loading. Dredge noise may exceed the Level B threshold for continuous noise at a distance of approximately 862 m (0.54 mi) from the dredge during loading. Noise from dredging would be audible to the species known to occur in the area and may result in some masking of vocal behavior of the right, fin, and humpback whale.

As summarized in Richardson et al. (1995), there are few studies documenting responses of right, fin and humpback whales to dredging; other studies indicate responses of humpbacks to vessel depends heavily on their behavior (e.g., feeding humpbacks are less likely to react when actively feeding than when resting). Because dredging has occurred in this area previously and vessels are common, noise impacts are not expected to be significant.

In summary, the operations under the Proposed Action of the SRIPP are not anticipated to cause long-term adverse impacts on the habitat, calving areas, or the food resources of protected

marine mammals. A BA was prepared by NASA and submitted to the USFWS and NMFS to address any potential impacts from project activities (NASA, 2010d). The responding BO from NMFS is incorporated in this document and attached in its entirety as Appendix E.

Sea Turtles

Seawall Extension

Construction of the seawall could potentially take place during sea turtle nesting season and could result in disturbance to sea turtles that may occur in the vicinity of the construction activities. Construction activity, including noise, operation of vehicles and presence of personnel may discourage sea turtles from coming ashore. Direct effects to listed sea turtles from construction of the seawall extension could include inadvertent crushing of eggs, creation of ruts that could impede hatchlings from reaching the ocean, and deterring females from nesting due to noise and beachfront construction safety lighting.

According to the USFWS BO (Appendix D), sea turtles are not expected to be present in abundant numbers during the initial 435 m (1,430 ft) seawall extension because of the limited amount of suitable nesting habitat. Construction activity may also result in nearshore sediment suspension that would increase the turbidity and reduce visibility within the nearshore environment.

These effects are expected primarily in spring, summer, and fall, when the sea turtles are expected to occur in the region. During winter, sea turtles are not expected to be in the area.

Dredging and Sand Placement

As the initial fill cycle and subsequent renourishment cycles could take place during times of year when listed sea turtles are within the project area (April to November with the largest numbers present from June through October), adverse effects from dredging could occur (NMFS, 2010). The offshore borrow sites are not known to be an area where sea turtles concentrate to forage, though potential feeding habitat exists in the area. The action area is used primarily as a coastal corridor for turtle migration.

Of the listed species found in the action area, loggerhead and Kemp's ridley sea turtles are the most likely to utilize the areas for feeding, foraging mainly on benthic species such as crabs and mollusks. As no seagrass bed exists at the borrow areas, dredging activities are not expected to affect green sea turtles. The leatherback sea turtle preferred prey, jellyfish, is also not expected to be affected as jellyfish occur within the upper portions of the water column, away from dredging activities.

Some reduction in available benthos for feeding is anticipated within the borrow areas, but the effects are not anticipated to be significant, as foraging items would continue to be available both within the borrow areas and in the immediate vicinity at all times. In its BO (Appendix E), NMFS concludes that dredging activities are not likely to alter the habitat in any way that prevents sea turtles from using the action area as a migratory pathway to other near-by areas that may be more suitable for foraging.

Entrainment in dragheads is the primary risk regarding incidental take of sea turtles. Entrainment is believed to occur primarily as the dredge is being placed or removed from the bottom, creating suction in the draghead and it is likely that only those species resting or feeding on or near the bottom would be vulnerable to entrainment. The risk appears to be highest when bottom terrain

Environmental Consequences

is uneven or when the dredge is conducting “clean up” operations at the end of a dredge cycle. In these instances the draghead is often not buried in the sand, making sea turtles near the bottom more vulnerable. In its BO (Appendix E) NMFS included dredge operational procedures that should reduce the potential for turtle entrainment. Turtle deflectors, although not 100 percent effective, have been successfully used on dragheads to reduce the risk of sea turtles being captured and killed.

The number of interactions between dredge equipment and sea turtles seems to be best associated with the volume of material removed, which is related to the length of time dredging takes. A greater number of interactions are associated with a greater volume of material removed and a longer duration of dredging. The number of interactions is also influenced by the time of year dredging occurs, with more interactions recorded during the summer months. Interactions are also more likely at times and in areas when sea turtle forage items are concentrated in the area being dredged, as sea turtles would be more likely to spend time on the bottom while foraging. According to NMFS, few interactions with listed species have been recorded during offshore dredging in the vicinity of the project area. This is partially due to the infrequency of dredging and partially due to the transitory nature of most sea turtles in the area. As sea turtles are present, however, NMFS estimates that interactions would occur during the project life time.

Based on the distribution of sea turtles in the action area and the historic interactions between sea turtles and dredging and relocation trawling operations, NMFS stated in its 2010 BO for the SRIPP that it was reasonable to expect that one sea turtle is likely to be injured or killed for approximately every 1,146,800 m³ (1,500,000 yd³) of material removed from proposed borrow areas. NMFS also anticipates that 90 percent of interactions would occur with loggerhead sea turtles. Based on this assessment, NMFS anticipates that no more than 3 sea turtles are likely to be entrained in the initial dredge cycle when approximately 3,057,260 m³ (3,998,750 yd³) of material is removed. Because Alternative One proposes to remove 9,990,000 m³ (13,066,250 yd³) over the 50-year lifetime of the project, NMFS estimates that the SRIPP may result in a total of 9 sea turtle takes over the lifetime of the SRIPP. Approximately three sea turtle takes may occur during dredging operations for the initial beach fill operations and six sea turtle takes may occur during dredging for the nine renourishment events. Over the lifetime of the project, NMFS anticipates that no more than one turtle that would be taken would be a Kemp's ridley, and the rest would be loggerheads.

In addition to entrainment, sea turtles may collide with the dredge during transit between the offshore borrow site to pump-out buoy. Though collisions with vessels operating at speeds as slow as the dredge in transit (approximately 10 knots) are not common, the potential exists for collisions that may injure or kill sea turtles. The presence of an observer who can advise the vessel operator to slow the vessel or maneuver safely when sea turtles are present would further reduce the potential for a collision to a discountable level (NMFS, 2010).

Dredging operations would cause sediment to be suspended in the water column. This results in a sediment plume in the water, which starts at the dredge site and decreases in concentration as sediment falls out of the water column as distance increases from the dredge site. The degree and extent of sediment suspension depends on several factors, including particle size distribution, solids concentration, and composition of the dredged material. It may also depend on the dredge type and size, operational procedures used and the water composition and weather conditions at the time of dredging. While the increase in suspended sediments may cause sea turtles to alter

their normal movements, any interruption is expected to be insignificant as it would likely only lead to animals moving out of the way of the plume.

Dredging noise may also affect sea turtles, though it is not well understood to what extent. Very little research exists on the hearing capabilities of sea turtles, but it is thought that turtles are capable of hearing in low frequency ranges that overlap with the dominant frequencies of dredge noise. As described in the marine mammal section (Section 4.3.9) dredge noise levels would not exceed levels which are considered to be injurious by NMFS, therefore sea turtles are not likely to be adversely affected by dredging noise under Alternative One.

Pumping of sand slurry to the beach may result in increased turbidity in the nearshore waters as suspended fine grained material returns to sea, leaving the heavier sand on the beach. Increased turbidity may discourage turtles from coming ashore on or nearby Wallops Island beaches.

Initial Beach Construction and Renourishment

The addition of sand would result in a new beach that could provide suitable habitat for sea turtles. The physical characteristics of the beach would affect the suitability for sea turtle nesting. Crain et al. (1995) noted that turtle crawl and nesting numbers often increase after nourishment. While the quantity of available nesting habitat would increase, the quality of the initially created and subsequently renourished beach habitat may be such that it could adversely affect turtle nesting (Crain et al., 1995). Nourishment can alter a beach's sand density, compaction, shear resistance, moisture content, slope, sand color, grain size, grain shape, sand mineral content, and gas exchange (Nelson and Dickerson, 1988; Crain et al., 1995; NRC, 1995). These altered parameters may affect nesting females by changing their nest site selection, nest-chamber geometry, nest concealment (Crain et al., 1995), and may also influence the incubating environment of a nest, which may affect hatchling success (Rumbold et al., 2001) and hatchling sex ratios (Nelson and Dickerson, 1988). The compaction caused by the placement of very fine sand and/or the use of heavy machinery on nourished beaches can result in reductions in nesting success (i.e., false crawls occur more frequently) (Nelson and Dickerson, 1987; Nelson et al., 1987). In turn, increased false crawls may result in increased physiological stress to nesting females. Sand compaction may also increase the length of time required to excavate nests and result in increased physiological stress (Nelson and Dickerson, 1988).

Studies by Kikukawa et al. (1998 and 1999) found that the most important parameters in nest site selection were compaction of the sand, followed by distance from the nearest human settlement. Others have found that artificial lighting on the beachfront reduces the number of loggerheads relative to areas with little or no artificial lighting (Witherington, 1992). Regarding post-nourishment hardness, studies at Jupiter Island, FL found that elevated beach hardness values persisted for three summers after nourishment (Steinitz et al., 1998). Ryder (1993) found a decrease in beach hardness one year after nourishment near the surf zone, but no decrease in the middle of the beach, where turtles would be expected to nest. Other locations have found that nourished beaches remain unnaturally hard for up to seven years, depending on weather and wave conditions along with the quality of the fill (Moulding and Nelson, 1988).

The formation of beach scarps could also adversely affect sea turtles. A beach scarp is a vertical or near vertical portion of the beachface located between the berm crest and the mean water line. The elevation change at a scarp can range from a few inches to several feet in height. Scarps are the result of small, everyday wave activity, rather than storm waves which typically reach and/or overtop the berm. Berm scarps have been found to impede turtles from reaching nesting areas,

Environmental Consequences

increasing the number of false crawls and decreasing the proportion of crawls resulting in nests (Crain et al., 1995; NRC, 1995; Steinitz et al., 1998). Additionally, scarps could cause turtles to lay nests in unsuitable locations (below the escarpment) where nests have a greater potential to be destroyed by wave action and flooding. If a scarp forms after egg laying occurs, it would present an obstacle to hatchling turtles trying to reach the ocean. If beach fill is built too high, scarps may occur. The berm height selected for the beach fill design was set at 2 m (6 ft) amsl which is an average of the berm elevations found at the north and south ends of the project. For this reason, it is expected that if any scarping occurs, it would be minor (less than a foot or so of elevation change). Also, since the northern end of the project is expected to accrete, it is expected that if scarping occurs, it would be limited to the southern three-fourths of the project (approximately 4,300 m [14,000 ft]). To mitigate potential effects, turtle nest sites would be monitored and scarps could be mechanically removed in the vicinity of nest sites at the opening of the nest's hatch window.

Once the beach fill is completed, sand fencing would be installed in shore-perpendicular segments along the seaward toe of the dune (Figure 15). NASA consulted with VDGIF and USFWS regarding location and orientation of the sand fencing to allow movement of adult sea turtles above the berm and into the dune area. If turtles enter this area for nesting, the sand fence design would not inhibit them from returning to sea. If nesting sea turtles hatch landward of the sand fence, most of the hatchlings would be able to move around the fencing to reach the sea.

Determining how all of the abovementioned factors would dictate the viability of the restored Wallops Island beach as a long term sea turtle nesting site cannot be predicted with great precision due to unknowns such as weather patterns, exact beach construction methods, and timing of project implementation. Several general conclusions can be drawn, however. The nourished beach would likely be harder than natural conditions following each construction cycle. Exactly how long it would remain this way is unknown, but it can be reasoned that this could last for several years following each sand placement cycle. As the material proposed for nourishment is coarser than the native beach sand, it would be somewhat less susceptible to compaction as compared to a choice of finer materials. Regarding lighting, there would be bright lighting on the beach during the beach building process to ensure worker safety. It is likely that parts of the initial fill cycle and future renourishment cycles would take place during turtle nesting season and could result in missed nest attempts. However, in the long term, following nourishment, there is very little human presence along the Wallops Island shoreline at night, and because lighting of the buildings closest to the beachfront is minimal, it can be reasonably expected that the long term effects on sea turtle nesting would be minimal.

The backpassing of sand from north Wallops Island would produce similar adverse effects in that it could result in inadvertent crushing of nests and would likely result in sand compaction from movement of heavy equipment and that it could affect the natural slope of the beach, which could make the site less attractive to nesting females. Wood and Bjorndal (2000) found that beach slope appeared to have a great influence on nest site selection. Additionally, removing sand from this area would lower beach elevations, which could present a higher risk of nest washout or flooding. To mitigate potential direct impacts to nesting sea turtles, NASA would only excavate sand for future renourishment outside of plover and sea turtle nesting season (March 15 through November 30 or the last date of potential sea turtle hatchling emergence based on when the last eggs were laid).

In its BO, the USFWS estimates that future renourishment activities, including both excavation of sand from the north Wallops Island borrow could lead to failure of up to two sea turtle nests, including all eggs, within the first year following each nourishment cycle. One additional nest is expected to fail in the second year following each beach nourishment. In addition, injury or death of one adult sea turtle during beach renourishment and associated activities is expected to occur within each beach renourishment cycle.

In summary, the SRIPP would result in adverse effects on sea turtles; however the benefits of adding approximately 6.0 km (3.7 mi) of habitat where there currently is none would likely outweigh the effects in the long term. To mitigate construction impacts to the greatest extent practicable, NASA would ensure that daily monitoring of the beach is performed if beach construction coincides with sea turtle nesting season. If turtle nests are identified within the planned work area, they would be marked, avoided by construction equipment, and reported to USFWS. NASA would coordinate with USFWS in developing site-specific mitigation measures to ensure adequate protection.

NASA has determined that Alternative One may affect, and is likely to adversely affect the loggerhead sea turtle, and may affect, but is not likely to adversely affect the leatherback, Kemp's ridley, or Atlantic green sea turtles.

Birds

No impacts on the bald eagle or peregrine falcon are anticipated under Alternative One primarily because their habitats would not be disrupted by SRIPP activities. Because an existing bald eagle nest exists in the project vicinity, NASA would survey a 200 m (660 ft) buffer around any planned work area on north Wallops Island to ensure that no new eagle nests are present. A remote possibility exists that dredging of the offshore borrow sites may indirectly affect the Gull-billed tern and Roseate Tern by disturbing potential feeding grounds, but these activities are not anticipated to result in significant impacts on these species.

Initial Beach Construction and Seawall Extension

Initial beach construction and seawall extension would likely take place during plover nesting season. Effects on Piping Plovers are expected, and would likely be similar to those discussed for other nesting and foraging shorebirds in Section 4.3.2.2. Initial construction would likely have limited impact on plovers as there is currently little suitable nesting habitat where work would take place. Potential effects could include startling, driving plovers from nests and potentially exposing eggs to harm, including predation or overheating. Noise from beach construction could also move foraging plovers from preferred feeding grounds to less suitable areas. There is the possibility that chicks could be entrapped in ruts and/or crushed by construction equipment; however the likelihood would be small due to the noise keeping the birds away from moving equipment. Minor impacts could also be expected from the burial and smothering of plover food sources at the extreme north and south ends of the project site (where there is existing natural beach). Sand fencing that would be installed soon after beach construction may affect plovers by deterring nesting close to the sand fence (USFWS, 2010a). Sand fencing may also increase the risk of plover depredation by providing cover for predators in close proximity to plover nests.

The new beach would likely provide additional suitable habitat for shorebirds including the Piping Plover. The new beach would initially be devoid of Piping Plover prey species. Some species are likely to recolonize the area within a few months, while other species, such as some

Environmental Consequences

flies, insects, and crustaceans may require a longer time to recolonize. Though the beach would initially be less suitable for Piping Plovers, over time the beach would be expected to acquire the faunal characteristics of the surrounding natural beaches through natural processes such as wave action, wind, and rain (USFWS, 2010a). The beach may serve as a higher quality foraging habitat for plovers than surrounding natural beaches, because the beach would remain free from vegetation for a period of time and may be higher and wider than nearby eroding beaches.

Renourishment

After each renourishment cycle, newly placed sand would likely be devoid of plover food sources for at least several months. As such, large areas of the beach, including the intertidal zone where plovers typically feed, could be of little value to plovers. This could cause plovers to relocate to other areas, thereby expending additional energy. If plovers readily use the newly created beach for nesting and foraging, effects of full renourishment during nesting season would likely be in direct adverse effects on both reproductive success and the availability of food sources.

In the past, north Wallops Island has been a regular nesting site for plovers. Although the use of the north Wallops Island area as a source of sand would be restricted to the non-nesting season, the longer term effects on plovers would be adverse, and would include lowering the beach elevation, thereby increasing risk of nest flooding or washout, and degrading the existing habitat by eliminating ephemeral pools and large sand flats that are favored by plovers.

The USFWS estimates that future renourishment activities, including both excavation of sand from the north Wallops Island borrow area and placed of the sand, is expected to result in loss of up to four Piping Plover nests (up to 16 eggs/chicks) in the first breeding season following each renourishment cycle. The action is also expected to result in loss of two plover nests (up to 8 eggs/chicks), through either nest failure or adults failing to nest, in the year following renourishment for each renourishment cycle.

In summary, as with other avian species that nest and feed along the beach, implementation of the project would produce adverse effects to Piping Plovers; however the benefits of adding habitat where there currently is none would likely outweigh the effects in the long term. To what degree the newly created beach would be used cannot be predicted, however it can be reasonably expected that some nesting would occur along the new beach. To mitigate potential adverse effects for all components of the project, NASA would ensure that daily surveys of the beach are performed when work takes place during plover nesting season. If nests are discovered within the planned work area, NASA would mark the site, ensure that it is avoided by construction equipment, and work with USFWS to develop appropriate site specific mitigation measures. Mitigation measures are discussed in more detail in Chapter 5 of this PEIS. Regarding the timing of future renourishment cycles, NASA would continue to monitor the Wallops Island beach following initial construction of the beach to establish the extent of actual plover use and would work with USFWS to determine the appropriate timing for renourishment at the time when the need is identified.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

Vegetation

Impacts on threatened and endangered vegetative species from Alternative Two would be similar to those described under Alternative One.

Marine Mammals

No impacts on threatened and endangered marine mammals from the construction of the seawall or the placement of sand on the beach are anticipated. Construction of a groin would temporarily disturb foraging habitat, but this disruption is not anticipated to significantly impact marine mammals. Impacts on threatened and endangered marine mammals from dredging activities would be similar to those discussed under Alternative One.

Sea Turtles

Impacts on sea turtles from seawall extension, beach fill placement, and dredging activities would be similar to those discussed under Alternative One. Construction of a groin would temporarily disturb foraging habitat and may lead to some habitat loss due to erosion within a groin “shadow” approximately 300 m (1,000 ft) downdrift of the structure (see Section 4.2.2.1 for details); however, renourishing the beach would reduce the potential for downdrift erosion by providing continual sand on the Wallops Island shoreline.

Birds

Impacts on threatened and endangered birds under Alternative Two would be similar to those described under Alternative One. Construction of a groin may lead to some habitat loss due to erosion within a groin “shadow” approximately 300 m (1,000 ft) downdrift of the structure (see Section 4.2.2.1 for details); however, renourishing the beach would reduce the potential for downdrift erosion by providing continual sand on the Wallops Island shoreline.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

Vegetation

Impacts on threatened and endangered vegetative species from Alternative Three would be similar to those described under Alternative One.

Marine Mammals

No impacts on threatened and endangered marine mammals from the construction of the seawall or the placement of sand on the beach are anticipated. Construction of a breakwater would temporarily disturb foraging habitat, but this disruption is not anticipated to significantly impact marine mammals. Impacts on threatened and endangered marine mammals from dredging activities would be similar to those discussed under Alternative One.

Sea Turtles

Impacts on sea turtles from seawall extension, beach fill placement, and dredging activities would be similar to those discussed under Alternative One. Construction of a breakwater would

Environmental Consequences

temporarily disturb foraging habitat and may lead to some habitat loss due to erosion within a 2.5-km (1.5-mi) area downdrift of the structure (see Section 4.2.2.1 for details); however, renourishing the beach would reduce the potential for downdrift erosion by providing continual sand on the Wallops Island shoreline.

Birds

Impacts on threatened and endangered birds under Alternative Three would be similar to those described under Alternative One. Construction of a breakwater may lead to some habitat loss within a 2.5-km (1.5-mi) area downdrift of the structure (see Section 4.2.2.1 for details); however, renourishing the beach would reduce the potential for downdrift erosion by providing continual sand on the Wallops Island shoreline.

4.3.10.1 Agency Consultation

NASA prepared a BA (Appendix C) as a component of the formal consultation process provided under Section 7 of the ESA. More detailed procedures for this formal consultation process are defined in 50 CFR 402.14(c). Early consultation is conducted when the action agency is planning a project or program that may affect protected species; however, not every project detail may be known. During previous consultations for the SRIPP, the specific borrow area(s) off the coast of Wallops Island had not been identified. However, NASA completed early consultation for potential dredging within a broad area of State waters east of Wallops Island for the SRIPP by submitting a BA in May 2007. NASA received a BO for proposed dredging in State waters from NMFS on September 25, 2007. In a letter to USFWS dated March 1, 2007, NASA transmitted a BA addressing potential impacts of the SRIPP on the Piping Plover. In a letter dated April 24, 2007, USFWS stated that the SRIPP (as defined in 2007) would not adversely affect threatened or endangered species under their jurisdiction. The March 2007 BA and the NMFS September 2007 BO laid the groundwork for the consultation process and allowed all three agencies to efficiently continue consultations for this project.

With the preparation of the February 2010 BA for the SRIPP, NASA, in conjunction with BOEMRE and USACE, continued the Section 7 consultation process by submitting additional project information to NMFS and USFWS. As with the 2007 BA, the February 2010 BA was prepared under the assumption that the dredging would continue at varying degrees of intensity for the next 50 years, with renourishment cycles approximately every 5 years. In response to the February, 2010 BA, NMFS provided its BO to NASA on July 22, 2010; and USFWS provided its BO on July 30, 2010. The BOs are referenced in the appropriate sections throughout the document, and determinations are summarized below.

In developing the BOs, NMFS and USFWS provided terms and conditions for reasonable and prudent measures that NASA must follow to reduce potential effects to listed species to be in compliance with the ESA. These measures are included in Chapter 5, Mitigation and Monitoring. Additionally, as required by the ESA, if changes to the SRIPP occur or if effects to species differ from what was stated in the 2010 BOs, NASA would re-initiate agency consultation.

Determination of Effects to Federally Protected Species

Table 52 includes NASA's, NMFS', and USFWS' determinations of effects to federally protected species under the ESA.

Table 52: Determination of Effects to Federally Protected Species

Species	NASA's Determination	NMFS Determination	USFWS Determination
Seabeach amaranth	May affect, not likely to adversely affect	n/a	Not likely to jeopardize the continued existence of species
Humpback Whale	May affect, not likely to adversely affect	Not likely to adversely affect	n/a
Fin Whale	May affect, not likely to adversely affect	Not likely to adversely affect	n/a
Right Whale	May affect, not likely to adversely affect	Not likely to adversely affect	n/a
Leatherback Sea Turtle	May affect, not likely to adversely affect	Not likely to adversely affect	Not likely to jeopardize the continued existence of species
Kemp's Ridley Sea Turtle	May affect, likely to adversely affect	May adversely affect, not likely to jeopardize the continued existence of species	n/a
Loggerhead Sea Turtle	May affect, likely to adversely affect	May adversely affect, not likely to jeopardize the continued existence of species	Not likely to jeopardize the continued existence of species
Atlantic Green Sea Turtle	May affect, not likely to adversely affect	Not likely to adversely affect	Not likely to jeopardize the continued existence of species
Piping Plover	May affect, likely to adversely affect	n/a	Not likely to jeopardize the continued existence of species

The NMFS BO estimates that there would be potential effects to listed species under the agency's purview from the following sources; 1) dredging operations, 2) placement of dredge material, 3) physical alteration of the action area including disruption of benthic communities and changes in turbidity levels, and 4) dredge noise and resultant increases in underwater noise levels. NMFS concludes that dredging activities are not likely to alter the habitat in any way that prevents sea turtles from using the action area as a migratory pathway to other near-by areas that may be more suitable for foraging. NMFS also concludes that adverse effects of the SRIPP are limited to the loggerhead and potentially the Kemp's ridley sea turtle, which are the most likely species to forage and nest within the project area.

The USFWS states in its BO that because there is little or no suitable habitat for listed species in the project area currently, the direct effects of the initial beach fill and seawall extension are likely to be minimal. The USFWS also states that indirect effects resulting from the creation of beach and dune habitat of unknown quality and quantity in close proximity to an area near NASA operations would likely result in adverse effects to Piping Plovers, sea turtles and possibly seabeach amaranth. The USFWS indicates that the indirect effects may include increased disturbance and interference with normal behavior resulting in reduced feeding, breeding and sheltering activity, and destruction/loss of eggs and young or failure of nests. The

Environmental Consequences

indirect effects to seabeach amaranth would be limited to changes in the suitability of potential habitat resulting from potential contaminants and disturbance.

4.4 SOCIAL AND ECONOMIC ENVIRONMENT

4.4.1 Land Use

No Action Alternative

Under the No Action Alternative, the SRIPP would not be implemented; however, maintenance and emergency repair activities would maintain the use of existing facilities; therefore, these activities would not result in changes to land use. However, maintenance of existing conditions may not adequately protect existing and planned infrastructure and facilities closest to the beach on Wallops Island. If significant beach loss did occur (i.e., during a large storm event), currently at-risk infrastructure on Wallops Island could be damaged, resulting in loss of these facilities and changes to land use if they cannot be repaired or reconstructed in their original location.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

Implementation of the SRIPP would result in ongoing use of existing and planned facilities on Wallops Island; therefore no changes to land use would occur.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

Implementation of the SRIPP would result in ongoing use of existing and planned facilities on Wallops Island; therefore no changes to land use would occur.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

Implementation of the SRIPP would result in ongoing use of existing and planned facilities on Wallops Island; therefore no changes to land use would occur.

4.4.2 Infrastructure and Facilities

No Action Alternative

Under the No Action Alternative, the SRIPP would not be implemented; however, maintenance and emergency repair activities would maintain the use of existing facilities. However, maintenance of existing conditions may not adequately protect existing and planned infrastructure and facilities closest to the beach on Wallops Island. Beach erosion, especially during storm events, could result in damage to or loss of \$1 billion in infrastructure and facilities, and loss of the capabilities of WFF and tenant's operations.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

Under Alternative One, SRIPP activities would maintain the use of existing and planned facilities on Wallops Island. The SRIPP would protect from damage to or loss of \$1 billion in infrastructure and facilities, and from the loss of the capabilities of WFF and tenant's operations.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

Alternative Two would provide an equal level of storm damage reduction to infrastructure and facilities on Wallops Island as Alternative One.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

Alternative Three would provide an equal level of storm damage reduction to infrastructure and facilities on Wallops Island as Alternative One.

4.4.3 Recreation

No Action Alternative

Under the No Action Alternative, the SRIPP would not be implemented; however, maintenance and emergency repair activities would occur. The Wallops Island beach would not be re-established where it is completely eroded; therefore, recreational use of the beach including fishing from the shore would continue to be limited.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

Use of sections of the Wallops Island beach would be restricted during SRIPP activities. However, because other beaches in the area and other parts of Wallops Island could be used as alternate locations for recreational purposes, no adverse impacts are anticipated.

While some recreational boaters and divers may utilize the marine waters within the SRIPP project area, they have considerable discretion in their choice of recreation locations. As a result, temporary clearances for safety purposes that would be implemented under the SRIPP would have little or no effect on the numbers of vessels or people involved in recreational activities, the success of their activities, or the satisfaction of participants in their recreational experience. When a safety clearance of the project area would be required, a Notice to Mariners would be provided in advance. This notification would continue to allow boaters to select an alternate destination without substantially affecting their activities. Barge trips to and from the offshore borrow sites and Wallops Island would result in increased traffic on the ocean, but because boaters can avoid the barges with ease, no severe disruptions to recreational boating or diving are anticipated.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

The types of impacts described under Alternative Two would be the same for Alternative One. However, a slight increase in the disruption to local shore fishermen and recreational boaters would occur during the groin construction period. Because recreational boaters could avoid the groin area during construction, no serious disruptions to recreational boating are anticipated.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

The types of impacts described under Alternative Three would be the same for Alternative One. However, a slight increase in the disruption to local shore fishermen and recreational boaters would occur during the breakwater construction period. Because recreational boaters could avoid the breakwater area during construction, no serious disruptions to recreational boating are anticipated.

4.4.4 Fisheries

No Action Alternative

Under the No Action Alternative, the SRIPP would not be implemented; however, maintenance and emergency repair activities would occur. Because these activities would take place on Wallops Island or in the nearshore area, it is anticipated that the No Action Alternative would

Environmental Consequences

result in only temporary impacts on any commercial or recreational fishing taking place from the Wallops Island beach or immediately offshore.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

Under Alternative One, there could be temporary impacts on commercial and recreational fishing resources during the placement of beach fill material on Wallops Island due to elevated turbidity levels in the nearshore environment and disruption of the benthos, which would cause fish to avoid the disturbed areas. No impacts to commercial and recreational fishing are anticipated from construction of the seawall or use of the north Wallops Island borrow site for renourishment. There would be temporary adverse impacts on commercial and recreational fishing at the offshore borrow sites during dredging. As described in Section 3.2.5 (Benthos), benthic habitat would be temporarily disturbed and it is anticipated that fish would migrate short distances to avoid the dredging operations.

Fishermen who participated in the spring 2009 SRIPP survey mostly had permits for bluefish, black sea bass, scup, squid/mackerel/butterfish, and summer flounder. Fishing for these species at Unnamed Shoals A and B would be temporarily adversely impacted by the presence of the dredge in the area and the increase in turbidity during dredging, which may interfere with fish feeding (Gordon et al., 1972), and consequently the fishing quality in the area. However, Unnamed Shoals A and B are only two of many shoals in the project vicinity and have not achieved nearly the same level of popularity with commercial and recreational fishermen as other nearby areas, such as Blackfish Bank Shoal. Thirty-six of the survey respondents (55 percent) reported fishing within 8 km (5 mi) of either Blackfish Bank or the Wallops Island shoreline. Of those 36 respondents, 24 said they fished at Blackfish Bank (NASA, 2009d). Fishermen could easily avoid fishing at Unnamed Shoals A and B during dredging operations.

Only one local vessel that had a permit for surf clams responded to the SRIPP survey, but vessels registered in other cities may also fish the area. Surf clams are present in the project area from the beach zone to a depth of about 45 m (150 ft), and would be the most adversely impacted of the commercially and recreationally fished species. Because the offshore shoals are within the surf clam habitat area, they could be entrained in the dredges, smothered from the placement of dredged sediments on the beach, or have difficulty feeding on plankton due to increased turbidity in the nearshore environment and at the offshore borrow sites. Surf clams are a common prey item for many pelagic fish. Studies conducted from 2002 to 2005 by VIMS examined the effects of dredging to the benthic community in offshore sand shoals (Diaz et al., 2006). The study suggests that benthic invertebrate communities destroyed by the dredger are able to rebound within a few years (Diaz et al., 2006). Impacts on surf clam populations would be mitigated by maintaining the morphology of the shoals and leaving undisturbed areas of benthic habitat in between passes of the dredger. These techniques would allow for quicker repopulation of the benthic layer. The loss of surf clams in the dredged areas on Unnamed Shoals A and B could reduce the numbers of fish present in the project area; however, these impacts are anticipated to be temporary and highly localized, and are not expected to significantly affect commercial or recreational fishing. In addition, according to Mr. Tom Hoff of the Mid-Atlantic Fishery Management Council (personal comm.), approximately 80 percent of the vessels fishing for surf clams of the Atlantic coast landed their catches in New Jersey, 5 to 10 percent in Ocean City, Maryland, 10 percent off the Delmarva Peninsula, and 5 to 10 percent off New England. The NMFS 2008 commercial fishery landings ranked by U.S. port also indicate that the majority of commercial fishing on the East coast is done north of the project area in States like New Jersey,

Massachusetts, and Maine. The ports closest to the project area are lower ranked ports, with Ocean City, Maryland ranked 52, and Chincoteague, Virginia ranked 77 out of 90 ranked U.S. ports (NMFS, 2009).

NASA's SRIPP activities would not impact daily commercial fishing routes, including ingress and egress from Chincoteague Inlet.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

Under Alternative Two, the types of impacts on commercial and recreational fisheries would be similar to those discussed under Alternative One; however, because less beach fill volume (initial and renourishment volumes) would be required compared to Alternative One, the beach nourishment would require less time to execute and fewer trips to the shoals, resulting in fewer disruptions to fishermen. Elevated turbidity is expected during the construction of the new groin, but it would also provide additional habitat for fish as well as benthic organisms that attached to hard substrates such as sponges and crab that would live on and in the crevices of the rocks.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

Under Alternative Three, the types of impacts on commercial and recreational fisheries would be the same as those discussed under Alternative One; however, because less beach fill volume (initial and renourishment volumes) would be required compared to Alternative One, the beach nourishment would require less time to execute and fewer trips to the shoals, resulting fewer disruptions to fishermen. Elevated turbidity is expected during the construction of the new breakwater, but it would also provide additional habitat for fish as well as benthic organisms that attached to hard substrates such as sponges and crab that would live on and in the crevices of the rocks.

4.4.5 Population, Employment and Income

No Action Alternative

Under the No Action Alternative, the SRIPP would not be implemented; however, minor maintenance and emergency repair activities would occur. Under this alternative, damage and/or loss of WFF assets could occur; these losses would delay Wallops Island mission assignments and could eliminate technological capabilities as well as employment opportunities.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

Construction activities would result in beneficial economic impacts to the overall economy. In addition to a temporary increase in the number of workers at WFF, economic impacts from the Proposed Action would result from construction material purchases in the region generating local sales, construction payroll expenditures for labor on-and off-site, and related spending by supplying firms and laborers or "multiplier effects" created by the project investment. These economic benefits would occur for a relatively limited time during actual construction.

Direct effects would involve generation of employment and spending by workers within Accomack County. Construction activities would also result in indirect economic activity by supplying industries that furnish requisite input materials and services to the industries directly involved in construction. These indirect impacts reflect the intermediate production or increased economic activity to supply services, materials, and machinery necessary to support the construction program. In turn, the labor force would re-spend a portion of their salary and wage

Environmental Consequences

earnings on various consumer expenditures, producing a “ripple effect.” This effect is observed as indirect economic activities, such as demand for goods and services, responds to the direct economic stimulus. Some non-local construction workers and vessel operators and crew are anticipated to require lodging in local motels and hotels.

The SRIPP would reduce the potential losses of work days and jobs that could result from storm damages, and therefore delays to Wallops Island missions, or the loss of the infrastructure resulting in elimination of WFF’s and tenant’s technological capabilities. Additionally, launches from the Wallops Island Launch Complex 0 provide benefits to the local economy. Per launch event, the local economy typically benefits approximately \$1,000,000 from the launch team alone (e.g., hotel, per diem rates for meals and incidentals, rental car), \$2,000,000 for services and commodities support, and \$3,000,000 to \$5,000,000 from tourism (Reed, pers. comm.). Alternative One of the SRIPP would reduce the potential storm-related damages resulting from shoreline retreat to the launch pads within Launch Complex 0.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

The types of impacts and benefits would be similar to those described under Alternative One. However, there would be a slight increase in benefits to the local economy compared to Alternative One due to the construction of a groin, which would result in additional employment opportunities for local construction workers and increased numbers of people in Accomack County.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

The types of impacts and benefits would be similar to those described under Alternative One. However, there would be a slight increase in benefits to the local economy compared to Alternative One due to the construction of a breakwater, which would result in additional employment opportunities for local construction workers and increased numbers of people in Accomack County.

4.4.6 Health and Safety

No Action Alternative

Under the No Action Alternative, the SRIPP would not be implemented; however, minor maintenance and emergency repair activities would occur. Maintenance and emergency repair activities could result in short-term impacts on human health and safety and the increased usage of local fire, police, and medical services. Construction safety procedures and appropriate training implemented at WFF and NASA would ensure that construction and dredging contractors perform all work in accordance with OSHA standards. Therefore, it is anticipated that the No Action Alternative would not impact health and safety.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

Construction activities could result in short-term impacts on human health and safety and the increased usage of local fire, police, and medical services. Construction safety procedures and appropriate training would be implemented at WFF and NASA would ensure that construction and dredging contractors perform all work in accordance with OSHA standards. Therefore, it is anticipated that Alternative One would not impact health and safety.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

Health and safety impacts and mitigation would be the same as described under Alternative One.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

Health and safety impacts and mitigation would be the same as described under Alternative One.

4.4.7 Environmental Justice

No Action Alternative

Under the No Action Alternative, maintenance and emergency repair activities would be similar to activities already conducted at WFF; therefore, since the EJIP found that current WFF actions do not disproportionately affect low-income or minority populations (NASA, 1996), no impacts on low-income or minority populations would occur.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

Typical construction activities may result in noise, air emissions, water quality degradation, construction related traffic, and other impacts that can potentially affect minority and low-income persons. However, the SRIPP activities are not expected to occur near any low-income or minority communities or residences. The nearest community located within a low-income or minority census block is located over 3.1 km (1.9 mi) from Wallops Island, outside of any potential effects related to the SRIPP activities. During project planning, NASA regularly holds public meetings and issues announcements to ensure that members of the public are aware of upcoming activities. These announcements are published through a variety of outlets including the internet, local radio, local newspapers, and local town hall meetings. This outreach effectively ensures that people of all income and ethnicities have the opportunity to comment on NASA's activities, including the SRIPP. Therefore, SRIPP impacts are not expected to cause any disproportionate impacts to minority and low-income persons.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

Although the specific actions under Alternative Two would differ from Alternative One, the nature of impacts would be similar. Therefore, no impacts on environmental justice are anticipated under Alternative Two.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

Although the specific actions under Alternative Three would differ from Alternative One and Two, the nature of impacts would be similar. Therefore, no impacts on environmental justice are anticipated under Alternative Three.

4.4.8 Cultural Resources

The geographical area within which an undertaking may affect historic properties is the APE. As stipulated in Section 106, Federal agencies must identify historic properties within the APE and consider the effects of the undertaking on these properties. The *Historic Resources Survey and Eligibility Report for Wallops Flight Facility* (NASA, 2004) referenced earlier in this report serves as the baseline for the identification of the above-ground historic properties at WFF, while the archaeological sensitivity model presented in the *Cultural Resources Assessment, NASA Wallops Flight Facility* (NASA, 2003b) serves as the baseline for identifying potential archaeological resources. Together these studies, addressed in the Cultural Resources

Environmental Consequences

Management Plan for WFF, likely account for many of the historic properties that are present at WFF and as such allow for a general assessment of the potential for an undertaking to affect historic properties.

Underwater actions, which include dredging within Unnamed Shoal A or Unnamed Shoal B, pump-out operations in the nearshore environment east of Wallops Island, and the construction of a groin or breakwater, would only affect archaeological resources. These actions have no potential to affect above-ground resources. The locations of the pump-out stations is estimated to be at the 9 m (30 ft) depth contour which is 3 km (2 mi) offshore; however, the exact location and number, and methods of the pump-out buoys would be determined by the contractor. NASA consulted with VDHR on this issue; additional Section 106 consultation would be required for the areas around the pump-out stations once the locations have been identified.

For any identified cultural resources that may be affected by NASA activities under the SRIPP, NASA would be responsible for complying with Section 106 and Section 110 of the NHPA. NASA would consult with the VDHR and any other interested parties for actions that would potentially impact NRHP-listed or eligible resources to identify the area of potential effects, the effects the action would have on cultural resources, and the appropriate measures to avoid or mitigate impacts on cultural resources.

No Action Alternative

Above-Ground Resources: Under the No Action Alternative, shoreline retreat would continue. Maintenance and emergency repairs to existing structures would likely be necessary as a result of future storm events. As needed, maintenance and emergency repairs to damaged structures would need to be completed in accordance with Section 106 and Section 110 of the NHPA. This would include the review of any newer buildings or structures that have reached the NHPA 50-year threshold for their National Register eligibility after the *Historic Resources Survey and Eligibility Report for Wallops Flight Facility* was approved by VDHR. Therefore, it is anticipated that the No Action Alternative could have adverse effects on above-ground resources.

Archaeological Resources: The only potential impacts on archaeological resources would be the use of heavy equipment disturbing unknown archaeological sites along the beach. However, based on the Reconnaissance Level Archaeological Survey conducted in September 2006, there is little potential for archaeological sites to occur along the beachfront. Therefore, it is anticipated that the No Action Alternative would have no adverse effect on archaeological resources.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

Seawall and Beach Fill

Above-Ground Resources: NASA has determined that the Proposed Action does not have the potential to directly affect above-ground historic properties within the APE. Additionally, NASA has determined that the project may have indirect (visual) effects on above-ground historic properties should they be present in the APE, but that these would not be adverse.

Archaeological Resources: Terrestrial archaeology would likely not be affected for beach fill activities because there would be only surface disturbance on the beachfront and no archaeological material or features were found during the Phase I Archaeological Survey conducted in September 2006. Because there were no historic properties identified within the

APE on Wallops Island and because the archaeological review of recent ground disturbance in the area found no archaeological resources, NASA has determined that no archaeological historic properties would be affected by the seawall extension or beach construction. Archaeological resources in the area of the pump-out buoys are unknown at this time; therefore, no determination can be made regarding potential effects.

Section 106 Consultation: On December 9, 2009, NASA submitted a letter to VDHR with NASA's determinations of effects for cultural resources as stated above. In a letter dated January 5, 2009, VDHR concurred with NASA's determination "that there are no historic properties location within the project area and that no further work is needed within the area studied," and that Alternatives One, Two, and Three of the SRIPP "will not adversely affect any historic properties" (Appendix K).

The Section 106 process is still ongoing for the pump-out buoy portion of the SRIPP. On August 4, 2010, NASA corresponded with the State Historic Preservation Office via e-mail regarding the anchoring of the pump-out buoys. NASA stated that it was unknown at the present time what methods the dredging contractor may use to pump sand from the dredge vessels to the shoreline. As such, the contractor would be required to supply NASA with a dredge plan prior to implementation. NASA would review the plan with VDHR and the two agencies would jointly decide if further survey work is required. VDHR responded on August 9, 2010, stating that it agreed with this approach (Appendix K). Furthermore, in the event that previously unrecorded historic properties are discovered during project activities, NASA would stop work in the area and contact VDHR immediately.

Offshore Borrow Sites

Analysis of the data from the 2009 remote sensing survey coupled with the frequent fishing that takes place at or near Unnamed Shoal A, indicated that none of the anomalies detected during the survey have potential to represent significant submerged cultural resources.

Section 106 Consultation: In October 2009, NASA submitted a cultural resources report to BOEMRE stating that "No further avoidance or work is recommended for the isolated anomalies or five target clusters identified [at Unnamed Shoal A and Unnamed Shoal B]." In an email dated December 15, 2009, BOEMRE agreed with NASA's determination and no archaeological mitigation is required (Appendix K). BOEMRE also stated that an unanticipated discovery of archaeological resources would result in the immediate halt of operations within 305 m (1,000 ft) of the area of the discovery. NASA would then be required to report the discovery to the Regional Supervisor, Leasing and Environment, Gulf of Mexico Region within 72 hours of discovery. The Regional Supervisor would then inform NASA as to how to proceed (Herkhof, pers. comm.).

North Wallops Island Borrow Site

Because there were no historic properties identified within the APE on Wallops Island and because the archaeological review of recent ground disturbance in the proposed north Wallops Island borrow site area found no archaeological resources, NASA has determined that no archaeological historic properties would be affected by the Proposed Action.

Section 106 Consultation: On December 9, 2009, NASA submitted a letter to VDHR with NASA's determinations of effects for cultural resources as stated above. In a letter dated January

Environmental Consequences

5, 2009, VDHR concurred with NASA's determination "that there are no historic properties location within the project area and that no further work is needed within the area studied," and that Alternatives One, Two, and Three of the SRIPP "will not adversely affect any historic properties" (Appendix K). In the event that previously unrecorded historic properties are discovered during project activities, NASA would stop work in the area and contact VDHR immediately.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

Seawall and Beach Fill

The impacts and consultation discussed under Alternative One for seawall and beach fill components of the SRIPP would be the same for the seawall and beach fill components of Alternative Two.

Groin

Results from the 2009 cultural resources wading survey of the proposed groin location and Wallops Island shoreline survey did not identify any significant cultural resources. The final 70 m (200 ft) of the survey area were not surveyed due to safety concerns regarding impalement and entanglement of divers on rebar left from the dumping of construction debris. Moreover, based on the ground disturbance that has occurred at this site including construction of the original groin, disposal of concrete construction waste throughout the area, and the general erosion and sediment transport that routinely takes place along the Wallops Island shoreline, this section has a very low potential to contain significant historic resources. Because there were no historic properties identified within the APE on Wallops Island and because the archaeological review of recent ground disturbance in the area found no archaeological resources, NASA has determined that no archaeological historic properties would be affected by construction of the proposed groin.

Section 106 Consultation: On December 9, 2009, NASA submitted a letter to VDHR with NASA's determinations of effects for cultural resources as stated above. In a letter dated January 5, 2009, VDHR concurred with NASA's determination "that there are no historic properties location within the project area and that no further work is needed within the area studied," and that Alternatives One, Two, and Three of the SRIPP "will not adversely affect any historic properties" (Appendix K). In the event that previously unrecorded historic properties are discovered during project activities, NASA would stop work in the area and contact VDHR immediately.

Offshore Borrow Sites

The impacts and consultation discussed under Alternative One for dredging Unnamed Shoal A or B would be the same for Alternative Two.

North Wallops Island Borrow Site

The impacts and consultation discussed under Alternative One for use of the north Wallops Island area as a borrow site would be the same for Alternative Two.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

Seawall and Beach Fill

The impacts and consultation discussed under Alternative One for seawall and beach fill components of the SRIPP would be the same for the seawall and beach fill components of Alternative Three.

Breakwater

Results from the 2009 remote sensing survey indicated that no significant submerged cultural resources exist in the proposed breakwater location. Because there were no historic properties identified within the APE of the breakwater and because the archaeological review in the area found no archaeological resources, NASA has determined that no archaeological historic properties would be affected by construction of the proposed breakwater.

Section 106 Consultation: On December 9, 2009, NASA submitted a letter to VDHR with NASA's determinations of effects for cultural resources as stated above. In a letter dated January 5, 2009, VDHR concurred with NASA's determination "that there are no historic properties location within the project area and that no further work is needed within the area studied," and that Alternatives One, Two, and Three of the SRIPP "will not adversely affect any historic properties" (Appendix K). In the event that previously unrecorded historic properties are discovered during project activities, NASA would stop work in the area and contact VDHR immediately.

Offshore Borrow Sites

The impacts and consultation discussed under Alternative One for dredging Unnamed Shoal A or B would be the same for Alternative Three.

North Wallops Island Borrow Site

The impacts and consultation discussed under Alternative One for use of the north Wallops Island area as a borrow site would be the same for Alternative Two.

4.4.9 Transportation

4.4.9.1 *Land-Based*

No Action Alternative

Under the No Action Alternative, SRIPP would not be implemented; however, maintenance activities and emergency repairs would occur. These activities would cause recurring traffic to and from and on Wallops Island, the nature and magnitude of which would depend upon the types of maintenance and repairs needed.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

Temporary impacts on traffic flow would occur during construction activities due to an increase in the volume of construction-related traffic at roads in the immediate vicinity of Wallops Island. Construction traffic would include bulldozers, excavators, and cranes, brought in via truck, haul/dump trucks, worker vehicles, and others. Traffic lanes may be temporarily closed or

Environmental Consequences

rerouted during construction, and construction equipment and staging could interfere with typical vehicle flow. NASA would coordinate all transportation activities, including closures, traffic control, safety issues, etc. with Accomack County and the Virginia Department of Transportation Accomack Residency Office. To mitigate potential delays, NASA would:

- Provide adequate advance notification of upcoming activities for all areas that would be affected by construction-related traffic, temporary closures, or re-routing
- Coordinate any traffic lane or pedestrian corridor closures with all appropriate officials
- Place construction equipment and vehicle staging so as to not hinder traffic and pedestrian flow

All project-related transportation vehicles would consist of legal Department of Transportation loads, although if a crane is transported over land, it may be characterized as oversize and would require a permit from the Virginia Department of Motor Vehicles for transportation.

During renourishment cycles, sediment may be obtained from north Wallops Island. Heavy equipment including pan excavators, dump trucks, excavators, and bulldozers would travel along the existing roads and along the beach to access the north Wallops Island borrow sites; no new permanent or temporary roads would be constructed to access the borrow site.

Unnamed Shoal A and Unnamed Shoal B Borrow Sites

Minor construction traffic is anticipated to be associated with the Unnamed Shoal A and Unnamed Shoal B borrow sites. Employees would drive to the docked dredging barges to load them with any needed equipment. However, this amount of traffic would not be a significant increase from the usual daily landside traffic on Wallops Island.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

The types of landside transportation impacts and mitigation measures would be the same as those described under Alternative One, except there would be an increase in traffic during the construction of the groin.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

The types of landside transportation impacts and mitigation measures would be the same as those described under Alternative One; however there would be slightly more construction traffic for installation of the breakwater.

4.4.9.2 Maritime

No Action Alternative

Under the No Action Alternative, SRIPP would not be implemented; however, maintenance activities and emergency repairs would occur. It is unlikely that maintenance and repairs would occur in or from the water. If boats or barges were required, a slight increase in maritime traffic could occur which would depend upon the types of the repairs that were needed; however, any increase in maritime traffic would be insignificant.

Alternative One (Preferred Alternative): Full Beach Fill, Seawall Extension

No maritime traffic would occur for construction of the seawall, sediment re-working on the beach after the dredge material is placed, or for use of the north Wallops Island borrow site.

Dredging of either offshore shoal would be accomplished using hopper dredges, which are ships capable of dredging material, storing it onboard, transporting it to the disposal area, and pumping it on-shore. Two hopper dredges would likely run at the same time, as one ship is dredging at either Unnamed Shoal A or B, the second ship would be offloading sediment on the beach. After filling its hoppers with sand, the dredge would then travel the approximately 15 km (10 mi) toward Wallops Island. The pathway from Unnamed Shoals A and B to the pump out site is not a straight line, but a dogleg shape, for the purpose of avoiding Chincoteague Shoal and Blackfish Bank. The dredge would travel from Unnamed Shoal A or B to the turning point approximately 15 or 23 km (9 or 14 mi) away respectively, then on to moor to the pump-out buoy located 10,000 feet from shore (5 km [8 mi] from the turning point). Booster pumps may be needed to aid the offloading of sand from this pump out station to the shoreline.

Navigational accidents, such as vessel collisions, would be avoided by following proper safety protocols as outlined in 72 Collision Regulations (COLREGS), The International Navigational Rules Act of 1977, and the Inland Navigation Rules Act of 1980 (USCG, 2009a). The barge route would extend directly from Unnamed Shoals A and B to the Wallops Island shoreline.

A Private Aid to Navigation (PATON) permit would need to be obtained from the USCG to place temporary buoys for dredging activities. The management of the PATON can be deferred to State or local authorities, or to agencies such as the USACE or BOEMRE. The USCG will usually only become involved in PATON management if there is not a designated mooring area and a buoy needs to be placed on the chart or in situations when a large commercial mooring buoy needs to be lit or charted, however, only after the selected local authority has approved the placement (USCG, 2009b).

Temporary increases in the volume of maritime traffic would occur for approximately seven months during initial beach nourishment activities and approximately two months during each renourishment cycle. Potential impacts on the three general types of maritime traffic in the project area, military and government, commercial, and recreational, are discussed below.

Military and Government Traffic

Due to the presence of regular military and government traffic in the project area, and the overlap of the U.S. Navy Virginia Capes Range Complex operating area, it is likely that the dredges would encounter these vessels during travel between the offshore shoals and the beach. NASA would coordinate all transportation activities, marine traffic control, safety issues, etc. with USCG and the U.S. Navy. To mitigate potential delays and ship strikes, NASA would:

- Select the dates, times, and routes that the dredges would take with efforts to avoid the majority of existing military traffic.
- Provide adequate advance notification of upcoming activities to all agencies that would be affected by dredging-related traffic or re-routing.

With implementation of mitigation and notification measures, impacts on maritime government and military traffic would be temporary and minor.

Environmental Consequences

Commercial Traffic

Although commercial vessels may pass by the dredging sites on their way to Port of Baltimore, MD, and the Port of Virginia, in Norfolk, there are no TSS lanes designated in the project area. Therefore, it is unlikely that the dredges would interfere with commercial traffic. Additionally, the dredges would comply with Federal navigational regulations (72 COLREGS) which specify requirements for any seagoing vessel operating in U.S. waters outside inland demarcation lines, which is the area enclosed by the shoreline. In the project area it is the line drawn from Assateague Beach Tower Light to the tower charted at latitude 37°52.6' N, longitude 75°26.7' W. The COLREGS include requirements such as having the proper day signals and navigational lights. Therefore, no significant impacts on commercial maritime traffic are anticipated.

Recreational Traffic

Fishing and recreational boating traffic occurs in the project area primarily offshore of Wallops and Assateague Islands and at offshore shoals. Although recreational traffic may be present in the project areas concurrently with dredging and beach nourishment operations, the dredges would be outfitted with the proper lights and signals under 72 COLREGS, so they can easily be seen and avoided. Although recreational fishing and boating routes would be unavailable for use in the areas immediately surrounding the offshore dredging sites and the Wallops Island beach during SRIPP operations, the majority of the project area would still be available for travel. Therefore, no significant impacts on recreational maritime traffic are anticipated.

Alternative Two: Full Beach Fill, Groin, Seawall Extension

Maritime transportation impacts and mitigation measures under Alternative Two would be similar to those described under Alternative One; however, there would be fewer dredge trips from the offshore shoals to the nearshore pump-out buoy due to less sand needed for beach nourishment. Also, there would be an increase in traffic in the nearshore environment off Wallops Island during the one month period for construction of the groin.

Alternative Three: Full Beach Fill, Breakwater, Seawall Extension

Maritime transportation impacts and mitigation measures under Alternative Three would be similar to those described under Alternative One; however, there would be fewer dredge trips from the offshore shoals to the nearshore pump-out buoy due to less sand needed for beach nourishment. Also, there would be an increase in traffic in the nearshore environment off Wallops Island during the one month period for construction of the breakwater.

4.5 RELATIONSHIP BETWEEN SHORT-TERM USE OF THE HUMAN ENVIRONMENT AND MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

NEPA requires analysis of the relationship between a project's short-term impacts on the environment and the effects those impacts may have on the maintenance and enhancement of the long-term productivity of the affected environment. Impacts that narrow the range of beneficial uses of the environment are of particular concern. This means that choosing one option may reduce future flexibility in pursuing other options, or that committing a resource to a certain use may often eliminate the possibility for other uses of that resource.

Short-term refers to the total duration of shoreline restoration activities, whereas long-term refers to an indefinite period beyond 50-year life of the SRIPP activities. Initial activities, such as

dredging and sea wall construction, result in short-term, localized impacts (primarily to the natural environment) that would be reduced by the mitigation measures described under each resource area.

The Proposed Action would result in short- and long-term environmental effects. However, the Proposed Action would not likely be expected to result in any impacts that would reduce environmental productivity, permanently narrow the range of beneficial uses of the environment, or pose long-term risks to health, safety, or the general welfare of the public.

The SRIPP would also result in beneficial effects. As described in Chapter 5, NASA would monitor the Wallops Island shoreline and offshore borrow sites to gain a better understanding of physical oceanographic processes, effects on biological resources, and longshore sediment transport during the lifetime of the SRIPP. This information would be available to the public and would benefit the scientific community, as well as NASA, in understanding the effects of shoreline restoration and offshore dredging. In addition, the SRIPP would restore a substantial area of the Wallops Island beach where no beach currently exists. The restoration of the beach would provide new habitat to terrestrial species, including federally protected species such as the Piping Plover and loggerhead turtle.

By reducing the level of storm damages to the launch pads and other infrastructure on Wallops Island, the SRIPP is enabling continued scientific research. The SRIPP would allow the continuation of critical NASA missions such as suborbital research from NASA's sounding rocket program and re-supply of the International Space Station.

4.6 IRREVERSIBLE OR IRRETRIEVABLE COMMITMENT OF RESOURCES

NEPA requires that environmental analysis include identification of "...any irreversible and irretrievable commitments of resources which would be involved in the Proposed Action should it be implemented." Irreversible and irretrievable resource commitments are related to the use of non-renewable resources and the effects that the uses of those resources would have on future generations. Irreversible effects primarily 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).

Energy typically associated with construction activities would be expended and irretrievably lost under all of the SRIPP alternatives including the No Action Alternative. Fuels used during transportation of construction materials (i.e., rock and mobilization of equipment to the site) and the operation of equipment and barges would constitute an irretrievable commitment of fuel resources.

Sediment removed from the offshore shoals would be an irreversible use of the mineral resource. If it is found that the northern end of Wallops Island could be mined for larger volumes beyond what is proposed in this PEIS, then the rate and volume of consumption of the offshore borrow areas used to maintain the Wallops Island shoreline could be reduced. 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.

4.7 CUMULATIVE EFFECTS

The CEQ defines cumulative effects 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 (Federal or non-Federal) or person undertakes such other actions*” (40 CFR 1500). Sections 4.2 – 4.4 of this PEIS described the potential direct and indirect impacts from the three alternatives evaluated for the SRIPP.

Cumulative effects can result from actions that overlap spatially and temporally. Past, present, and reasonably foreseeable future actions that may result in cumulative effects when combined with the SRIPP are described below in Section 4.7.1. Additionally, given their location in the coastal landscape, the natural and human resources within the area are affected by difficult to predict natural processes such as sea-level rise and storms. As such, cumulative effects from the SRIPP would be re-evaluated and described in future NEPA documentation for renourishment events or if the SRIPP Preferred Alternative changes based on adaptive management.

4.7.1 Actions Affecting Resources of Concern

The SRIPP is evaluated in the context of changes, both anthropogenic and natural, that have occurred at Wallops Island in the past and that would occur in the future even if the Proposed Action is not implemented. There are several ongoing and planned projects at WFF, particularly on Wallops Island. In addition, there are other projects and activities outside of the WFF boundaries that may contribute to cumulative impacts on resources in the area. These projects and actions include; dredging of offshore shoals, navigation channel maintenance, beach nourishment projects, commercial fishing, and submarine infrastructure projects such as construction of pipelines or cables. Other activities include residential and commercial development and agriculture within the watershed, recreational beach use, conservation management of adjacent barrier islands, and ongoing operations at WFF.

Past actions that are described below include activities that have occurred at WFF since development of Wallops Island by the federal government in the 1930s. For future actions, projects and activities that may reasonably occur within the 50-year life span of the SRIPP are considered. The cumulative effects analysis considers varying geographic scales based on the resource of concern and these scales are defined for each resource.

Climate change and sea-level rise, although not “actions” by definition, are very likely to influence many of the resource areas also impacted by the SRIPP, and accordingly are considered within this cumulative effects analysis.

4.7.1.1 Past Activities and Projects

This section provides a brief summary, by decade, of the major actions at WFF since its inception. The temporal baseline of the cumulative effects starts in 1938 with the first available aerial photograph of Wallops Island showing initial development by the USCG and Wallops Island Association Hunt Club. The majority of WFF has been subject to continuous change and development since its founding in the 1940s. Changes to the island include frequent construction, infrastructure upgrades, and removal of structures and facilities driven by technological developments and advances in rocket science and related fields. Over the years, the launch range has grown to six launch pads, assembly facilities, and state-of-the-art instrumentation. Since 1945, NASA has launched more than 16,000 rockets. The 2004 EPA report *Aerial Photographic*

Analysis of NASA Wallops Flight Facility Site, Wallops Island, Virginia provided a majority of the information on the historical activities and resulting environmental impacts at WFF.

4.7.1.1.1 1930s and 1940s

The earliest development of Wallops Island was documented in 1938. At that time, the island was being used by the Wallops Island Association Hunt Club. Several hunt club buildings were located at the beach on the northern part of the island. The Sloop Gut boat basin had been dredged by 1938 and three access roads connected the hunt club buildings to the dock on Sloop Gut. A USCG life boat station was also present in 1938. Noticeable excavation and fill activities were occurring on the north part of the island. The south part of the island was inactive in 1938. A farmstead surrounded by agricultural land existed on Wallops Mainland (EPA, 2004).

WFF was established in 1945 under NASA's predecessor, the NACA. By mid-1946, NACA had constructed two docks on the Mainland and dredged a channel between one of them and Assawoman Creek (Shortal, 1978). NACA development occurred on the southern portion of the island and the first launch pad at Wallops Island was in use in mid-1945, with a second launch pad in use by 1946. By 1947, the island included several launch support buildings and facilities including a power plant.

Although a naval air station was built on Wallops Neck in 1942, naval use of Wallops Island started in 1946 when the Naval Aviation Ordnance Test Station was established to provide a test range and training for personnel to test, modify, and develop guided missiles, aircraft weapons, and aviation fire control equipment.

By the end of the 1940s, several new access roads, ground scars (indicating excavation) and fill areas, additional infrastructure (buildings, towers, ASTs), and a new dock along Cat Creek can be seen in photographs.

Shoreline Stabilization

A sheet-pile seawall was constructed in 1945-1946. There was erosion and storm damage to the Wallops Island Association Clubhouse at the north end of the island in May 1949.

4.7.1.1.2 1950s

In the 1950s, the amount of infrastructure on Wallops Island expanded greatly. Additional launch support infrastructure, new research facilities, and many new roads were constructed. Approximately 20 new buildings were added to the south end of the island. Some of the other infrastructure included: three rocket-motor facilities, an instrumentation laboratory, camera stations, fuel storage buildings, ferry slips, concrete pads, above ground storage tanks, radar and antennas, a multistage launcher and administration and service buildings. The ferry channel between the Wallops Island dock and the Mainland Dock at Assawoman Creek was dredged periodically through 1957 (Shortal, 1978). Starting in 1954, a channel east of Bogue Bay was dredged as part of the Coast of Virginia Project, now known as the Virginia Inside Passage (Roehrs and Walsh, 1987). Periodic maintenance dredging of the Virginia Inside Passage has occurred by USACE since then. In the south part of the island a new dock was built (EPA, 2004).

Between 1955 and 1957, roughly 180 napalm drops occurred in the Gunboat Point area of Wallops Island (Photograph 17, although the quantity of drops is likely higher since not all of the reports recording napalm activity can be obtained. Napalm is composed of a mixture of salts of

Environmental Consequences

aluminum and acids that create aluminum soap which is then mixed with gasoline to form a gel. Most of the components volatilized upon ignition; however, in some instances, the gel dispersed across a large area. The maximum length of napalm dispersal for one drop was 200 yards (600 ft) (shown inside the Gunboat Point hazard area on Photograph 17). Naval use of the northern half of Wallops Island to test and proof Navy aerial ordnance continued until 1959.

Photo 17: Gunboat Point Range on North Wallops Island



Shoreline Stabilization

Between 1956 and 1959 eight groins were installed at 122-m (400-ft) intervals along 853 m (2,800 ft) of beach, which can be seen in a 1959 photo (Photograph 18) showing the groin field extending southward from the newly built causeway. In addition to the steel sheet pile, portions of the seawall were constructed using wooden bulkheads, concrete aprons, and rock rubble mounds.

4.7.1.1.3 1960s

NASA continued to expand its facilities on Wallops Island in the 1960s. The causeway between the mainland and Wallops Island was completed in 1960 (Photograph 18).

Photo 18: Newly constructed causeway in 1959



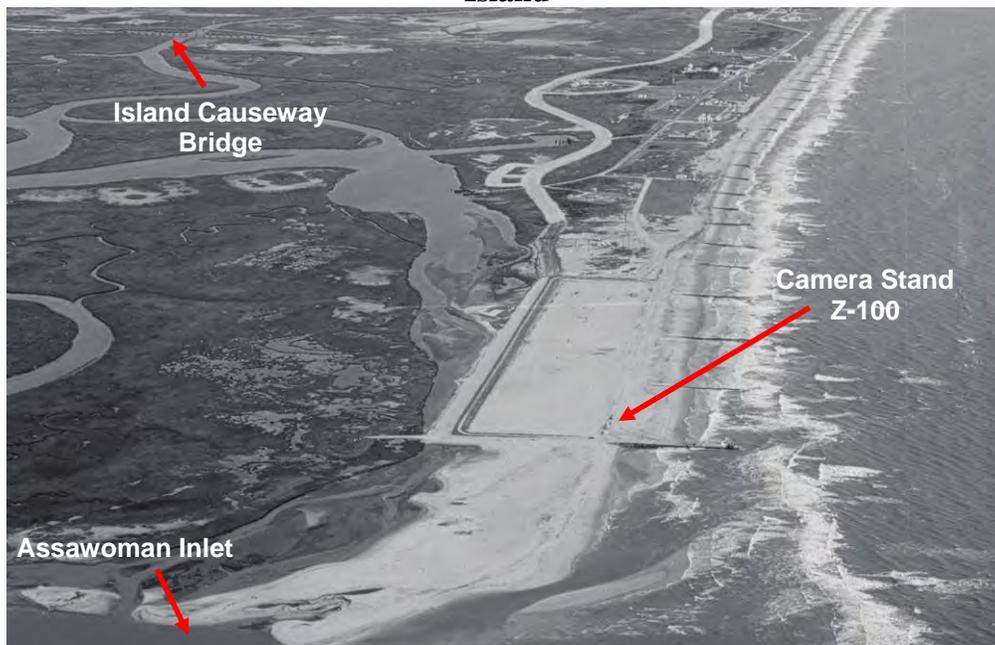
Construction of Launch Area No. 3 began with the construction of two concrete pads and the building of a blockhouse between them (Shortal, 1978). A new access road ran parallel to the beach and new buildings, tanks, bunkers, and impoundments are observed in photographs. In the 1960's, Assawoman Inlet was still open. In 1966, large sections of concrete rubble were visible south of the roadway leading to Camera Stand Z-100 (see Figure 4 for the location of Z-100). Excavation and fill activities continued at various locations across the island.

Shoreline Stabilization

The seawall was extended further to the north in 1960. Sections of the sheet pile seawall failed following the Ash Wednesday storm in 1962. The storm also breached the south end of the island at the location of the present UAS runway and connected Hog Creek directly with the ocean. This breach was mechanically closed with a large rectangular fill (Photograph 19). Construction and a sand pumping operation in 1963 worked to correct the damage from the 1962 washout areas.

Environmental Consequences

Photo 19: 1965 photograph showing large rectangular fill area on south end of Wallops Island



4.7.1.1.4 1970s

New construction slowed in the 1970s but was still ongoing. Excavation and fill activities occurred, and some new facilities such as ASTs and buildings were added. Additional concrete rubble and rusted metal objects are visible in the debris pile along the road to Camera Stand Z-100 on the southeast portion of Wallops Island.

Shoreline Stabilization

A total of 47 wood groins had been built along the Wallops Island shoreline by 1972. Most of the groins ranged in length from 30 - 120 m (120 - 400 ft) and the spacing between them varied from 60 - 200 m (200 - 650 ft). The seawall was extended, augmented, and repaired several times through the 1970s.

4.7.1.1.5 1980s

Minor construction occurred throughout the 1980s. More concrete rubble was placed along both sides of the road leading to Camera Stand Z-100 in the early 1980s. In 1985, the Navy constructed the Aegis Engineering and Training Complex buildings on Wallops Island.

Shoreline Stabilization

The seawall was extended, augmented, and repaired several times through the 1980s. By the 1980s, the groins showed signs of serious deterioration. In 1988, NASA and the U.S. Navy installed two experimental beach prism/beam sand retention units on Wallops Island. Moffatt and Nichol (1989) evaluated these and concluded that both types of experimental shore protection structures failed to provide any significant protection.

4.7.1.1.6 1990s

Upgrades to infrastructure and some construction occurred in the 1990s. Significant erosion of the shoreline is visible in photographs. The Navy constructed several buildings on Wallops Island in the 1990s including the Aegis Cruiser Facility and the Ship Self Defense Facility, both located mid-island.

Shoreline Stabilization

Since the mid 1990s, varying amounts of material dredged from Chincoteague Inlet have been disposed of approximately 1,220 m (4,000 ft) offshore of Wallops Island by the USACE Norfolk District (see Section 2.4.3 of this PEIS). Photos from the 1990s show the Assawoman Inlet as closed. In the mid 1990s, NASA built the current rock seawall generally in the same location as the previous seawalls. The wooden groins were mostly removed at approximately the same time, though several short sections of wooden pilings still remain in place. Photos from the 1990s generally show a small section of beach remaining in front of the seawall.

4.7.1.1.7 2000s

Large concrete pads currently seen on the beach and in the water appear to be similar to the construction debris in 1966 photos. Most of the impoundments and ground scars identified in previous photos remain. The Navy constructed Building V-21 in 2003, Building V-3 (DDG) in 2009, and the ARTIST radar facility that is located close to the existing shoreline in 2009.

Shoreline Stabilization

NASA made frequent repairs to the seawall in the 2000s. In 2006, NASA placed 1,400 m (4,600 ft) of temporary geotextile tube along the beach south of the seawall. Large waves have occasionally damaged portions of the tubing. In mid-November 2009 a Nor'easter caused flooding and substantial damage to the geotextile tubes. Approximately 790 m (2,600 ft) of replacement geotextile tubes were installed in this same general area in spring 2010.

4.7.1.2 Summary of Impacts

Table 53 below shows the areas affected at various points during the history of Wallops Island since U.S. government use starting in 1938 for the following categories: wetland dredge, wetland fill, impervious surface, miscellaneous habitat impacts, and total disturbance. NASA used geographically referenced aerial photography of Wallops Island between 1938 and 2007 to delineate the categories in GIS. Impervious area estimates included roads, buildings, and other infrastructure. Shoreline fill represents times when a noticeable amount of fill material was placed on the Wallops beach. The miscellaneous habitat impacts were determined by delineating the areas that were noticeably disturbed from one aerial photograph to the next, and that did not fit into the other categories (impervious areas, dredge, and fill categories were excluded). Additionally, NASA estimated the total amount of land area gained along the shorefront from 1938 to 2007 by subtracting the difference between accretion and erosion and found that 210 ha (518 ac) of beach-related habitat on north Wallops Island was created over this period.

Wetlands impacts were estimated by overlaying the outlines of historic disturbed land areas identified in the 2004 EPA report onto USFWS National Wetlands Inventory maps and recent infrared aerial photography. Figure 54 provides a visual overview of all the areas affected by activities at Wallops Island between 1938 and 1994.

Environmental Consequences

It should be noted that the figures presented in Table 53 are only estimates of impacts, and were based upon interpretation of aerial photographs, some of which were very old. As such, these estimates are only “ballpark” figures, and should only be used for drawing general conclusions.

Table 53: Summary of Hectares (Acres) Affected by Various Actions at Wallops Island 1938 to 2010+

Year	Wetland Dredge	Wetland Fill	Shoreline Fill	Impervious Surface	Miscellaneous Habitat Impacts	Total Disturbance
1938	11.3 (28)	0	0	0.08 (0.2)	0.7 (1.8)	12.1 (30)
1949	5.5 (13.7)	2.2 (5.5)	0	0.3 (0.8)	16 (39.6)	24.3 (60)
1957 ^a	1.5 (3.7)	15.1 (37.4)	0	0.9 (2.3)	15.5 (38.2)	33.2 (82)
1966 ^b	20.2 (50)	132 (327)	17.6 (43.5)	18.2 (45)	41.1 (101.5)	222.6 (550)
1974	0	0	0	0.6 (1.6)	7.2 (17.7)	7.8 (19)
1979	0	0	0	1 (2.5)	0.4 (1)	1.4 (3.5)
1988	0	0	0	2 (5)	6.5(16)	8.5 (21)
1994	0	0	0	0.8 (2)	0.4 (1)	1.2 (3)
2010	0	0	0	8.5 (20.9)	9.4 (23.2)	17.8 (44)
2010+ ^c	0	3.1 (7.6)	66 (163)	6.3 (15.6)	3.2 (8)	75.4 (186)
TOTAL	38.6 (95.4)	152.4 (377.5)	83.6 (209.5)	38.8 (95.9)	100.4 (248)	415 (1026)

Note: Totals may not add up exactly when compared to specific values in each cell due to rounding.

^aNorth Island fill area filled again = upland habitat conversion

^bIsland causeway counted as both wetland fill and impervious surface but only the fill area was counted in the total disturbed area

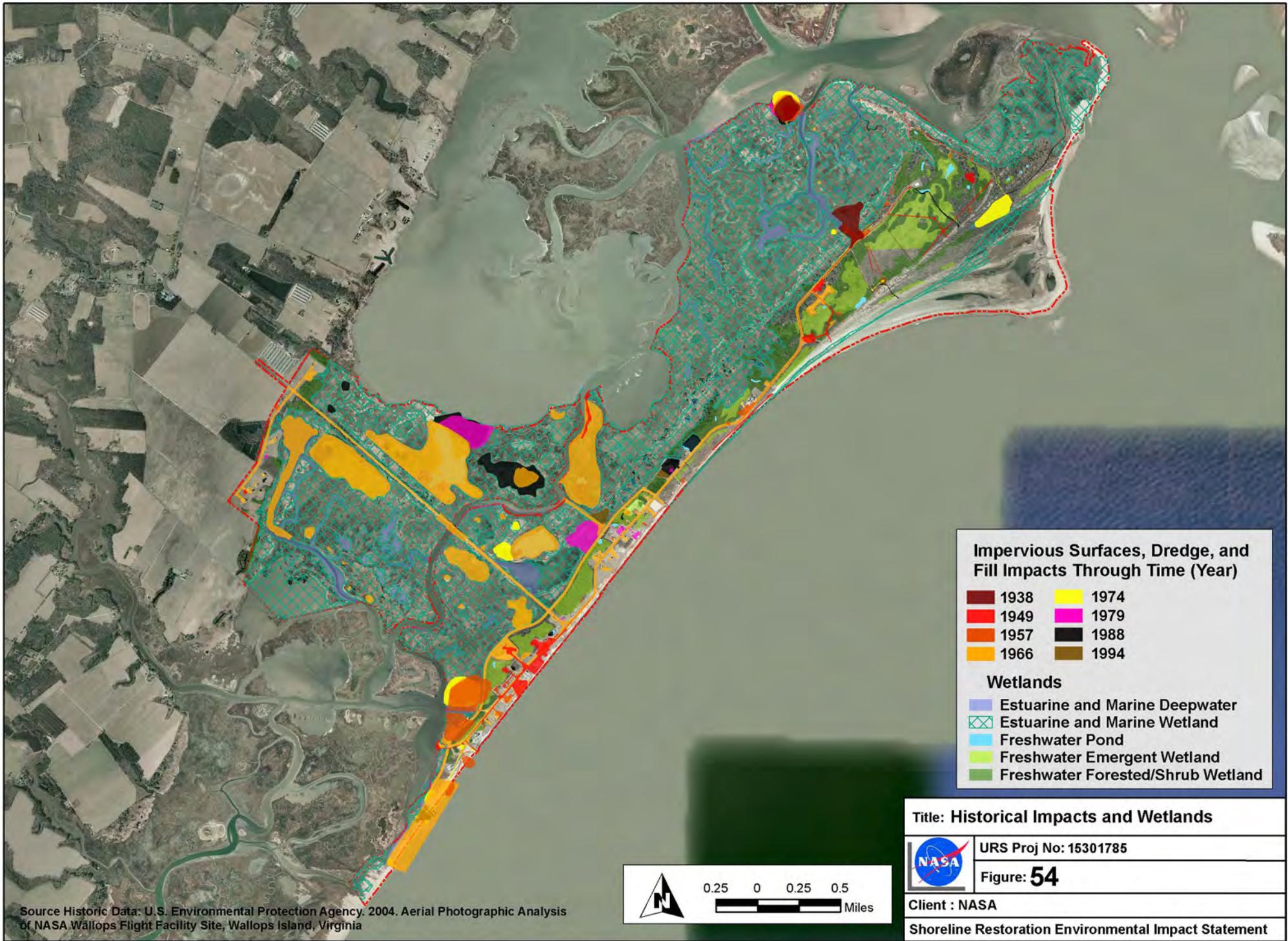
^c2010+ = proposed construction including UAS Airstrip, Expansion of the Wallops Island Launch Range (including construction of the Payload Processing Facility and Payload Fueling Facility), and beach fill (rockwall core)

4.7.1.3 Present and Reasonably Foreseeable Future Activities and Projects

4.7.1.3.1 NASA

Present Activities

NASA can currently launch up to approximately 102 rockets a year from the launch areas on Wallops Island. These include a maximum of 60 from the Sounding Rocket Program, 12 from orbital rocket missions at Pad 0-B (Figure 55) and 30 from Navy missiles and drones (NASA, 2005). Debris from various WFF launch operations (i.e., spent rockets, payloads, drones, and rocket-boosted projectiles) lands in the Atlantic Ocean. This debris may consist of a variety of components including metals, batteries, electrical components, and propellants.



Impervious Surfaces, Dredge, and Fill Impacts Through Time (Year)

- 1938 ■ 1974
- 1949 ■ 1979
- 1957 ■ 1988
- 1966 ■ 1994

Wetlands

- Estuarine and Marine Deepwater
- Estuarine and Marine Wetland
- Freshwater Pond
- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland

Title: Historical Impacts and Wetlands

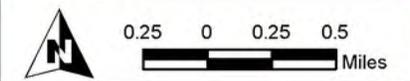


URS Proj No: 15301785

Figure: **54**

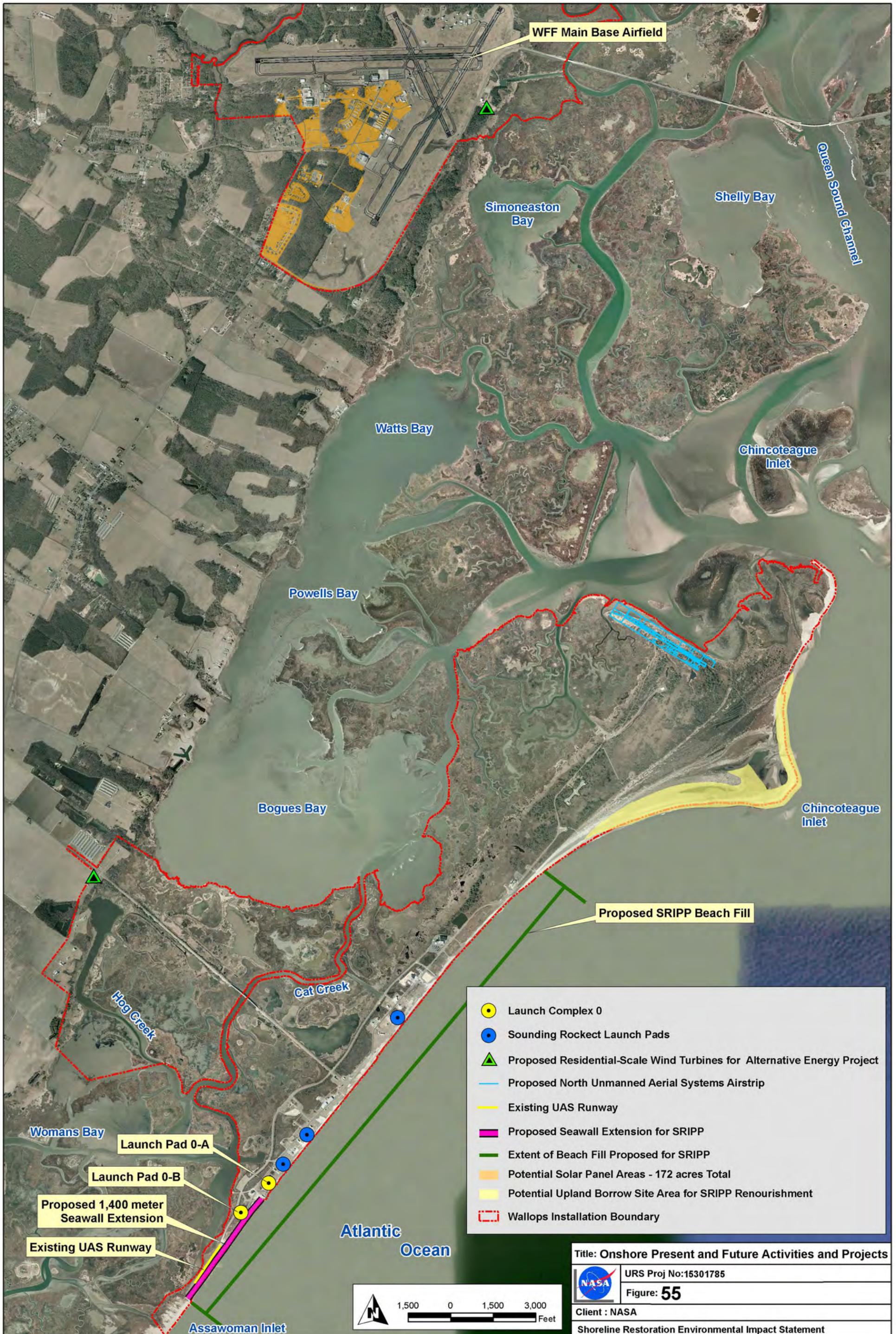
Client : NASA

Shoreline Restoration Environmental Impact Statement

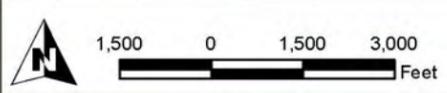


Source Historic Data: U.S. Environmental Protection Agency, 2004. Aerial Photographic Analysis of NASA Wallops Flight Facility Site, Wallops Island, Virginia

This page intentionally left blank.



- Launch Complex 0
- Sounding Rocket Launch Pads
- ▲ Proposed Residential-Scale Wind Turbines for Alternative Energy Project
- Proposed North Unmanned Aerial Systems Airstrip
- Existing UAS Runway
- Proposed Seawall Extension for SRIPP
- Extent of Beach Fill Proposed for SRIPP
- Potential Solar Panel Areas - 172 acres Total
- Potential Upland Borrow Site Area for SRIPP Renourishment
- - - Wallops Installation Boundary



This page intentionally left blank.

NASA also conducts the following activities:

- Flights from South UAS Airstrip
- Piloted flights from WFF Main Base
- Launching of weather balloons over the ocean
- Launching autonomous underwater vehicles
- Assembling and transporting payloads
- Tracking and data systems
- Open burning in designated area
- Rocket boosted projectile testing

NASA conducts routine activities including repairs and maintenance of existing infrastructure such as grounds, roads, buildings, and utilities on a regular basis to ensure the ongoing operation of the facility. A more detailed description of these activities is provided in the 2005 Site-Wide EA.

Future Projects

Currently, NASA is planning three projects on Wallops Island and one project at the Main Base that may result in impacts to environmental resources within the SRIPP project area. These projects are described briefly below.

North Unmanned Aerial Systems (UAS) Airstrip at Wallops Island

NASA is currently considering the construction of an UAS airstrip on north Wallops Island (Figure 55). The purpose of the North UAS Airstrip would be to provide a venue and infrastructure to support launch and recovery operations for UASs. UASs are small aircraft that serve as platforms for small science instruments. They are controlled remotely by a pilot on the ground and are powered by batteries or small gasoline engines. The east-west orientation of this airstrip would provide an alternative to the north-south positioning of the current UAS airstrip on south Wallops Island. An EA is currently being prepared. The implementation date of the UAS airstrip would occur no earlier than mid-2011.

Expansion of the Wallops Flight Facility Launch Range

NASA and MARS facilities are currently being upgraded to support up to and including medium large class suborbital and orbital expendable launch vehicle (ELV) launch activities from WFF. Components of the project include site improvements required to support launch operations (such as facility construction and infrastructure improvements); testing, fueling, and processing operations; up to two static fire tests per year; and launching of up to six ELVs and associated spacecraft per year from Pad 0-A. Implementation of the project would result in a maximum of 18 orbital-class launches from MARS Launch Complex 0 per year (12 existing launches from Pad 0-B, and 6 additional launches from Pad 0-A). The first orbital launch from Pad 0-A is currently planned for mid-2011. More information is available in the EA prepared for this project (NASA, 2009a).

Environmental Consequences

Wallops Flight Facility Alternative Energy Project

The purpose of WFF's Alternative Energy Project is to generate clean, renewable energy from a technologically proven source that will be used by WFF in order to meet Federal renewable energy requirements. WFF is proposing to construct solar panels at Wallops Main Base and two residential-scale wind turbines, one on Wallops Mainland and one near the Visitor's Center on the Main Base. NASA is currently preparing an EA for the project; implementation of this project is planned for early 2011.

Wallops Research Park

The goal of the Wallops Research Park (WRP) project is to create an integrated business park for aerospace research and development programs, scientific research, commercial space industries, and educational centers. Development of the WRP is taking place adjacent to the Main Base at WFF over an expected 20-year period; some development has occurred, but the majority of the Proposed Action has not yet been constructed. WRP would consist of a multi-use development created for non-retail commercial, government space, science research, educational facilities, and public recreation areas. Please refer to the 2008 WRP EA for more information (NASA, 2008b).

4.7.1.3.2 Projects and Actions by Others

There are ongoing and reasonably foreseeable offshore projects that have been considered in evaluating cumulative effects on resources within the region. These projects occur within a broader nearshore and inner continental shelf region of the SRIPP project area.

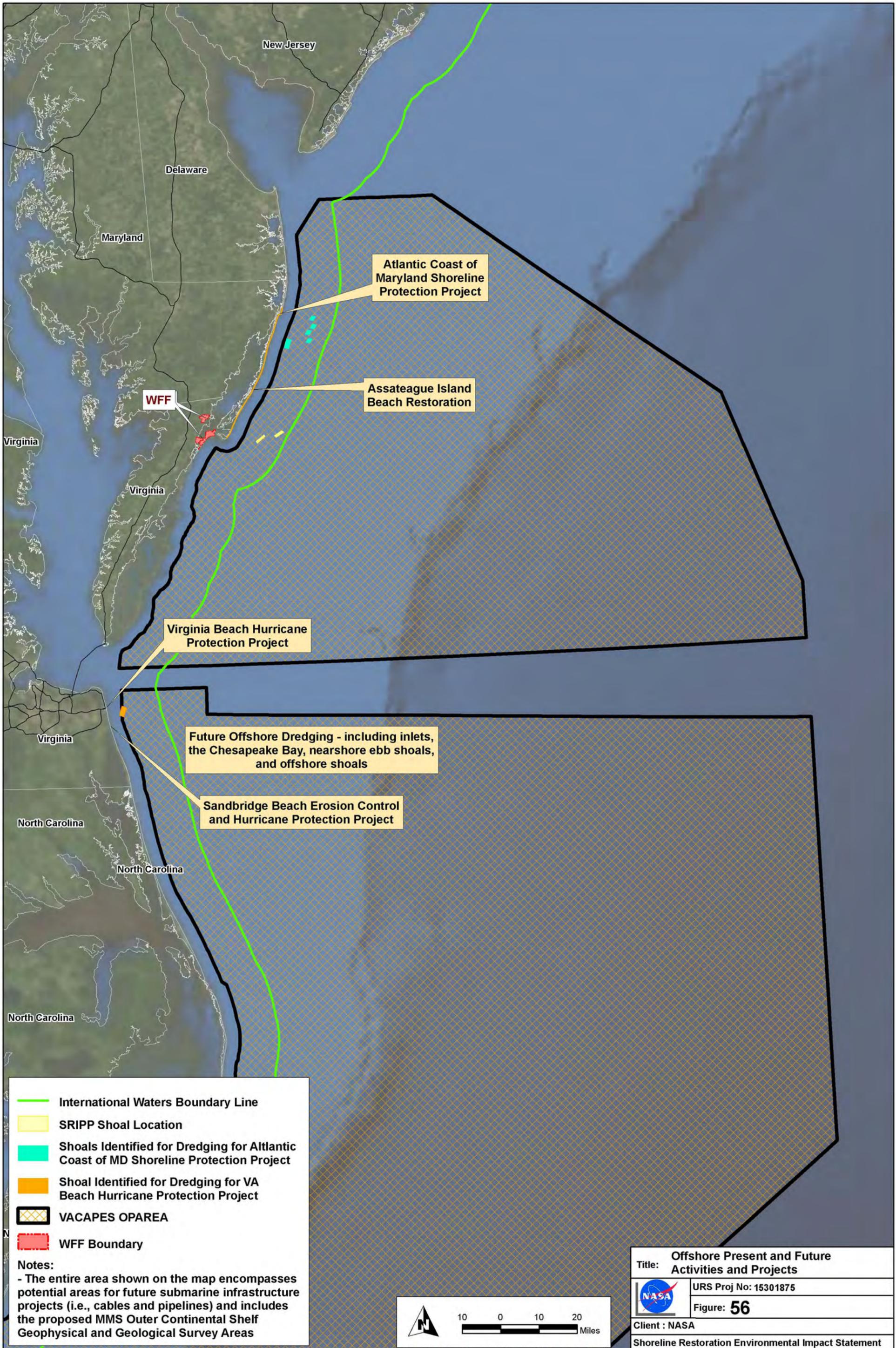
Virginia Capes Operating Area

The Virginia Capes Operating Area (VACAPES OPAREA) is a surface and subsurface operating area off the Virginia and North Carolina coasts within the VACAPES Range Complex (Figure 56). The mission of the VACAPES Range Complex is to provide sustainable and modernized ocean operating areas, airspace, ranges, range infrastructure, training facilities, and resources to fully support U.S. Navy training requirements. The VACAPES OPAREA is used by the U.S. Navy Atlantic Fleet training for research, development, testing, and evaluation activities, and associated range capabilities enhancements, including infrastructure improvements.

The VACAPES OPAREA includes the nearshore area from just off the mouth of Delaware Bay south to Cape Hatteras. The western boundary is roughly the 3-nautical-mile State territorial limit and the eastern boundary extends 287 km (178 mi) into waters more than 4,000 m (13,120 ft) deep. Additional information on the VACAPES activities is provided in the U.S. Department of the Navy Final Environmental Impact Statement (EIS) (2009).

Offshore Dredging

Offshore dredging projects in both Maryland and Virginia have been included in the evaluation of cumulative effects. Although the shoals identified as potential sand sources for the SRIPP are located in northern Virginia, they are at the southern end of the Assateague Ridge field that extends offshore of Maryland (Swift and Field, 1981). Therefore, projects utilizing sand from this offshore shoal complex are considered in the evaluation of the cumulative effects.



New Jersey

Delaware

Maryland

Atlantic Coast of Maryland Shoreline Protection Project

WFF

Assateague Island Beach Restoration

Virginia

Virginia

Virginia Beach Hurricane Protection Project

Future Offshore Dredging - including inlets, the Chesapeake Bay, nearshore ebb shoals, and offshore shoals

Sandbridge Beach Erosion Control and Hurricane Protection Project

Virginia

North Carolina

North Carolina

North Carolina

- International Waters Boundary Line
- SRIPP Shoal Location
- Shoals Identified for Dredging for Atlantic Coast of MD Shoreline Protection Project
- Shoal Identified for Dredging for VA Beach Hurricane Protection Project
- VACAPES OPAREA
- WFF Boundary

Notes:
 - The entire area shown on the map encompasses potential areas for future submarine infrastructure projects (i.e., cables and pipelines) and includes the proposed MMS Outer Continental Shelf Geophysical and Geological Survey Areas



Title: Offshore Present and Future Activities and Projects	
	URS Proj No: 15301875
Figure: 56	
Client : NASA	
Shoreline Restoration Environmental Impact Statement	

This page intentionally left blank.

Maryland

Atlantic Coast of Maryland Shoreline Protection Project

To help remedy the sand loss in Ocean City, MD (located approximately 80 km [50 mi] north of WFF) from beach erosion because of storms, the USACE began a beach renourishment effort for Ocean City in the late 1980s. Ocean City's Beach Renourishment Project is an ongoing effort. In general, the dredging is on a 4-year cycle and is planned to continue for another 40 years. The last renourishment cycle was completed in 2006, with the next renourishment cycle planned for 2010. For this upcoming renourishment cycle, the USACE is considering four offshore shoals in Federal waters east of Ocean City Inlet (the southernmost proposed shoal is approximately 16 km [10 mi] southeast of the inlet) to provide some or all of the volume for the project duration. Currently, the USACE plans to provide approximately 535,000 m³ (700,000 yd³) of material to the beach in each renourishment cycle. Additional information is provided in the Atlantic Coast of Maryland Shoreline Protection Project Final Supplemental EIS (USACE, 2008).

Assateague Island Beach Restoration

Beginning in 2003, the NPS undertook a beach restoration effort at Assateague Island to mitigate the effects of the Ocean City Inlet jetty system built in the 1930s. The objective of the NPS project is not traditional beach nourishment to protect the shoreline from storm damage or to halt erosion, but rather to restore Assateague Island's sand budget and ensure that natural coastal processes continue to dictate the evolution of the island (NPS, 2003). Approximately 1 million m³ (1.4 million yd³) of sand was taken from Great Gull Bank for initial nourishment, a shoal approximately 8 km (5 mi) east of northern Assateague Island. For renourishment, sediment has been dredged approximately twice yearly from an ebb shoal immediately offshore of Ocean City Inlet. This ebb shoal will continue to be used for renourishment activities for the project duration of 40 years. Additional information is provided in the EA prepared for this project (NPS, 2003).

Virginia

To date, there has been no sand dredged from Federal waters offshore of Virginia north of the mouth of the Chesapeake Bay. However, sand has been dredged from offshore Federal waters south of the Chesapeake Bay. These projects are described below.

Sandbridge Beach Erosion Control and Hurricane Protection Project

The City of Virginia Beach has utilized sand from Sandbridge Shoal since 1998 to renourish Sandbridge Beach. Sandbridge Shoal is located approximately 4.5 to 6.6 km (2.8 to 4.1 mi) offshore. In 1998, the city dredged 4.4 million m³ (5.7 million yd³) of sand. In 2002, the city dredged an additional 1.53 million m³ (2.0 million yd³). The Navy's Dam Neck facility has also utilized Sandbridge Shoal, dredging 619,000 m³ (809,000 yd³) of sand in 1996 and 535,000 m³ (700,000 yd³) in 2003.

An EA for the Sandbridge Beach Erosion Control and Hurricane Protection Project was prepared in June 2009 by the USACE Norfolk District in cooperation with the BOEMRE. The EA indicates that approximately 1.1 to 1.5 million m³ (1.5 to 2 million yd³) of sand would be placed on the beach approximately every 3 years. The cycle may occur less often, but probably no less than once every 5 years for the 50-year project life.

Environmental Consequences

Virginia Beach Hurricane Protection Project

The City of Virginia Beach and the USACE maintain a hurricane protection project that includes beach nourishment. The Virginia Beach project includes a seawall and maintenance of the beach from Rudee Inlet to 89th Street, including a larger dune system from 58th to 89th streets. The initial and renourishment sand source is material dredged from Thimble Shoal and the Atlantic Ocean channels. In the future, material may be obtained from an area off Cape Henry.

Future Offshore Dredging

Communities and facilities along the Eastern Shore may require sand sources for beach nourishment. The sand to support these projects will come from a variety of sources including inlets, the Chesapeake Bay, nearshore ebb shoals, and potentially offshore shoals. Although no other specific offshore dredging projects have been identified at this time, in addition to the projects listed above, it is possible that within the 50-year life span of the SRIPP, other offshore areas will be dredged.

Other Offshore Projects and Actions

Submarine Infrastructure Projects – Cables, Pipelines

Although no submarine infrastructure projects are proposed at this time for the SRIPP project area and vicinity, it is possible that within the 50-year life span of the SRIPP a cable, pipeline, or other submarine infrastructure project would occur. It is likely that a project of this nature would result in disturbance of the seafloor and benthic communities. Submarine infrastructure may be placed on the sediment surface or buried within the sediment. All projects of this nature would require review and permits from BOEMRE and other Federal agencies as required for projects in Federal waters, and State and Federal agencies as necessary for work done in State waters. The potential environmental impacts would be considered and documented through the NEPA process for federally funded projects.

Offshore Renewable Energy Projects

There has been some preliminary interest in developing wind farms off the coast of Virginia and Maryland. The Commonwealth of Virginia and BOEMRE held an offshore renewable energy task force meeting on December 8, 2009, to discuss renewable energy development on the OCS. BOEMRE received two proposals for leases approximately 12 miles offshore of Virginia Beach for wind farm development. Maryland issued a Request for Interest and Information with regard to potential offshore wind energy development, with a deadline for responses in early 2010. Offshore wind projects may look to site their turbine foundations in the shallower waters available on shoal crests. Offshore renewable energy projects would require review and approvals from BOEMRE and other Federal agencies as well as the adjacent coastal States. The potential environmental impacts would be considered and documented through the NEPA process for federally funded or permitted projects.

Offshore Oil and Gas Exploration

On May 27, 2010, U.S. President Barack Obama announced Secretary of the Interior Ken Salazar's decision to cancel Lease Sale 220, a proposal to allow oil and gas extraction off the coast of Virginia. As such, no oil and gas projects in the Mid-Atlantic region offshore of Virginia are known at this time; however, it is possible that offshore areas may be explored for oil and gas resources. All projects of this nature would require review and permits from BOEMRE and their

potential environmental impacts considered and documented through the NEPA process. Potential oil and gas exploration and production in this area would result in potential impacts not only to the offshore environment, but also to the onshore environment where supporting infrastructure would be constructed.

The BOEMRE held scoping meetings in April 2010 for preparation of a PEIS for geological and geophysical surveys throughout the mid- and south Atlantic OCS associated with future siting of renewable energy projects, marine minerals extraction, and oil and gas exploration. Geological surveys would include: coring, shallow test drilling, and the boring of deep stratigraphic test wells. The geophysical surveys would include seismic surveys that would not disturb the ocean bottom.

Commercial Fishing

As described in Chapter 3, there is commercial fishing activity within the project area. Trawl scars and lost trawl gear on the seafloor were observed during the remote sensing study conducted for the underwater archeological work on the shoals. Churchill (1989) determined that as much as approximately one-third of the seafloor off the Maryland coast out to about 48 km (30 mi) offshore was disturbed by commercial trawling activity in a single year. Assuming this 1985 estimate applies to the Virginia coast, approximately 2,590 km² (1,000 mi²) of the approximate 7,900 km² (3,050 mi²) within the waters 48 km (30 mi) offshore of Virginia would be disturbed in a single year by trawling. Trawling disturbs the sediment surface and the associated benthic communities. Conversely, sand dredging operations can extend several feet into the substrate, depending on the sediment characteristics and dredge specifications.

4.7.1.3.3 Climate Change

The U.S. Global Change Research Program (USGCRP) evaluates climate change impacts on water resources, ecosystems, agriculture and forestry, health, coastlines and arctic regions in the United States by region. According to the USGCRP (2009), the annual average temperature in the southeast region has risen 1 C° (2° F) since 1970, with the greatest seasonal increase in the winter months. According to the USGCRP, there has been a 30 percent increase in fall precipitation over most of the southeast U.S. and an increase in heavy downpours during rain events throughout the year. Summer precipitation has decreased over almost the entire region. The power of Atlantic hurricanes has increased since 1970, associated with an increase in sea surface temperature.

Additionally, the uptake of anthropogenic CO₂ by the ocean changes the chemistry of the oceans and can potentially have significant impacts on the biological systems in the upper oceans (Tedesco et al., 2005). Acidification of the oceans is anticipated as a result of increased rates of CO₂ in the atmosphere compared to pre-industrial times.

Continued warming is projected, with the greatest temperature increases in summer. Sea-level rise is projected to accelerate, increasing coastal inundation and shoreline retreat. The intensity of hurricanes is likely to increase, with higher wind speeds, rainfall/ intensity, and storm surge height and strength. The USGCRP predicts that sea-level rise and the likely increase in hurricane intensity and associated storm surge will be among the most serious consequences of climate change in the region (USGCRP, 2009).

The largest components of climate change that would contribute to cumulative impacts when combined with the SRIPP would be sea-level rise and increased storm intensity and/or

Environmental Consequences

frequency. The predictions of future sea-level rise vary widely. In establishing the beach fill volumes for the SRIPP, the USACE used a rate of sea-level rise of 11 mm (0.4 in) per year (Appendix A). As such, NASA based the cumulative effects analysis on an increase in sea-level of 0.5 m (1.5 ft) over the 50-year SRIPP project life.

While the climate change information presented in this section and Chapter 3 of this PEIS represents the best professional judgment and expertise of scientists, researchers and resource managers, there is inherent uncertainty in hypothesizing future changes in a highly dynamic, ever changing system and there will always be the need for more information and data to better anticipate future state changes.

4.7.2 Potential Cumulative Effects

The following section addresses those resources that have been identified as having the potential to be affected from the incremental effects of the SRIPP in combination with past actions and the present and reasonably foreseeable projects and activities described in Section 4.7.1.1 and 4.7.1.2 above. The additive effects of anticipated climate change are also presented in this section. The resources of concern discussed below are those described in Sections 4.2 through 4.4 that may be affected by the SRIPP. These include: offshore sand shoals, marine water quality, wetlands and subaqueous bottoms, air quality, noise (including underwater noise), benthos, fish, marine mammals, threatened and endangered species, and socioeconomic resources.

4.7.2.1 *Physical Environment*

For the bathymetry, offshore sand shoals, shoreline change, marine water quality, and the climate change sections below, the geographic scope for cumulative impacts evaluation is the inner continental shelf from Ocean City, MD to Sandbridge, VA.

Bathymetry

Impacts from SRIPP: Within the borrow area(s), dredging would remove up to several feet of sediment, therefore increasing the water depths. Dredging may occur once in a given area of a shoal or multiple times, depending on bathymetric recovery as determined by monitoring. The area impacted within the borrow site during a typical renourishment event would depend on the volume of sand needed and the thickness of material dredged.

Non-SRIPP Impacts: The bathymetry of Shoals A and B, as well as other shoals in the region, would be influenced primarily by hydrodynamic processes (i.e., currents and waves). Storm events would result in the greatest changes in shoal bathymetry. In addition, the bathymetry of shoals in the region would be affected by proposed dredging projects as well as infrastructure projects (e.g., submarine cables, wind turbine foundations, or pipelines) that would be constructed on them.

Effects from Climate Change: Sea level is expected to rise in the project area due to climate change, increasing the depth of water above the shoals within the dredged areas and in the nearshore environment where sand placement would occur along the Wallops Island shoreline. Over the 50-year time frame of the SRIPP, the change in water depth over the shoals from climate change would be negligible; however, along the shoreline, small changes in water depth due to climate change would be more pronounced, but would be mitigated by construction of a new beach under the SRIPP.

Summary: Proposed SRIPP dredging would contribute cumulatively to changes in offshore bathymetry when combined with other offshore dredging projects on the inner continental shelf of Virginia and Maryland by lowering the elevation of the seafloor within the dredged areas. Dredging projects in the region include navigation channel maintenance and borrow for beach nourishment. Dredging has occurred and is proposed for shoals located in Federal waters offshore of Ocean City and Assateague Island, MD, to the north of the SRIPP project area, and Sandbridge Shoal, VA, to the south; both of these locations are tens of kilometers/miles away from the SRIPP project site.

Because of their spatial and temporal separation, the cumulative effects on bathymetry as a result of offshore dredging would be negligible. In addition, the offshore dredging projects have relatively small footprints and shallow dredging depths. The USACE (2008) assumed that the maximum thickness of material that would be removed for future Ocean City beach fill requirements could be up to 3 m (10 ft). It is assumed that the maximum thickness of material removed from offshore shoals for the SRIPP would be approximately 3 m (10 ft). In addition to the direct changes to bathymetry, there would be indirect effects to marine life. These impacts are discussed in the sections below.

Offshore Sand Shoals

Impacts from SRIPP: Based on an initial beach fill target of approximately 2.4 million m³ (3.2 million yd³) and assuming a loss of 25 percent of the material during dredge and sand placement operations, a total of approximately 3.1 million m³ (4 million yd³) of sand would be dredged from Shoal A. Roughly 20 percent of the Shoal A's total volume would be removed if only Shoal A were used to obtain fill material over the lifetime of the SRIPP. Because Unnamed Shoal A would be used for the initial fill, Unnamed Shoal B would have less total volume removed over the SRIPP lifetime. Therefore, roughly 7 percent of Shoal B's volume would be removed if it was used to obtain the entire SRIPP renourishment volumes.

Non-SRIPP Impacts: According to the USACE, dredging conducted for Ocean City and Assateague Island, MD, has removed 11 million m³ (14.3 million yd³) of sand from detached nearshore and offshore shoals (USACE, 2008). The USACE estimates that an additional 11.4 million m³ (15 million yd³) could be required for the Atlantic Coast of Maryland Project through 2044. The total cumulative volume for the project would exceed 22 million m³ (29 million yd³).

Sandbridge Shoal is the only other shoal in Federal waters offshore of Virginia that has been dredged and will likely be dredged in the foreseeable future. The total potential volume of sand available on Sandbridge Shoal offshore of south Virginia is estimated to be 31 million m³ (40 million yd³) by Hardaway et al. (1998). Cumulative dredging impacts on Sandbridge Shoal through 2050 are estimated to be over 15 million m³ (20 million yd³), or over 50 percent of the total volume present.

Effects from Climate Change: Depending on the strength and frequency of future storms, additional sand may be needed for both the proposed SRIPP and other shoreline restoration projects, which would increase the potential cumulative impact of the actions.

Summary: The proposed SRIPP dredging operations would contribute incrementally to the overall removal of sand resources from shoals located on the inner continental shelf in the Mid-Atlantic region offshore of Maryland and Virginia. Dredging conducted for Ocean City and Assateague Island, MD, has removed 11 million m³ (14.3 million yd³) of sand from detached

Environmental Consequences

nearshore and offshore shoals (USACE, 2008). The USACE estimates that an additional 11.4 million m³ (15 million yd³) could be required for the Atlantic Coast of Maryland Project through 2044. The total cumulative volume for the project would exceed 22 million m³ (29 million yd³).

The Maryland Geologic Survey estimates that the total volume of potential sand resources suitable for beach restoration projects contained within the shoals offshore of Maryland exceeds 1.2 billion yd³ as shown on Table 54 (Conkwright and Gast, 1994a,b; Conkwright and Gast, 1995; Conkwright and Williams, 1996). The cumulative total of sand that may be dredged from offshore Maryland represents approximately 2 percent of the total amount of potential sand resources available.

Unlike Maryland, there has been no comprehensive inventory and estimate of the total volume of potential sand resources contained within sand shoals offshore of Virginia. The potential volumes of sand resources estimated for Unnamed Shoal A and B identified for this project are approximately 52 million m³ (68 million yd³) for Unnamed Shoal A and 100 million m³ (132 million yd³) for Unnamed Shoal B. In addition, Blackfish Bank has approximately 19 million m³ (25 million yd³) of sand. Under the Preferred Alternative, assuming that Unnamed Shoal A would be used for initial and all renourishment cycles, the SRIPP would remove approximately 5 percent of the total volume of Unnamed Shoal A for the initial fill and 19 percent of the total volume available on the shoal through 2050 (Table 54).

Table 54: Volume of Potential Suitable Sand Resources for Shoreline Restoration in Maryland and Virginia

Area	Total Potential Suitable Sand Resources Present m ³ (yd ³)	Sand Dredged 1988–2009 m ³ (yd ³)	Potential Sand to be Dredged 2010–2050 m ³ (yd ³)	Cumulative Total Through 2050 m ³ (yd ³)	Percent of Volume Present
Maryland					
Total ^a	900,000,000 (1,200,000,000) ^a	10,900,000 (14,306,000) ^d	11,000,000 (15,000,000) ^d	22,406,000 (29,306,000)	2
Virginia (partial list)					
Blackfish Bank Shoal ^b	19,000,000 (25,000,000)	0	0	0	0
Unnamed Shoal A	52,000,000 (68,000,000) ^b	0	9,990,000 (13,066,250)	9,990,000 (13,066,250)	19
Unnamed Shoal B ^f	100,000,000 (132,000,000) ^b	0	0	0	0
Sandbridge Shoal	31,000,000 (40,000,000) ^c	3,524,000 (4,610,000)	12,200,000 (16,000,000) ^e	15,760,000 (20,610,000)	52

^a = Maryland Geologic Survey (Conkwright and Gast 1994a,b and 1995; Conkwright and Williams, 1996; USACE 2008)

^b = USACE, 2010a

^c = Hardaway et al., 1998

^d = USACE, 2008 (Supplemental EIS estimated maximum volume)

^e = USACE, 2009b ([Sandbridge EA] assumes eight renourishment cycles from 2010 to 2050 at 1.5 million m³ [2 million yd³] per cycle)

^f = Volumes shown for both Unnamed Shoal A and Unnamed Shoal B assume that only one shoal (A or B) would be used for all renourishment cycles

The offshore dredging projects described above have removed and will remove substantial amounts of sand from individual offshore shoals. However, the cumulative amount of sand removed for these projects is approximately 3 percent of the overall quantity (in excess of 1.5 billion yd³) of sand remaining and left intact on the continental shelf off the coasts of Maryland and Virginia.

It is not anticipated that SRIPP dredging activities, when combined with the dredging activities of other offshore shoals in the region, would result in significant cumulative impacts because the impacted areas are small compared to the total amount of undisturbed offshore shoals. It is possible that future demand for beach renourishment sand, submarine infrastructure projects, oil and gas exploration, or offshore renewable energy projects would result in additional disturbance of shoals, which may lead to adverse impacts on the geomorphic integrity of the offshore sand shoal environment.

Barrier Island Shorelines

Impacts from SRIPP: Implementation of the beach fill component of the SRIPP would result in significant changes to the Wallops Island shoreline. The initial beach fill would extend the existing shoreline a total distance of 73 m (240 ft) to the underwater seaward extent of the fill, 21 m (70 ft) of which would be aboveground beach. The initial beach fill would create a beach profile with a 1.8-m-high (6-ft-high) berm and a 4.3-m-high (14-ft-high) dune at the seawall (Figure 16). Because there is no existing beach along the 6.0-km (3.7-mi) fill area proposed under the SRIPP, the SRIPP would create a shoreline between the northern end of the rock seawall and the southern end of the existing geotextile tubes. The renourishment fills would restore the shoreline to the same position that would exist after the initial fill is completed.

The sand that would be dredged offshore and placed along the shoreline would contribute sand to the local nearshore sediment transport system. Some of the sand that would be placed along the Wallops Island shoreline under the SRIPP would be transported south, therefore providing some mitigation to erosional processes occurring on the northern part of Assawoman Island.

Non-SRIPP Impacts: As described in Sections 1.2.5 and 4.7.1.1, beginning in the late 1950s NASA attempted several projects to prevent shoreline retreat on Wallops Island. These included construction of a sheet pile seawall, wooden groins, a rock seawall, and a large rectangular fill on the south end of Wallops Island in the 1960s (Photograph 19). The rock seawall still exists today. As evidenced by the location of the beach to the south of the seawall (Figure 3), the seawall has stopped further erosion and fixed the waters edge. It has resulted in the loss of beach and associated overwash habitat landward along an approximate 4,300-m (14,000-ft) stretch of the island.

The northern portion of Assawoman Island has been eroding since NASA has occupied Wallops Island. When Fishing Point was smaller, the divergent nodal zone was further north than its estimated present position. Under these conditions, it is likely that the seawall affected sand transport to the south and may have impacted Assawoman Island. The southward migration of Fishing Point (Section 3.1.4.3 of this PEIS), has sheltered the Wallops Island shoreline from ocean waves approaching from the northeast, with the divergent nodal zone shifting south as the southern tip of Fishing Point continues to grow (explained in Section 3.1.5.4, Longshore Sediment Transport), Assawoman Island is expected to remain exposed to the ocean waves and erosion within the 50-year time span of the SRIPP.

Environmental Consequences

The cumulative effects of the shoreline restoration and nourishment projects in the region are maintaining and sustaining the beach resource, creating additional area of dry beach habitat for wildlife and human use, creating the potential for dune vegetation habitat, and sustaining intertidal or wet beach habitat.

Within a regional context, the area from Ocean City MD to Sandbridge, VA includes several beach nourishment projects that are ongoing and proposed in the future. As described above, these projects include; the Atlantic Coast of Maryland Project, Assateague Island Beach Restoration Project, Sandbridge Beach Erosion Control and Hurricane Protection Project, and the Virginia Beach Hurricane Protection Project. Each of these projects is designed to restore and maintain shorelines within their respective project limits. From a regional perspective, they would not significantly affect shoreline changes outside of their project boundaries.

Effects from Climate Change: Increase in sea-level rise and storm intensity and/or frequency would accelerate shoreline erosion, lead to more frequent washover events, and cause a loss of dune structure. It is likely that the barrier islands would migrate westerly, however to what degree is uncertain.

Summary: Because NASA would construct and maintain a new beach in front of the seawall under the SRIPP, effects of climate change on the Wallops Island and northern Assawoman Island shorelines would likely be reduced. Within the regional context of the Virginia Barrier Islands, the cumulative effects from beach nourishment projects would be highly localized, and the effects of climate change would continue.

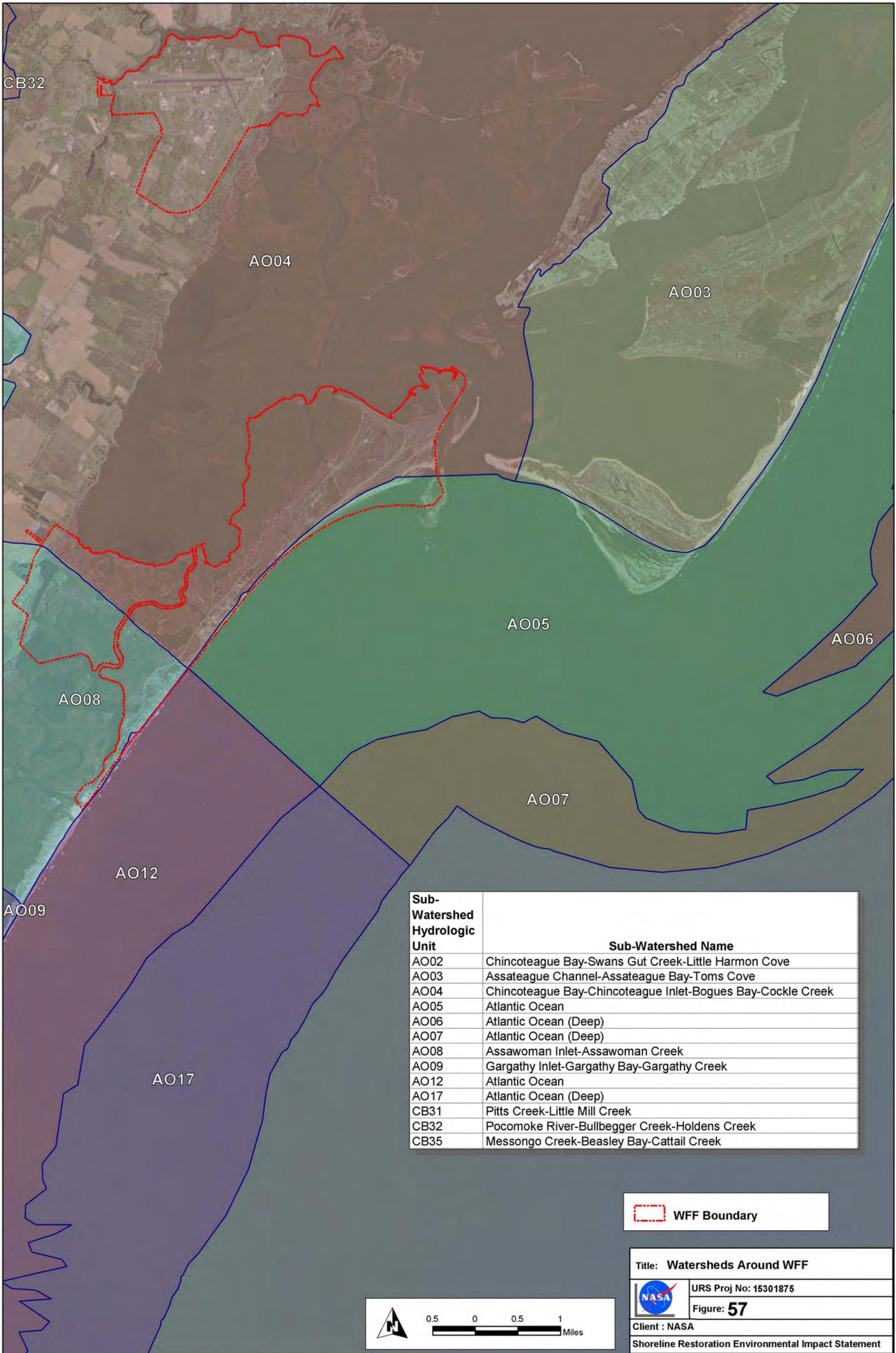
Water Resources

Water Quality

Geographic Scope: The geographic scope of the water resources cumulative impacts analysis includes surface waters that are along the Wallops Island shoreline that would be affected by extension of the seawall and work on the beach and the Atlantic Ocean waters, both nearshore and offshore in the vicinity of Unnamed Shoals A and B. The watersheds that encompass the Wallops Island Shoreline extend out into the Atlantic Ocean (shown as AO05 and AO12 on Figure 57) and are distant from watersheds that drain the mainland or contain fresh waters.

Impacts from SRIPP: The SRIPP would have minor and temporary localized adverse impacts on marine water quality due to elevated levels of turbidity during dredging and sand placement operations, including both the actual placement of sand and during anchoring of the pump-out buoys. Turbidity would be expected to extend about 500 m (1,640 ft) from the offshore shoals during dredging, which would occur periodically throughout the life of the SRIPP.

Non-SRIPP Impacts: Past, present, and proposed actions at Wallops Island cumulatively affect the amount and patterns of stormwater runoff due to impervious surfaces. Some of this runoff reaches the Atlantic Ocean and may include sediment, petroleum products, and heavy metals. Over time, the amount of runoff from Wallops Island has increased as new impervious surfaces (primarily buildings and roads) have been constructed. Between 1938 and 1994, approximately 39 ha (96 ac) of impervious surface was added. Construction since 1994 has contributed additional impervious area and the future projects planned at WFF, particularly the expansion of the WFF Launch Range and the UAS Airstrip on the north end of the island, would result in increased impervious surface area.



Sub-Watershed Hydrologic Unit	Sub-Watershed Name
AO02	Chincoteague Bay-Swans Gut Creek-Little Harmon Cove
AO03	Assateague Channel-Assateague Bay-Toms Cove
AO04	Chincoteague Bay-Chincoteague Inlet-Bogues Bay-Cockle Creek
AO05	Atlantic Ocean
AO06	Atlantic Ocean (Deep)
AO07	Atlantic Ocean (Deep)
AO08	Assawoman Inlet-Assawoman Creek
AO09	Gargathy Inlet-Gargathy Bay-Gargathy Creek
AO12	Atlantic Ocean
AO17	Atlantic Ocean (Deep)
CB31	Pitts Creek-Little Mill Creek
CB32	Pocomoke River-Bullbegger Creek-Holdens Creek
CB35	Messongo Creek-Beasley Bay-Cattail Creek

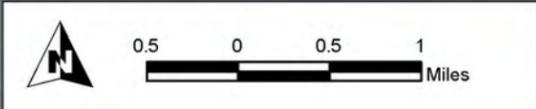
 WFF Boundary

Title: Watersheds Around WFF

 URS Proj No: 15301875
Figure: 57

Client : NASA

Shoreline Restoration Environmental Impact Statement



This page intentionally left blank.

Tidal wetlands improve water quality by trapping sediments, reducing turbidity, restricting the passage of toxics and heavy metals, decreasing biological oxygen demand, trapping nutrients, and buffering storm and wave energy. Loss of these resources over time has likely contributed to a minor to moderate long-term adverse effect on water quality within the analysis area.

Additionally, construction activities including grading, clearing, filling, and excavation for the future projects would result in disturbance of the ground surface and would have the potential to cause soil erosion and the subsequent transport of sediment or nutrients into waterways via stormwater. NASA has and would continue to minimize impacts on surface waters by acquiring construction and industrial Virginia Storm Water Management Program permits and by developing and implementing a site-specific Storm Water Pollution Prevention Plan and Erosion and Sediment Control plans prior to land-disturbing activities. NASA would follow Virginia Storm Water Management Program requirements for proper sizing and planning for stormwater conveyance from new infrastructure.

Other projects occurring in regional marine waters (offshore dredging in Maryland and Virginia waters, submarine infrastructure, renewable energy, and oil and gas exploration) would also result in temporary elevated levels of turbidity from disturbances on the seafloor. However, these projects would be temporally and spatially separated on the inner continental shelf and would result in negligible cumulative impacts on water quality.

Debris and materials (metals, batteries, electrical components, and propellants) from spent rockets, payloads, drones, rocket-boosted projectiles, and other objects enter the Atlantic Ocean waters within the region of the SRIPP project area from existing WFF Launch Range operations, future WFF projects (expansion of the Wallops Island Launch Range), and U.S. Navy activities within the VACAPES OPAREA. The VACAPES Range Complex operations would also introduce small amounts of potentially hazardous chemicals into the marine environment (U.S. Department of Navy, 2009). The water quality analysis of all current and proposed VACAPES operations indicated that concentrations of constituents of concern would be well below the water quality criteria established to protect aquatic life. The combined effects of the WFF and VACAPES materials entering the marine environment could result in localized cumulative impacts to water quality and aquatic life depending upon the distributional pattern of the debris.

Other non-hazardous expended material, defined as all parts of a device made of nonreactive materials, including parts made of metals such as steel or aluminum; polymers such as nylon, rubber, vinyl, and plastics; glass; fiber; and concrete would accumulate in the SRIPP project area over time from a variety of sources. While these items represent persistent seabed litter, their strong resistance to degradation and their chemical composition mean that they do not chemically contaminate the surrounding environment by leaching heavy metals or organic compounds. Expended material that sinks to the sea floor would gradually degrade, be overgrown by marine life, and/or be incorporated into the sediments. Floating non-hazardous expended material may be lost from vessels and would either degrade over time or wash ashore as flotsam.

Effects from Climate Change: Impacts on marine water quality from climate change would primarily be a reduction in pH (Tedesco et al., 2005) and changes in temperature. However, it is unknown whether detectable changes in ocean water quality in the project area would be seen over the 50-year life of the SRIPP.

Environmental Consequences

Summary: The project activities listed above would occur within the open ocean where the hydrodynamics of the water column are subject to mixing and exchange due to currents and wave movement. Toxic concentrations and elevated levels of turbidity would be localized and temporary due to mixing and dilution. Therefore, the incremental contribution to cumulative water resource impacts from the SRIPP combined with other operations and projects in marine waters would be negligible. No long-term or significant adverse cumulative impacts on surface waters would occur when the SRIPP activities are considered in combination with other projects and activities.

Wetlands

Geographic Scope: The geographic scope of the wetlands cumulative impacts analysis includes wetlands on and immediately surrounding Wallops Island. The primary focus of this analysis is estuarine (tidal) wetlands as these would provide the ecological services to the resources most affected by the SRIPP, including marine fish and shorebirds. Palustrine (non-tidal) wetlands are discussed to a lesser degree.

Impacts from SRIPP: The SRIPP would have no direct impacts on vegetated wetlands. The SRIPP could contribute indirectly over the long term to a loss of marsh on the west side of the island as a result of preventing island overwash, which contributes sediment to the system and can “build” marsh. Additionally, because wetlands provide value to other resource areas within an ecosystem, the past, present, and future impacts on wetlands at WFF are presented below.

Non-SRIPP Impacts: Based on interpretations of aerial photographs, approximately 152 ha (377 ac) of wetlands were affected by activities on Wallops Island between 1938 and the 1994 (Table 53). The majority of wetland changes can be attributed to excavation and fill operations during the construction of the Wallops Island Causeway in the late 1950s and early 1960s. Based upon the geographic location of most of the changes, it can be assumed that the majority of the impacts were to tidal wetlands (Figure 54). These impacts occurred prior to the enactment of the CWA in 1972 and were therefore not likely regulated or mitigated. Between the early 1970s and 1997 no effects on vegetated wetlands were documented. Since 1997 NASA has recorded the amount and type of wetlands that have been affected at Wallops Island and the Mainland (Table 55). Note that the total net change from the projects presented in Table 55 is positive, meaning that because of compensation, 1.5 ha (3.7 ac) of wetlands have been restored on Wallops Island between 1997 and 2008.

Table 55: Area of Wetlands Affected from Recent Past Projects on Wallops Island and Mainland

Date	Project	Area Affected ha (ac)	Impact Type	Compensation ha (ac)	Net Change ha (ac)
Oct. 1997	Pad 0-B	0.13 (0.32) ¹	Permanent Fill	0.71 (1.76)	0.55 (1.44)
Feb. 2002	Navy MFR	0.0085 (0.021)	Temporary Fill	0.0085 (0.02) ¹	0 (0)
Nov. 2004	Navy DDG	0.85 (2.1)	Permanent Fill	0.76 (4.35)	0.91 (2.25)
Apr. 2008	Boat Dock	0.014 (0.033)	Permanent Fill, Shading	0.026 (0.064)	0.0125 (0.031)
	Total	1 (2.47)		2.5 (6.2)	1.5 (3.7)

Table 56 shows the area of wetland impacts for projects that are currently underway and proposed at Wallops Island. For nearly all of the current projects, wetlands impacts would result from permanently filling the wetland, except for the UAS Airstrip which would also include the conversion of approximately 1.0 ha (2.5 ac) of wetlands.

Table 56: Estimated Area of Wetlands Affected for Current Proposed Projects on Wallops Island and Mainland

Project ¹	Wetland Classification: ha (ac)			
	Palustrine Forested	Palustrine Scrub/Shrub	Palustrine Emergent	Estuarine Intertidal and Estuarine and Marine Subtidal
UAS Airstrip ²	0.1 (0.3)	0.8 (2.0)	0.5 (1.2)	-
Alternative Energy Project	-	-	-	-
SRIPP	-	-	-	-
Expansion of WFF Launch Range ³	-	0.2 (0.5)	1.4 (3.5)	0.04 (0.1)
Total	0.1 (0.3)	1.0 (2.5)	1.9 (4.7)	0.04 (0.1)

¹Existing WFF launch activities do not directly affect wetlands

²Estimate based on USACE-confirmed delineation

³Estimate based on USFWS National Wetland Inventory

Effects from Climate Change: Marsh accretion experts believe that most of the marshes along the Delmarva coast are keeping pace with current rates of sea-level rise, but are unlikely to continue to do so if the rate of sea-level rise increases by another 2 mm (0.08 in) per year (Strange 2008c, interpreting the findings of Reed et al., 2008). However, localized field measurements indicate that accretion rates may be insufficient to keep pace even with current rates of sea-level rise (Strange, 2008d). For instance, accretion rates as low as 0.9 mm (0.04 in) per year (Phillips Creek Marsh in upper Northampton County, VA) and as high as 2.1 mm (0.08 in) per year (Chimney Pole Marsh in lower Accomack County, VA) have been reported (Kastler and Wiberg, 1996), and the average relative sea-level rise along the Eastern Shore is estimated as 2.8 to 4.2 mm (0.11 to 0.17 in) per year (May, 2002). In some areas, marshes may be able to migrate onto adjoining dry lands. For instance, lands in Worcester County that are held for the preservation of the coastal environment might allow for wetland migration. In unprotected areas, marshes may be able to migrate inland in low-lying areas. From 1938 to 1990 mainland salt marshes on the Eastern Shore increased in area by 8.2 percent, largely as a result of encroachment of salt marsh into upland areas (Kastler and Wiberg, 1996). If sea-level rise outpaces accretion and/or migration of wetlands then a net loss of wetlands due to inundation would occur within the cumulative effects analysis area. Additionally, wetlands could be converted to mud and/or sand flats due to overwash events from an increase in intensity and/or frequency of storms.

Regarding the effects of climate change on non-tidal wetlands (that are primarily in the interior of Wallops Island), relatively small changes in precipitation, evaporation, or transpiration, which could alter surface water or groundwater levels by as little as a few centimeters, could reduce wetlands in size, convert some wetlands to dry land, or shift one wetland type to another. These

Environmental Consequences

wetlands may also be affected by saltwater intrusion. The extent of these effects would not likely be substantial when considered over the next 50 years.

Summary: Currently, Wallops Island has approximately 1,090 ha (2,695 ac) of wetlands, which covers approximately 80 percent of the total area on Wallops Island. Historic activities affected approximately 152 ha (377 ac); activities between 1997 and 2008 affected 1 ha (2.47 ac), but with mitigation resulted in 1.5 ha (3.7 ac) of wetlands restored; and projects currently planned at Wallops Island would result in impacts on 3.1 ha (7.6 ac) of wetlands, not including mitigation that would be completed. Over time, this net loss of wetlands within the analysis area has resulted in a long-term adverse effect to wetlands and the resources they support. The largest areas of historic wetland fill adjacent to the Wallops Island causeway have established themselves as wetland systems dominated by *Phragmites*. *Phragmites* wetlands are typically regarded as lower quality because native plants are unable to grow and the species provides little or no food or shelter for most saltmarsh-dependent wildlife, including invertebrates, fish, and waterbirds. Although these areas provide fewer ecological services than a natural marsh system that is typically dominated by *Spartina spp.*, they still provide water filtration and nutrient uptake. Additionally, older stands of *Phragmites* have been observed to trap sediment at a rate that could parallel or exceed the rate of sea-level rise in some areas (Rooth et al., 2003). At a time when sea-level rise threatens to inundate large areas of marsh within the analysis area, this could be a beneficial impact.

The actions proposed for the SRIPP in conjunction with climate change would slow the inland retreat of Wallops Island as sea level rises by limiting overwash and erosion of the coastline, which in the short term could result in maintaining the existing amount of marsh on Wallops Island and Mainland. Without implementation of the SRIPP, bay-side marshes on Wallops Island could be converted to mud and/or sand flats or open water. However, in the longer term, the prevention of overwash, in addition to rising water levels, could be a long-term adverse effect to tidal wetlands as they could be inundated without the additional sediment. Limited benefits to nontidal wetlands could include reduced washover and inundation from saltwater during storm events.

To reduce the potential effects on wetlands from current and future projects, in 2010 NASA prepared a wetlands inventory and assessment for Wallops Island and Mainland. The primary goal of this effort was to identify appropriate areas for compensatory mitigation if future projects would result in unavoidable impacts on wetlands. Table 57 below shows the areas of the wetland systems that would be restored or enhanced when needed. Restoration activities may include reconnecting the restored area to its historic water source, minor grading, removal and control of invasive or undesirable vegetation, and the re-establishment of native vegetation to increase plant diversity. Enhancement is proposed in areas that currently exist in a degraded state due to the dense colonization of invasive or undesirable plant species and may include the removal and control of such species and the re-establishment of native vegetation to increase plant diversity.

Assuming a 2:1 required compensation ratio (meaning 1 acre of mitigation credit given for 2 acres enhanced) and a 1:1 ratio for restoration, WFF has identified area to compensate for unavoidable impacts to approximately 1.66 ha (4.1 ac) of estuarine intertidal emergent, 0.91 ha (2.25 ac) of palustrine scrub-shrub, and 3.80 ha (9.4 ac) of palustrine forested wetlands.

Table 57: Areas Identified for Wetland Compensation

Wetland Mitigation Area	Mitigation Type ha (ac)			
	Restoration	Enhancement		
	Palustrine Forested	Palustrine Scrub/Shrub	Palustrine Emergent	Estuarine Intertidal and Estuarine and Marine Subtidal
System 2	1.22 (3.02)	1.32 (3.27)	-	2.21 (5.45)
System 3	0.25 (0.61)	-	-	0.89 (2.19)
System 4	-	0.89 (2.21)	-	0.22 (0.54)
System 5	2.35 (5.81)	-	-	-
Total	3.82 (9.44)	2.22 (5.48)	-	3.31 (8.18)

Figures 58 and 59 show Mainland and Wallops Island wetland compensation areas, respectively.



Note: Acreages shown on Figure 58 are size of entire system, not the available wetland compensation area.

Figure 58: Proposed Mainland Wetland Compensation Areas



Note: Acreages shown on Figure 59 are size of entire system, not the available wetland compensation area.

Figure 59: Proposed Wallops Island Wetland Compensation Areas

In summary, NASA has compensated for more wetlands impacts than have occurred in the recent past and has identified areas to compensate for nearly all future wetland impacts if they occur. For those impacts that would require compensation of wetland areas currently not identified in Table 57 (palustrine emergent, for example), NASA would strive to identify additional areas and would consult with other resource agencies regarding avoidance, minimization, and mitigation measures. If wetland impacts could not be avoided, NASA would obtain necessary permits and implement compensatory wetland mitigation so that no net functional loss of wetlands on Wallops Island and Mainland would occur. As such, the effects of future NASA actions are not likely to be substantial. However, it should be noted that the extent of effects of climate change within the analysis area would be a much greater factor in

determining the ultimate significance of cumulative impacts on wetlands within the SRIPP's 50-year design life.

Cumulative impacts to unvegetated aquatic habitat are described in the Benthos/Subaqueous Bottom Habitat subsection of 4.7.2.2 Biological Environment, below.

Air Quality

Geographic Scope: The geographic scope of the air quality section relevant to air resources is Accomack County. This county is designated as being in attainment with the Federal NAAQS for all criteria pollutants, and therefore past actions have not degraded the county's air quality. There are no air quality monitoring stations currently on the Eastern Shore, but according to the Accomack County Comprehensive Plan, "The establishment of an air quality monitoring station in the county, however, would allow for the detection of any air quality deterioration and the study of long term trends" (Accomack County Comprehensive Plan, 2008).

Impacts from SRIPP and Non-SRIPP Activities: Construction-related and operational activities that would occur under the Proposed Action for the SRIPP and the other projects that are reasonable and foreseeable at WFF would occur at different locations and at different times over a period of several years. Tables 50 and 51 show the estimated emissions from the preferred alternatives of current and planned WFF projects using conservative assumptions to create worst-case scenarios. As a conservative approach, cumulative air emissions from these WFF projects were compared to projected emissions for the entire Accomack County, which were adjusted for population growth (acting as a surrogate for anticipated emissions growth); these county emissions were considered to be reasonable and foreseeable to occur in proximity to the Proposed Action Alternatives.

Site preparation (i.e., earth moving and soil disturbance) and wind erosion for the projects would result in various amounts of fugitive particulate (i.e., dust) emissions (PM_{10} and $PM_{2.5}$). The amount of fugitive dust emissions would depend on numerous factors, such as the degree of vehicular traffic, amount of exposed soil, soil moisture content, and wind speed. Construction activities would create combustion product (tailpipe) emissions (mostly PM, NO_x , and CO) from vehicles (e.g., contractor POVs, delivery trucks, and heavy construction equipment), and temporary non-road equipment powered by internal combustion engines.

To provide a worst case scenario, BMPs were not integrated into the emission calculations. However, in practice, BMPs (e.g., dust suppression, establishment of lower speed limits in construction areas) and legal requirements (i.e., use of low-sulfur fuel, anti-idling regulations) would be implemented during each project to minimize and mitigate those emissions to the maximum extent practicable. Criteria pollutant emissions from mobile sources associated with the WFF projects listed in Table 58 would be short term, negligible, and localized. If the WFF projects listed in Table 58 were to occur at the same time during a renourishment activity, the cumulative emissions would be 12 percent of the projected county emissions. Most of the NO_x emissions shown in Table 58 from SRIPP Alternative One are temporary in nature (257 days) resulting from the initial dredging activities offshore. There would not be any emissions associated with the project again until the fifth year when renourishment activities would occur, estimated as taking 65 days to complete the dredging. The worst case emissions from those renourishment activities would be substantially less than the initial emissions (i.e., 180 mt [200 tons] of NO_x from Shoal B).

Environmental Consequences

The operational phases of these projects would produce similar criteria pollutant emissions on an annual basis, although only the first year of operational emissions was estimated. BMPs (e.g., use of alternative fueled vehicles at WFF) and installation of the solar panels proposed for the Alternative Energy Project would result in a regional reduction in criteria pollutant and GHG emissions resulting from the reduction in electricity production at the source(s) of electric power generation that currently supplies WFF. In addition, a positive impact in a regional reduction in criteria pollutant emissions could result from the decreased use of fossil fuels during the production of electricity at the electric power generation plant that currently supplies WFF.

Table 58: WFF Cumulative Project Criteria Pollutant Emissions in Tons

Project	CO	NO _x	VOC	PM ₁₀	SO _x
UAS Airstrip	31	62	12	66.1	6
Alternative Energy Project	2.5	3.9	<1.0	<1.0	<1.0
SRIPP Emissions Within Accomack County ¹	24.5	88.8	5.7	5.0	10.1
SRIPP Emissions Offshore ²	96.1	793.5	27.8	24.2	11.7
Expansion of WFF Launch Range – Alternative One	7.7	20.5	2.1	1.8	25.7
WFF Launch Range Activities ³	1.9	19.2	1.6	2.5	28.7
Total	164.1	992.7	50.0	100.6	83.1
Total Emissions Accomack County ⁴	ND ⁵	2,526	5,603	ND	988.0
Cumulative WFF Emissions as a Percentage of Projected Accomack County Emissions	ND	3.5%	<0.1%	ND	1%

¹Based on SRIPP activities occurring on Wallops Island including seawall construction and beach fill work.

²These numbers provide a worst case estimate of emissions from Alternative One: seawall construction, dredging and initial beach fill utilizing Shoal B only, which shows the highest emissions.

³Based on 2008 WFF baseline emissions.

⁴Since Accomack County is an attainment area for all criteria pollutants and is not associated with any air quality planning areas, the county does not have any emission projections. Therefore, based on communication with VDEQ (Ballou, pers. comm., 2010), it was recommended that the most recent (2005) mobile and stationary emissions for Accomack County be used, while adjusting those emissions based on the projected population growth. According to the U.S. Census Bureau (2010), the population change in Accomack County was only 0.4 percent between April 2000 and July 2009. To be conservative, the 2005 emissions provided by VDEQ were adjusted by a projected 1 percent growth.

⁵ND = No data

Because offshore emissions during dredging and transport under the SRIPP would occur over the open ocean, they were not added to the cumulative emissions for all WFF projects that are compared to the total Accomack County emissions—only the SRIPP activities occurring on Wallops Island (seawall extension and beach work) were included in these calculations (bottom row of Table 58), which show air emissions between <1 and 3.5 percent of county emissions for three of five criteria pollutants having Accomack County reported values.

Although cumulative impacts from all construction-related and operational activities are anticipated to be minimal, WFF is in the process of decentralizing their central boiler plant/steam

system with individual propane-fired boilers. Table 59 provides the estimated emissions reduction resulting from this action.

Table 59: Emissions Reduction Resulting from Central Boiler Plant Decentralization

Pollutant	2007 Emissions (tons)	Proposed Emissions After Decentralization (tons)	Percent Change
CO	1.86	2.6	39% increase
NO _x	17.8	4.55	74% reduction
PM	1.2	0.25	79% reduction
SO _x	27	<1	99% reduction

Greenhouse Gas Emissions and Climate Change

The potential effects of proposed GHG emissions are by nature global and cumulative, since individual sources are not large enough alone to have an appreciable effect on the climate. Such an impact on global climate change would only occur when GHG emissions from anthropogenic sources and sinks combine with proposed GHG emissions on a global scale.

Overall, construction vehicles, equipment, and non-road vehicle sources would emit minimal GHG emissions during the site preparation and construction phases of the projects shown in Table 60. However, dredging operations for the SRIPP would produce considerably more GHG emissions compared to the other WFF projects. The operational phases of the WFF projects would also create GHG emissions on an annual basis, although only the first year of operational emissions was estimated.

Table 60: WFF Cumulative Project Greenhouse Gas Emissions

Project	CO ₂ e Emissions ¹ (metric tonnes)
Wallops Research Park	Data Unavailable ²
UAS Airstrip	17,390
Alternative Energy Project	218
SRIPP	37,250
Expansion of WFF Launch Range – Alternative One	445
WFF Launch Range Activities ³	1,400
Total	56,703
U.S. 2007 Baseline GHG Emissions (note: this is in 10 ⁶ metric tonnes per year) ⁴	7,150
Cumulative WFF GHG Emissions as a Percent of U.S. GHG Emissions	7.93x10 ⁻⁴

¹Only CO₂e emissions are included as this is a representation of all GHG emissions.

²Quantitative air analysis not performed for this project.

³Based on 2008 WFF baseline emissions.

⁴Source: EPA, 2009

Given the absence of science-based or adopted NEPA significance thresholds for GHGs, the cumulative WFF CO₂e emissions were compared to the 2007 U.S. GHG baseline inventory to determine the relative increase in proposed GHG emissions (since GHG information was not

Environmental Consequences

available at the county level to allow for any reasonable comparison of emissions). Table 60 summarizes the estimated annual GHG emissions from Alternative One and compares the total to the most recent U.S. annual baseline GHG emissions. This data shows the cumulative CO₂e emissions from WFF projects would amount to approximately 7.93×10^{-4} percent of the total GHG emissions generated across the U.S.; therefore, it can be inferred that impacts on global climate change would not be substantial.

Summary: Cumulative emissions from the Alternative Energy Project, Expansion of the WFF Launch Range, and the SRIPP are unlikely to lead to a violation of the NAAQS, as regional concentrations are already in attainment, with no indication that a re-designation for any criteria pollutant is imminent. Therefore, minimal and short-term cumulative impacts from construction-related and operational activities are anticipated without significant effects on local or regional air quality.

Although the SRIPP and other proposed projects would not cause substantial cumulative impacts associated with global climate change, there are several measures currently in place at WFF, as well as initiatives to be implemented in the near future, that would reduce energy consumption and thereby reduce GHG emissions. For example, installation of solar panels for the Alternative Energy Project would reduce the use of fossil fuels to generate electricity, both locally and regionally. This would result in a beneficial impact to the cumulative effects of planned and ongoing projects in the area, since it has been documented that the three largest GHG emission sources in Virginia are transportation, non-utility uses of fuel in commercial industrial and residential facilities, and electricity generation (Bryant, 2008).

In addition to the Alternative Energy Project, WFF has replaced almost 50 percent of its entire light-duty, government-owned fleet (30 out of 70 vehicles) with newer, more fuel-efficient vehicles, as well as switched all of its diesel vehicles to using 20-percent biodiesel. In addition, the decentralization of the central boiler plant/steam system with individual propane-fired boilers would result in an estimated emissions reduction of approximately 4,400 metric tonnes per year of CO₂.

4.7.2.2 *Biological Environment*

Benthos/Subaqueous Bottom Habitat

Geographic Scope: The geographic scope of the areas evaluated for cumulative effects on benthos includes the inner continental shelf offshore of Virginia and Maryland.

Impacts from SRIPP: For the SRIPP, assuming worst case and the entire 5.2 km² (2 mi²) borrow area would be dredged during the initial sand placement, a total of approximately 518 ha (1,280 ac) of benthic habitat would be directly and adversely impacted. In addition, cumulative dredging impacts for the nine renourishment events would total approximately 1,260 ha (3,100 ac) of benthic habitat. As a result, over the 50-year life cycle of the SRIPP, approximately 1,800 ha (4,450 ac) of benthic habitat would be adversely impacted. As described in Section 4.3.5, benthic communities within the dredged area should recover to pre-dredge levels of community composition and biomass a few years after dredging. Therefore, communities should have recovered prior to the next dredging event so that only the area most recently dredged is affected.

In addition to the offshore borrow areas, approximately 91 ha (225 ac) the subaqueous bottom habitat along the existing seawall would be buried during the initial fill placement.

Non-SRIPP Impacts: Impacts would occur from dredging, trawling, and submarine infrastructure construction. Specifically, the USACE (2008) estimates that the total seafloor area that would be affected over the life of the Atlantic Coast of Maryland Shoreline Protection Project through 2044 would be approximately 1,860 ha (4,600 ac). In addition, trawling would temporarily disrupt benthic habitat. With the exception of the SRIPP, there are no other NASA projects that would result in the filling of unvegetated subaqueous bottoms.

Summary: Combined, there are nearly 1,036,000 ha (2,560,000 ac) of seafloor offshore of Maryland and Virginia. Cumulatively over the lifetime of the projects, the SRIPP together with the Atlantic Coast of Maryland Shoreline Protection Project would affect nearly 3,700 ha (9,100 ac) of benthic habitat. Cumulatively, the reasonably foreseeable future dredging projects offshore would affect less than 0.4 percent of the nearshore seafloor in the region.

The proposed SRIPP offshore dredging would contribute incrementally to the cumulative impacts on the benthos at two scales: the larger context of the inner continental shelf offshore of Virginia and Maryland, as well as the individual shoal(s). The SRIPP dredging would contribute incrementally to the short-term, negative, and direct impacts on benthos living on the shoals within the overall Assateague Ridge complex.

Other offshore dredging projects that could affect the potential adult benthic recruitment to the SRIPP dredged area may further lengthen recovery time of the proposed SRIPP shoals. However, as described previously, the other dredging projects are located several kilometers away from Shoals A and B. In addition, commercial fishing activities such as trawling would also contribute to the cumulative impacts on benthic organisms, and in turn other marine species, by widespread benthic habitat disturbance. However, trawling and other commercial fishing activities generally do not remove sediment and impact a shallower sediment depth than dredging.

The cumulative reduction in benthic invertebrate fauna from the SRIPP when combined with other proposed and potential dredging activities would indirectly affect fish that forage on these benthic species. However, nearby shoals such as Blackfish Bank, Chincoteague Shoals, and other unnamed shoals in the area which would not be used for the SRIPP would provide alternate foraging grounds for marine species and, therefore, mitigate any adverse cumulative impacts.

Essential Fish Habitat

Geographic Scope: The geographic scope of the areas evaluated for cumulative effects on fish includes the inner continental shelf waters offshore of Virginia and Maryland as well as the bays, marshes, and waterways west of Wallops Island.

Impacts from SRIPP: The SRIPP may result in indirect impacts on vegetated wetlands and would contribute to the cumulative adverse effects on EFH for species that utilize the wetlands. The SRIPP would also impact EFH during the dredging of the offshore shoals. The dredging of either offshore shoal is expected to cause direct temporary adverse effects to EFH habitat by removing benthic habitat and degrading water quality due to an increase in suspended sediment concentrations.

Non-SRIPP Impacts: As described in the wetlands section above, there have been impacts to wetlands over the course of development of Wallops and surrounding areas. Additionally, future projects may adversely affect wetlands. Wetlands (particularly tidal/estuarine when considered in

Environmental Consequences

the context of this cumulative effects assessment) are EFH to a number of species as they provide critical areas for spawning, breeding, feeding, schooling, and growth. Wetlands also improve water quality to the benefit of EFH and the fish species these habitats support. Loss of these resources over time has likely contributed to a minor long term adverse effect on EFH within the analysis area.

Past, present, and future shoreline restoration projects off Ocean City and Assateague Island, MD adversely affect EFH temporarily both at the offshore dredging sites as well as the sand placement sites. In addition, EFH within the analysis area is adversely impacted by commercial fishing, dredging of navigation channels, and other dredge and fill projects. As described in the Benthos/Subaqueous Bottom Habitat section above, the SRIPP would contribute to the impact on benthic habitats in the region which is EFH to a number of species.

Effects from Climate Change: EFH may be affected by climate change through changes in temperature and habitat and distribution (e.g., coastal wetland inundation or burial by overwash). However, over the time frame of the SRIPP, these impacts are expected to be minimal.

Summary: Potential cumulative impacts would be long term, adverse, and direct. However, NASA would employ dredging methodologies (described in chapter 2.5.6) reduce the effects of the SRIPP on EFH. Additionally, the USACE has included mitigation measures such as a shallow dredge depth and a 5 percent dredge volume from each shoal into future borrow plans for the Atlantic Coast of Maryland Shoreline Protection Project (USACE, 2008). These measures would reduce potential impacts to EFH off the MD coast. Additionally, as WFF would compensate for any wetlands that would be adversely affected in the future, functional values as EFH would not be lost, and long-term effects would not be substantial.

Fish

Geographic Scope: The geographic scope of the areas evaluated for cumulative effects on fish includes the inner continental shelf waters offshore of Virginia and Maryland as well as inland bays, marshes, and waterways.

Impacts from SRIPP: The SRIPP would contribute to the overall adverse impacts to fish through (1) temporary water quality degradation from turbidity generated at the dredge site and placement area (2) temporary degradation of habitat at the dredge site(s), and (3) the placement of fill material along the shoreline. Dredging operations would directly affect fish through entrainment or indirectly through removal of their benthic forage base. However, given the planktonic dispersal of most OCS fishes and the relatively high adult mobility of even small species, fish utilization of shoals that are dredged would occur after each dredge operation. This utilization should proceed rapidly because the species assemblage outside the borrow sites is similar to the assemblage on the shoal. The placement of fill material would displace several hundreds of acres of water column and cover subtidal benthic habitat. It would create beach habitat in front of the seawall. As a result, fish common to the surf zone would be expected to reestablish themselves in the project area.

Non-SRIPP Impacts: Fish within the project area are adversely impacted by commercial fishing, water quality degradation (agricultural runoff, sedimentation, municipal stormwater runoff), and habitat loss and degradation. In addition, debris from spent rockets, payloads, drones, rocket-boosted projectiles, and other objects enter the Atlantic Ocean waters within the region of the SRIPP project area from existing WFF Launch Range operations, future WFF projects

(Expansion of the Wallops Island Launch Range), and U.S. Navy activities within the VACAPES OPAREA. This debris may temporarily degrade water quality in a localized area, but eventually the debris provides structure and habitat for fish.

The majority of the fish species found within the proposed dredge sites and the placement site are common and widespread throughout the nearshore continental shelf in the MAB. Several species, such as bay anchovy, summer flounder, sea bass, striped bass, and windowpane flounder utilize habitats in the estuaries and on the inner continental shelf of the Mid-Atlantic (CSA International, Inc. et al., 2009). As described in Section 3.1.4.1, the northern Virginia and southern Maryland shorelines are relatively undeveloped and as a result habitat and water quality impacts within the area are minor.

Effects from Climate Change: Sea-level rise would increase depth in the shoal area, though the effects would be minimal. Reductions in pH, changes in temperature, and changes in wetlands (i.e., inundation or burial by overwash) resulting from climate change may affect the composition of prey and predator fish species in the analysis area. However, over the time frame of the SRIPP, these impacts are expected to be minimal.

Summary: The magnitude of the cumulative impacts on fish from the temporary SRIPP impacts and past, present, and future projects would be minimal because there is a large area of habitat available within the regional context of the analysis area.

Marine Mammals

Geographic Scope: The geographic scope of the areas evaluated for cumulative effects on marine mammals includes the inner continental shelf waters offshore of Virginia and Maryland.

Impacts from SRIPP: If multiple dredging operations occur at the same time on shoals on the Assateague Ridge shoal complex, the noise associated with the operations may contribute to cumulative impacts on marine mammals in the area. As described in Section 4.3.9, since dredging operations are generally of relatively short duration, significant cumulative effects from associated noise are not anticipated. Dredging may impact marine mammals through noise generated during sand removal, changes to benthic habitats, and vessel collisions during transport of the material to a pump-out station offshore of the shoreline. It is assumed that noise would cause avoidance responses in species. Because the dredging operations would be limited to one or two shoals, it is not expected that multiple dredging operations would result in significant cumulative impacts to the prey base of threatened and endangered marine mammals.

The SRIPP vessel and dredging noises, when combined with other underwater noise levels in the region, particularly from U.S. Navy operations in the VACAPES Range Complex as well as noise generated from seismic surveys from offshore oil and gas development, may result in temporary adverse impacts on marine mammals traveling through the area. In addition to natural airborne and underwater noise (breaking waves, wind), anthropogenic sources of noise include military, general aviation, and commercial aircraft; shipping and fishing vessels; dredging; nearshore construction activities; military explosive use; oil and gas exploration and extraction; mineral exploration and extraction; and geophysical surveys.

Non-SRIPP Impacts: Sources of adverse effects to marine mammals in the action area include incidental takes in state-regulated fishing activities from commercial fishing, vessel collisions with private vessels, ingestion of plastic debris from fishing operations and other activities and

Environmental Consequences

pollution from atmospheric loading of pollutants or spills. NASA may fly aircraft with lasers occasionally over the ocean; however, NASA consulted with NMFS regarding its typical mission operations and concluded that the effects would be insignificant and discountable. Additionally, falling rocket debris from rocket launches could potentially affect marine mammals, though this is highly unlikely. In a consultation for the expansion of the WFF Launch Range, NMFS concluded that the effect of falling rocket debris to marine mammals would be “insignificant and discountable.”

MMS (2004) reported on dredging and marine mammal collisions. Vessel collisions with endangered whales are one of the major factors limiting their recovery. There has never been a report of a whale strike or mortality by a hopper dredge in the United States (NMFS, 2004), although there is one report of a right whale calf mortality resulting from a strike by a dredging vessel in South Africa (MMS, 2004). It is generally thought that hopper dredges move slow enough to minimize the risk of a strike with a marine mammal. Additionally, potential collisions with debris VACAPES activities, while unlikely, may occur.

Airborne noise attributable to military activities in the VACAPES Range Complex emanates from multiple sources including naval ship power plants, military aircraft, targets, bombs, missiles, small arms, and water-based demolitions. Sound from military sources in the VACAPES Range Complex is virtually all transitory, and can be widely dispersed or concentrated in small areas for varying periods. Sound levels from naval ships are analogous to the sound levels of commercial shipping. There are no underwater explosive ordnance areas in the VACAPES Range Complex that overlap with the SRIPP project area (Figure 56). An EIS completed in 2009 to address potential impacts from activities within the VACAPES Range Complex (U.S. Department of the Navy, 2009) stated that although it is possible a single animal may be significantly affected when considering all the events in the training complex, no significant effects are predicted and no significant impacts to populations of marine mammals are anticipated when the potential impacts due to sonar activities are included with the potential impacts due to range complex activities.

Effects from Climate Change: The impact of climate change on marine mammals is likely to be related to changes in sea temperatures, potential change in sea water chemistry due to melting ice, increased rainfall and ocean acidification, sea-level rise, the loss of polar habitats and potential shifts in the distribution and abundance of prey species (NMFS, 2010). However, over the time frame of the SRIPP, these impacts are expected to be minimal.

Summary: It is generally thought that hopper dredges move slow enough to minimize the risk of a strike with a marine mammal, so no cumulative impacts are anticipated from other dredging activities. Because the amount of additional noise attributable to SRIPP activities would be negligible compared to the VACAPES activities, there would be no significant impact to marine mammals in territorial waters.

Birds

Geographic Scope: The geographic scope of the areas evaluated for cumulative effects on migratory birds includes the inner continental shelf waters offshore of Virginia and Maryland for water-based impacts, as well as Wallops, Assateague and Assawoman Islands for land-based impacts.

Impacts from SRIPP: As described in Section 4.3.2.2, dredging operations at Unnamed Shoals A or B may cause seabirds to vacate the shoal area, where they sometimes feed on schooling fish. Direct site-specific adverse effects would also occur on bottom-feeding seabird species, such as seaducks. These birds feed on fish and invertebrates that would be temporarily removed or displaced during and immediately following a dredging event. Over the lifetime of the SRIPP, an estimated 10 dredging events at Shoals A and B could reduce the value of these shoals for feeding.

Onshore impacts for beach nesting and foraging birds could include startling, crushing eggs by motorized vehicles, and reduction in prey base along the newly created shoreline. Excavating sand from north Wallops Island would also lower the beach elevation, possibly resulting in a higher risk of flooding to shorebird nests. However, it is expected that the newly created beach would create a substantial amount of new shorebird nesting and foraging habitat where there currently is none, a beneficial effect.

Non-SRIPP Impacts: Other dredging projects and disturbances at shoals within the region would reduce the availability of seabirds to use alternative shoals for feeding; however given that there are approximately 24 shoals of relatively shallow water depth (less than approximately 8 meters) within the analysis area, the additive effects are not expected to be substantial. Other additive offshore impacts within the analysis area may include entanglement with commercial fishing gear (e.g., gillnets) and a reduction in forage fish from commercial fishing. The historic loss of vegetated tidal wetlands has resulted in additive adverse impacts to birds that feed on marine organisms, including fish, crustaceans, and mollusks. However, given the large available area available for foraging within the analysis area, impacts are not expected to have been significant. Additionally, any recent or future impacts wetland would be (or have already been) mitigated such that functional values to marsh-feeding birds would not be lost.

Temporary increases in noise are anticipated as a result of current and planned onshore projects in the analysis area. Temporary interruption of foraging and nesting activities for shorebirds may occur as a result of launch and static fire testing activities proposed for the Expansion of the WFF Launch Range project, the UAS Airstrip, or from existing WFF Launch Range activities. The nesting area designated on the northern end of Wallops Island is not expected to be affected by noise. Birds along the southern part of Wallops Island would be closer to the launch pads, and would be more susceptible to effects, which could include startling, deafening, and missed nesting attempts. Noise generated from rocket launches is generally low-frequency, of short duration, and occurs infrequently. Naturally occurring background noises in the existing and potential nesting areas, such as wave action and thunderstorms, are more frequent and of longer duration than noise from a rocket launch. No long-term changes to ambient noise levels are anticipated. Also, regarding effects from rocket launches, it is possible that lower intensity noise and lighting disturbances during launch preparations would deter birds from congregating near the pad, thus reducing the potential for injury or death when the rocket is launched.

In the event the new beach becomes suitable habitat for shorebirds, indirect cumulative effects on nesting shorebirds may occur from security patrols on the Wallops Island beach. Motorized vehicle use on beaches is a threat to Piping Plovers, as well as other shorebirds that nest on beaches and dunes. Vehicles can crush eggs, adults, and chicks (Burger, 1987). Continued recreational use of the Wallops Island beach could also present adverse effects (direct mortality or harassment) on nesting shorebirds including Piping Plovers. Pedestrians may flush incubating plovers from nests (Flemming et al., 1988), exposing eggs to predators or excessive

Environmental Consequences

temperatures. Repeated exposure of eggs on hot days may cause overheating, rendering the embryos unviable (Bergstrom, 1991); excessive cooling may kill embryos or retard their development, delaying hatching dates (Welty, 1982). Pedestrians can also disturb unfledged chicks (Burger, 1991), driving them from preferred habitats, decreasing available foraging time, and causing expenditure of energy.

Indirect effects to birds are likely to include an increased predation rate due to human activity on the beach. Human activity may result in litter on the ground, which could attract predators due to increased food availability. The increased numbers of predators may increase risk of disturbance, nest loss, and adult mortality of plovers and increase losses of sea turtle eggs and nests. Gulls, foxes, and raccoons can also be a major source of loss of eggs and juvenile plovers. WFF employs a variety of techniques to reduce predation on nesting shorebirds. The use of predator exclosures (fences around nests) has been successful in reducing predation on Piping Plover eggs (Melvin et al., 1992). However, these devices provide no protection for mobile adults or plover chicks, which generally leave the exclosure within a day of hatching and move extensively along the beach to feed. To reduce the risks of predation to nesting shorebirds and sea turtles on the Wallops Island beach, WFF employs biologists from USDA Wildlife Services who routinely perform predator removal.

Construction of the proposed UAS Airstrip would result in the loss of between 8 and 16 ha (20 and 40 ac) of forest and shrub/thicket vegetation at the north end of Wallops Island west of the proposed SRIPP renourishment area and the Piping Plover habitat. Additive impacts from construction would likely be minimal as the species affected by the SRIPP would not be expected to be present within the construction footprint. However, it is possible that adjacent marsh nesting and foraging waterbirds that also feed along the Wallops Island shoreline would be cumulatively affected (startled) by construction noise, especially if both the SRIPP and construction of the airstrip were to take place concurrently; however the impact would be temporary and minor. Because of the amount of habitat present, habitat loss is not anticipated to be a significant cumulative effect on birds, within the project area. During the actual operation of the existing and proposed UAS airstrips, shorebirds may be disturbed by aircraft maneuvering or overflying an area where nesting occurs. For operations at the current UAS airstrip on south Wallops Island, NASA consulted with USFWS and concluded that such activities would not likely adversely affect plovers if aircraft avoided known nesting areas by at least 300 m (1,000 ft). However, operation of aircraft, including UAS, has potential to affect plovers during and outside of nesting season. Shorebirds could perceive aircraft as potential avian predators. It is expected that not all aircraft operation is likely to result in disturbance, and plovers are most likely to be disturbed by flights at low altitude down the beach or just offshore. Effects on shorebirds may include flushing from nests when incubating eggs, and interruption of feeding or courtship. Because most of the noises associated with UAS operations are of low intensity and short duration, shorebirds would likely return to normal behavior within a few minutes of the noise.

In support of its Alternative Energy Project, NASA recently conducted over twelve months of mortality surveys at three existing towers on Wallops Island to determine the risk of these structures to birds in the area. Although none of the birds found during these surveys would be expected to be directly affected by the SRIPP, the survey indicated the general potential for avian mortality. As such, migratory birds affected by the SRIPP could be cumulatively impacted by the existing tall structures and towers on Wallops Island. Resulting effects would not be expected to

be substantial, however. Additionally, the two residential-scale wind turbines proposed under the Alternative Energy project would be on Wallops Mainland and Main Base, well away from the habitats of avian species likely to be affected by the SRIPP.

Effects from Climate Change: As discussed under wetlands in Section 4.7.2.1 above, sea-level rise would likely cause the natural barrier islands along the Delmarva coast to retreat inland and therefore reduce the amount of island area and consequentially reduce shorebird habitat area. This habitat modification due to sea-level rise would not occur to the same degree on Wallops Island because of the SRIPP thus cumulative effects of sea-level rise may have less of an impact on Wallops Island compared to the other barrier islands along the Delmarva coast. According to Wilke et al. (2008), overwash events are documented as one of the primary causes of nest loss for American Oystercatchers. An increase in the frequency of these events could lead to low rates of reproductive success, which would be insufficient to maintain a stable population. Moreover, Boettcher et al. (2007) state “one of the major impending threats facing Piping Plovers and other beach nesting species is an increase in the frequency of beach flooding as a result of global climate change and sea-level rise, which may lead to chronic reproductive failure and eventual loss of breeding habitat.” Sea-level rise of approximately 0.5 m (1.5 feet) over the 50-year analysis time frame would also flood portions of the tidal marshes west of Assateague, Wallops, and Assawoman Islands. Marsh nesting species would be most severely affected as rising water levels would likely result in more flooding and reduced nesting success (Erwin et al., 2006). Erosion of marsh islands may further reduce availability of preferred nesting sites, potentially resulting in selection of alternative nesting sites.

Summary: Offshore, the cumulative reduction in benthic invertebrate fauna from the SRIPP when combined with other proposed and potential dredging activities and anticipated sea-level rise which would increase depth in the shoal area, could negatively affect fish and in turn, marine birds that forage for fish in the project area. However, nearby shoals such as Blackfish Bank, Chincoteague Shoals, and the multitude of other unnamed shoals in the area which would not be used for SRIPP renourishment activities would provide alternate foraging grounds for marine birds which would mitigate any adverse cumulative impacts. The cumulative reduction in benthic invertebrate fauna from placement of a sand berm onshore, when combined with other proposed onshore activities and anticipated sea-level rise, could negatively affect benthic organisms and in turn, birds that forage for these organisms. However, nearby barrier islands in the area including Assateague, Assawoman, etc. would provide alternate foraging grounds for marine birds which would reduce the intensity of adverse cumulative impacts. It should be noted that if habitat on the naturally maintained barrier islands is lost due to the effects of climate change, their ability to provide suitable foraging and nesting areas nearby would be reduced, thereby making the Wallops beach all the more important to shorebird viability. In conclusion, given that the SRIPP would create an elevated beach where there currently is none, at a time when the availability of suitable beach habitat would likely be declining, the long-term effects would be beneficial.

Threatened and Endangered Species

The SRIPP may contribute incrementally to the cumulative impacts on threatened and endangered species in the project area. Cumulative impacts may result from; (1) the offshore dredging operation and the vessel transport of fill material, and (2) the placement of the sand on the shoreline. NASA determined that Expansion of the WFF Launch Range project would have

Environmental Consequences

the following impacts on threatened and endangered species: 1) may affect but is not likely to adversely affect seabeach amaranth; whales; the leatherback, Kemp's ridley, and Atlantic green sea turtles; and the Red Knot, and 2) may affect and is likely to adversely affect the loggerhead sea turtle and Piping Plover. The Alternative Energy Project would not result in any effects to threatened and endangered species. No evaluations of effects to federally listed species have been made for the North UAS Airstrip project yet.

Potential adverse cumulative impacts on threatened or endangered species could result in the following impacts from past, present and reasonably foreseeable activities in the project area, together with the SRIPP:

- Increase in ambient noise
- Increase in ambient light
- Creation of potential new habitat on Wallops Island Shoreline
- Removal of current or potential habitat.

Cumulative impacts to specific groups/species are presented below.

Sea Turtles

Geographic Scope: The geographic scope of the areas evaluated for cumulative effects on sea turtles includes the inner continental shelf waters offshore of Virginia and Maryland for water-based impacts, as well as Wallops, Assateague and Assawoman Islands for land-based impacts.

Impacts from SRIPP: NMFS estimates that the SRIPP may result in 9 sea turtle takes over the lifetime of the current SRIPP EIS Alternative One (see Section 4.3.10). Given the NMFS estimate that at least 90 percent of the injured/killed turtles for the SRIPP would be loggerheads (NMFS, 2010), at least 8 of the turtle takes for the SRIPP Alternative One of this PEIS would likely be loggerheads, and one may be a Kemp's ridley sea turtle. Based on Table 61, there is an average of 3 sea turtle takes per year from dredging operations in the USACE Norfolk District. The SRIPP would average approximately 0.18 sea turtle takes per year over the 50 year lifetime of the project, or less than 5 percent of the current yearly takes. Approximately three sea turtles takes may occur during dredging operations for the initial beach fill operations and six sea turtles takes may occur during dredging for the nine renourishment events.

The proposed SRIPP would create a beach where one currently does not exist and augment the existing beach at the northern and southern ends of Wallops Island. The new beach would provide additional potential habitat for sea turtle nesting; it is reasonable to assume that turtles may nest and utilize this additional habitat at some point after sand placement.

Non-SRIPP Impacts: Turtles are more likely to be directly affected by dredging than other threatened and endangered species in the area. As described in Section 4.3.10, the primary direct effect to sea turtles is entrainment in the drag heads. Indirect effects to turtles are the same as those described for marine mammals above and are not anticipated to be significant.

Table 61 summarizes the number of sea turtle takes, by month, from projects conducted in the USACE Norfolk District from 1980 to 2009. For the 30-year reporting period, a total of 63 sea turtle takes were recorded. Of the 63 total takes, 53 were loggerhead sea turtles. From 2000 to

2009, there have been no recorded takes of sea turtles for projects within the USACE Norfolk District (USACE, 2009c).

Table 61: Cumulative Sea Turtle Takes by Month and Species between 1980 and 2009, USACE Norfolk District

Month	Atlantic Green	Kemp's Ridley	Leatherback	Loggerhead	Unidentified	Total
Jan	0	0	0	0	0	0
Feb	0	0	0	0	0	0
Mar	0	0	0	0	0	0
Apr	0	0	0	2	0	2
May	0	0	0	8	1	9
Jun	1	0	0	10	0	11
Jul	0	0	0	2	1	3
Aug	0	1	0	7	1	9
Sep	0	1	0	10	1	12
Oct	0	3	0	12	0	15
Nov	0	0	0	2	0	2
Dec	0	0	0	0	0	0
Total	1	5	0	53	4	63

Source: USACE, 2009c

Predation of eggs and young by mammals, birds, and ghost crabs may eliminate up to 100 percent of the nests and any hatchlings that emerge on beaches where predation is not managed (National Research Council, 1990). WFF uses a variety of techniques to reduce predation on nesting sea turtles. Additionally, WFF employs biologists from USDA Wildlife Services who routinely perform predator removal to reduce the risk to nesting sea turtles on the Wallops Island beach. Indirect effects to sea turtles are likely to include an increased predation rate due to human activity on the beach.

Recreational activities may inadvertently disturb nesting females, crush eggs within the nest, or crush, entrap, or disturb hatchlings attempting to leave the nest. Vehicle use on the beaches may compact beach sand and/or disturb female turtles attempting to nest. However, as recreational use of the Wallops beach is relatively low, and is limited to WFF employees (who receive protected species awareness training), these effects are not expected to be substantial.

With the exception of some populations of Kemp's ridley sea turtles, almost all adult sea turtle nesting behavior occurs at night along coastal beaches. Studies indicate that adult turtles will avoid nesting on beaches that are brightly lit with artificial lighting or when bright lights form a backdrop beyond the dunes. This avoidance behavior constitutes habitat loss for the species involved because turtles may emerge at alternative sites along the coast which are a less suitable nesting habitat (Witherington and Martin, 1996).

Sea turtle hatchling emergence also occurs principally at night, although some emergence may occur in early-morning or late afternoon. Immediately after emergence, hatchlings orient toward the sea. Sea turtle hatchlings have an inborn tendency to move in the brightest direction. On a natural beach, the brightest direction is most often the open view of the night sky over, and reflected by, the ocean. Hatchlings also tend to move away from darkly silhouetted objects

Environmental Consequences

associated with the dune profile and vegetation. Bright, artificial light sources have been shown to interfere with sea-finding orientation, as the hatchlings move toward the bright lights. Hatchlings are believed to be more sensitive to bright lights than adult turtles.

Although the SRIPP would not add permanent light sources to the beach, existing WFF buildings and towers are sources of light along the shoreline of Wallops Island. Some infrastructure that is proposed for the Expansion of the WFF Launch Range project has exterior lighting requirements, but "turtle friendly" lights would be used, which are believed to be the least visible and disruptive to both sea turtles and migratory birds.

Effects from Climate Change: The impact of climate change on sea turtles is likely to be related to changes in sea temperatures, potential change in sea water chemistry due to melting ice, increased rainfall and ocean acidification, sea-level rise, and potential shifts in the distribution and abundance of prey species (NMFS, 2010). Additionally, with rising sea levels, turtle nests would be more susceptible to flooding during storm events. However, over the time frame of the SRIPP, these additive impacts are expected to be minimal.

Summary: Cumulative adverse effects on sea turtles may occur due to the multiple dredging operations planned in the offshore areas of Maryland and Virginia, non-SRIPP activities and projects at WFF, and other shoreline restoration projects in the region when combined with the SRIPP activities. However, given that the SRIPP would create an elevated beach where there currently is none, at a time when the availability of suitable beach habitat would likely be declining, the long-term effects would be beneficial. During project planning, NASA consults with NMFS and USFWS regarding potential effects on sea turtles; NASA would continue to implement all mitigation and monitoring measures that were determined through the Section 7 consultation process.

Piping Plover

Geographic Scope: The geographic scope of the areas evaluated for cumulative effects on Piping Plover includes Wallops, Assateague, and Assawoman Islands.

Impacts from SRIPP: Impacts on Piping Plovers from the SRIPP would be the same as those described above in Section 4.7.2.2 under the beach nesting birds discussion.

Non-SRIPP Impacts: Impacts on Piping Plovers from non-SRIPP activities and projects would be the same as those described above in Section 4.7.2.2 under the beach nesting birds discussion.

Effects from Climate Change: Impacts on Piping Plovers from climate change would be the same as those described above in Section 4.7.2.2 under the beach nesting birds discussion.

Summary: When adding the potential impacts from the SRIPP, the Expansion of the WFF Launch Range, the UAS Airstrip project, and existing rocket activities, adverse cumulative impacts may occur to Piping Plovers due to loss of habitat, noise impacts, and injury/deaths from off-road vehicle use and predation. The combination of all of these activities, when considered together, results in more frequent disturbance and, as a result, plovers would experience low levels of disturbance on a regular basis. The SRIPP along with other WFF projects would contribute to long-term adverse impacts on habitat loss in the overall region, although not to an extent considered significant when considered in conjunction with the amount of habitat available at Wallops Island, WFF, and along the Eastern Shore. Additionally, given that the SRIPP would create an elevated beach where there currently is none, at a time when the

availability of suitable beach habitat would likely be declining, the long-term effects would be beneficial.

Marine Mammals

Geographic Scope: The geographic scope of the areas evaluated for cumulative effects on marine mammals includes the inner continental shelf waters offshore of Virginia and Maryland

Impacts from SRIPP: Impacts on marine mammals from the SRIPP would be the same as those described above in Section 4.7.2.2.

Non-SRIPP Impacts: Impacts on marine mammals from non-SRIPP activities and projects would be the same as those described above in Section 4.7.2.2.

Effects from Climate Change: Impacts on Piping Plovers from climate change would be the same as those described above in Section 4.7.2.2.

Summary: Cumulative impacts to T&E marine mammal species are similar to those described for non-listed marine mammal species above.

Threatened and Endangered Species Mitigation

To mitigate adverse effects on protected species from all impact-producing factors, NASA would continue to coordinate with USFWS and USDA personnel in monitoring the Wallops Island beach for Piping Plover and sea turtle activity. Any nests discovered would be appropriately marked with a GPS unit and identified with signage. Areas designated as recreational use beach would be modified based upon plover and sea turtle nesting activity. Furthermore, the security contractor at WFF is in the process of installing a closed circuit monitoring system to allow surveillance from a central location. Upon completion of the closed circuit system, beach patrols are expected to decrease. As such, impacts to all listed species on the beach as a result of security patrols would likely diminish over time. Additionally, WFF Environmental Office staff would continue its outreach program to all users of the beach, including security staff and recreational users. Elements of the outreach program include installation of signage at all beach access points and development and dissemination of fact sheets, both of which contain information regarding the listed species that may be on the beach and the appropriate reporting protocol if the presence of a species is suspected.

4.7.2.3 Socioeconomic Environment

Geographic Scope: The geographic scope of the areas evaluated for cumulative effects on the socioeconomic environment are Accomack County and, specifically for commercial and recreational fishing, the inner continental shelf waters offshore of Virginia and Maryland.

Economic

Impacts from SRIPP: Construction activities would result in beneficial economic impacts to the overall economy. In addition to a temporary increase in the number of workers at WFF, economic impacts from the Proposed Action would result from construction material purchases in the region generating local sales, construction payroll expenditures for labor on-and off-site, and related spending by supplying firms and laborers or “multiplier effects” created by the

Environmental Consequences

project investment. These economic benefits would occur for a relatively limited time during actual construction.

The SRIPP would reduce the potential losses of work days and jobs that could result from storm damages, and therefore delays to Wallops Island missions, or the loss of the infrastructure resulting in elimination of WFF's and tenant's technological capabilities.

Non-SRIPP Impacts: Estimated tax revenue increases for the Expansion of the WFF Launch Range Project and Wallops Research Park combined are \$133 million due to the creation of an estimated 833 permanent jobs. Approximately \$28,000 would enter the local economy based on per diem rates alone over the 6-month construction period for the Alternative Energy Project. As discussed in Chapter 4 of this PEIS, the local economy typically benefits approximately \$1,000,000 from the launch team alone, \$2,000,000 for services and commodities support, and \$3,000,000 to \$5,000,000 from tourism per launch event from Launch Complex 0 at Wallops Island (Reed, pers. comm.). No estimates of economic benefits have been made for the UAS Airstrip project at this time.

Additionally, the value of each sounding rocket mission is \$3 million and currently approximately 30 sounding rocket missions occur per year (\$90 million annually). This money primarily stays at NASA and in the local economy. The value of each Expendable Launch Vehicle mission, 2-8 of which may occur annually, is \$200 million, with about \$3 million of that being provided locally for range support excluding tourism (\$6-24 million annually). Approximately 20 UAS missions could occur per week, each with a value of \$100,000, with about \$20,000 of that going directly to WFF for a week of flight (approximately \$1 million annually). In total, these sounding rocket, Expendable Launch Vehicle, and UAS missions and activities at Wallops Island add up to approximately \$115 million annually (Pittman, pers. comm.).

Summary: Jobs and tax revenue from WFF's existing activities, proposed projects, and the other regional projects described in Section 4.7.1.2 would result in beneficial cumulative economic impacts on the local economy of the Eastern Shore and the Maryland and Virginia coastal areas.

The projects and activities described above that occur on Wallops Island would benefit directly from the SRIPP through the continuation of activities by reducing potential losses of work days and jobs that could result from the loss of the infrastructure, resulting in elimination of WFF's and tenant's technological capabilities. Additionally, the Alternative Energy and Wallops Research Park Projects cumulatively add to the economic benefits from WFF operations.

Commercial and Recreational Fisheries

Impacts from SRIPP: The maximum SRIPP dredge area on either Unnamed Shoal A or Unnamed Shoal B would be approximately 520 ha (1,280 ac). The potential future dredge areas for the Atlantic Coast of Maryland Shoreline Protection Project total over 2,000 ha (4,590 ac) (USACE, 2008). The potential future dredge area of Sandbridge Shoal is approximately 1,620 ha (4,000 ac) throughout eight planned renourishment cycles (USACE, 2009b). Cumulatively, these projects comprise approximately 3,900 ha (9,600 ac).

There are over 777,000 ha (1,920,000 ac) of seafloor within 48 km (30 mi) of the Virginia shoreline, and approximately 233,000 ha (576,000 ac) of seafloor within 48 km (30 mi) of the Maryland coastline (USACE, 2008). Combined, there is nearly 1,036,000 ha (2,560,000 ac) of

seafloor offshore of Maryland and Virginia. Cumulatively, the reasonably foreseeable future dredging projects offshore will affect less than 0.4 percent of the seafloor potentially utilized by fishermen. The potential conflicts between commercial and recreational fishermen and the dredging operations would be temporary and localized.

Non-SRIPP Impacts: Commercial and recreational fishing activities result in impacts on fish and fisheries the SRIPP project area. Additionally, other offshore projects and activities described in Section 4.7.1.2 above would have similar impacts on fisheries, habitat, and marine organisms as described for the SRIPP (i.e., elevated turbidity levels during dredging, disruption to benthos). WFF's launch range operations also have the potential to temporarily affect commercial and recreational fishing in the vicinity of Wallops Island. For safety purposes, during the last several hours of a launch countdown, NASA requires that portions of the ocean east of Wallops Island are cleared of boat traffic. During most launches, NASA communicates with vessels to obtain their voluntary movement out of the hazard area. Other times, for larger missions, NASA may require the area be cleared, and coordinates with local authorities, including USCG and USACE to establish the legally enforceable off-limits areas. Clear zones typically last for several hours and depending on launch conditions, they could be established for specific times over the course of several days up to a week or more for each mission. The need for such clear zones could adversely affect commercial and recreational fishing by displacing boaters from preferred fishing grounds until operations are complete. However, there are times when boat passage through a hazard area is allowed if there is sufficient time during the launch countdown.

Summary: Dredging for the SRIPP would have a minor incremental cumulative effect on commercial and recreational fisheries in the area when combined with other dredging activities in MD and VA and periodic temporary closures of a portion of the ocean east of Wallops Island launches. Any effects from dredging activities would be highly localized and short-term. The establishment of offshore clearance areas would be a more frequent disturbance, however with appropriate coordination, effects are expected to continue to be minimal. To ensure minimal impacts on those fishing in offshore areas, NASA routinely communicates with the local community to ensure that the public is apprised of upcoming activities. For its launch range operations, NASA regularly issues Notices to Mariners in advance of its operations. Additionally, it works to remain abreast of local fishing activities by tracking fishing tournaments on its range schedule such that operations can be conducted with as limited disruption to fishermen as possible.

4.8 PERMITS, LICENSES, AND APPROVALS

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 SRIPP activities.

- CWA Section 404 Dredge and Fill Permit, USACE
- Rivers and Harbors Act Section 10 Permit, USACE
- CWA Section 401 Water Quality Certification/Virginia Water Protection Permit, VDEQ
- Virginia Stormwater Management Program Permits, VDCR
- VMRC Permits
- Federal Consistency Determination, VDEQ
- Biological Opinion, USFWS and NMFS
- Magnuson-Stevens Act, EFH consultation, NOAA
- VDHR Section 106 Consultation
- BOEMRE and USACE MOA for use of Federal offshore sand resources

CHAPTER FIVE: MITIGATION AND MONITORING

Because the SRIPP Proposed Action would take place in a complex and dynamic environment over a 50-year period, NASA would implement and continuously evaluate mitigation measures to ensure they are effective and appropriate. Due to a certain degree of uncertainty inherent in predicting how the Proposed Action activities would affect physical and biological resources, NASA would implement an adaptive management strategy for the SRIPP comprised of the following three elements:

- Base planning on existing and adequate knowledge of the project area, well-defined project goals, and current technology;
- Implement the Proposed Action with the initially planned mitigation measures described below; and
- Monitor and evaluate results.

The cycle would then reinitiate, driven by the monitoring results and project performance. Results could validate existing practices or reveal the need for alterations in project implementation or mitigation techniques. By monitoring and evaluating how measures are working, NASA would ensure that mitigation measures are optimized.

The following sections discuss NASA's 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 sections describe the mitigation measures that would be implemented for the components of the alternatives: seawall extension, offshore dredging, sand placement, groin or breakwater construction, and north Wallops Island borrow site excavation.

5.1.1 Physical Environment

5.1.1.1 *Seawall Extension*

The main physical effects of seawall construction activities would be soil and sediment disturbance and potential pollution releases from construction equipment.

Mitigation and Monitoring

NASA would implement erosion and sediment control BMPs to minimize erosion. Spill prevention BMPs would be implemented to reduce potential impacts on soils and sediments during seawall construction, and all work would be performed in accordance with WFF's ICP.

5.1.1.2 Offshore Dredging

The main physical effects of dredging the proposed offshore shoals would be removal of sand from the shoal, suspended sediment/turbidity, redistribution of sediment outside the dredge footprint, and changes to bathymetry. The dredge contractor would be responsible for proper storage and disposal of any hazardous material such as oils and fuels used during the dredging and beach nourishment operations. The U.S. EPA and USCG regulations require the treatment of waste (e.g., sewage, gray water) from dredge plants and tender/service vessels and prohibit the disposal of debris into the marine environment. The dredge contractor would be required to implement a marine pollution control plan to minimize any direct impacts to water quality from construction activity.

Offshore dredging would result in changes to the bathymetry of the selected offshore borrow site. To minimize impacts on the bathymetry, dredging would be conducted so that a relatively shallow, uniform thickness of material is removed from the borrow area.

5.1.1.3 Beach Construction and Sand Placement

To minimize impacts on sediments, the beach would be restored to a comparable sediment type (a similar percentage of sand, silt and clay), grain size, and color as the existing beach material.

5.1.1.4 Groin and Breakwater Construction

During groin construction, there would be an accumulation of sediment on the updrift side of the groin, and some shoreline erosion would occur on the downdrift side. The extent of the erosion would depend on the direction and rate of longshore sediment transport in the groin area. NASA would renourish the beach to reduce the potential for downdrift erosion by placing sand all along the Wallops Island shoreline. Additionally, the groin would be located within the sediment transport nodal zone along the beach to ensure minimal potential downdrift.

5.1.1.5 North Wallops Island Sediment Removal

The main physical effects of excavation activities on north Wallops Island for beach fill material would be sediment disturbance and potential pollution releases from construction equipment.

NASA would implement erosion and sediment control BMPs to minimize erosion. Spill prevention BMPs would be implemented to reduce potential impacts on soils and sediments during excavation, construction, and beach fill work. All work would be performed in accordance with WFF's ICP.

5.1.1.6 MEC

To minimize the risk of adverse impacts from UXO in the North Wallops Island borrow area, an MEC Avoidance Plan that addresses the potential hazards would be prepared. A visual and magnetic survey of the area to locate MEC would be completed and potential hazards removed prior to excavation.

5.1.2 Threatened and Endangered Species

5.1.2.1 Onshore

The main biological effects of seawall construction activities would be disturbance of potential beach habitat for shorebirds and sea turtles in the southern portion of the project area. To limit negative impacts on shorebirds during construction activities, NASA would educate all personnel working in the construction area on recognizing protected species and their likely habitat so that appropriate avoidance and minimization measures can be incorporated into activities.

Piping plover and sea turtle nests have not been documented in this portion of the project area; however, they may nest immediately to the south. If a nest or crawl tracks are found, NASA would consult with USFWS to develop site-specific mitigation measures.

Consistent with the 2010 USFWS BO (Appendix D), NASA would implement the following measures to minimize impacts during the initial phase of the project:

1. NASA would conduct routine surveys and monitoring for listed species and implement measures to avoid potential impacts whenever possible;
2. NASA would conduct surveys and monitoring to determine the effects of the proposed action on listed species and their habitat; and
3. NASA would actively manage habitats and human activity on the beaches to avoid and minimize potential impact on listed species.

To fulfill these measures, NASA would also comply with the following terms and conditions.

1. NASA would fully implement the activities related to listed species in Chapter Five of the SRIPP Draft PEIS: Mitigation and Monitoring Plan (NASA, 2010d) for seawall extension, offshore dredging, and sand placement activities. NASA would produce an annual report summarizing the survey and monitoring efforts, the location and status of all occurrences of recorded protected species, and any additional relevant information. Reports would be submitted to USFWS's Virginia Field Office in digital format at the address provided in the SRIPP BO by December 31 of each year.
2. NASA would develop a training and familiarization program for all personnel conducting construction activities and NASA operations in areas where listed species may occur. This training program would include basic biological information about all listed species and be sufficient to allow personnel to tentatively identify the species and its likely habitat and incorporate appropriate avoidance and minimization measures into their activities.
3. Excavation of sand from the north Wallops Island borrow area for future renourishment would be conducted outside of plover and sea turtle nesting season (March 15 through November 30 or the last date of potential sea turtle hatchling emergence based on when the last eggs were laid). Sand would be stockpiled outside of the north Wallops Island borrow area and outside of potential nesting habitat for plovers and sea turtles prior to placement for renourishment.
4. Once the newly constructed beach is in place, NASA would conduct surveys for injured, dead, or impaired birds and wildlife after launches of rockets that produce an expected sound intensity greater than 150 dB seaward of the dune or seawall. These surveys would

Mitigation and Monitoring

be conducted as soon as possible following launches and within 2 hours of the launch or the first daylight following launch. If surveys cannot be conducted within this period, NASA would place remotely operated video cameras on the beach to document and record responses of plovers and similar birds and any sea turtles. Cameras would be placed a maximum of 100 m (330 ft) apart and extend to the limit of the project area where sound intensity is expected to exceed 150 dB. Surveys for dead, injured, or impaired wildlife would still be conducted as soon as possible following a launch, in addition to the use of cameras. Reports and DVDs would be provided to USFWS within 15 days of each launch event.

5. Concentrations of contaminants (hydrogen chloride, aluminum oxide, and other potentially toxic substances) normally present in rocket exhaust would be measured on the beach closest to the flame trench following launches involving use of solid propellants. Measurements would be taken daily until the levels reach background levels or conservative estimated non-toxic levels of these contaminants for birds, sea turtles, and other wildlife species. This information would be used to determine the typical exposure to contaminants on the beaches over time following a launch. Measurements would be taken, analyzed, and submitted to USFWS for at least the first five launches after the placement of beach and dune adjacent to NASA infrastructure. Reports would be submitted to USFWS's Virginia Field office in digital format within 30 days of each launch event.
6. NASA would report any evidence of potential nesting activity of green sea turtles or leatherback sea turtles on Wallops Island to USFWS's Virginia Field Office within one business day of observing the activity.
7. Care would be taken to preserve biological material of any dead specimens of proposed or listed species found in the best possible state. NASA would also ensure that evidence intrinsic to determining the cause of death of the specimen is not unnecessarily disturbed. Upon locating a dead specimen, NASA would immediately notify USFWS.

Additionally, the sand fencing that would be installed at the toe of the dune would be perpendicular to the shoreline with regular spacing between sections to allow wildlife passage between the dune area and the ocean.

5.1.2.2 *Offshore*

As a requirement of the 2010 NMFS BO (Appendix E), NASA would implement the following measures to minimize impacts of incidental take of sea turtles:

1. NASA would contact NMFS within 3 days before dredging and again within 3 days after completion of dredging. NASA would report to NMFS whether:
 - a. During April 1 through November 30, when sea turtles are known to be present in the project area, hopper dredges are outfitted with state-of-the-art sea turtle deflectors on the drag head and operated in a manner that will reduce the risk of interactions with sea turtles;
 - b. An NMFS-approved observer is on board the vessel for any dredging occurring in the April 1 – November 30 time frame;

- c. All dredges are equipped and operated in a manner that provides endangered/threatened species observers with a reasonable opportunity for detecting interactions with listed species and that provides for handling, collection, and resuscitation of turtles injured during project activities; and
 - d. Measures are taken to protect any turtles that survive entrainment in the dredge.
2. All interactions with listed species would be properly documented and promptly reported to NMFS.

NASA would also ensure that the following terms and conditions are met to minimize and monitor the impact of incidental take:

1. NASA would contact NMFS' Section 7 Coordinator to alert NMFS to the commencement and cessation of dredging activities, to give NMFS an opportunity to provide NASA with any updated contact information or reporting forms, and to provide NMFS with information of any incidents with listed species.
2. If a sea turtle or its parts are taken in dredging operations, the take would be documented on the form included as Appendix H of the BO and submitted to NMFS along with the final report.
3. NASA would contact NMFS within 24 hours of any interactions with sea turtles, including non-lethal and lethal takes. Until alerted otherwise, NASA would contact the Section 7 Coordinator.
4. NASA would ensure that any sea turtles observed during project operations are measured and photographed (including sea turtles or body parts observed at the dredge location or on board the dredge, hopper, or scow) and the corresponding form completed and submitted to NMFS within 24 hours by fax.
5. In the event of any lethal takes of sea turtles, any dead specimens or body parts would be measured, photographed, and preserved (refrigerated or frozen) until disposal procedures are discussed with NMFS.
6. If a dead sea turtle or sea turtle part is taken in dredging operations, a genetic sample would be taken following the procedure outlined in the 2010 NMFS BO.
7. If a decomposed turtle or turtle part is entrained during dredging operations, an incident report would be completed and the specimen would be photographed. Any turtle parts that are considered "not fresh" (i.e., obviously dead prior to the dredge take) would be frozen and transported to a nearby stranding or rehabilitation facility for review. NASA would submit an incident report for the decomposed turtle part, as well as photographs, to NMFS within 24 hours of the take and request concurrence that this take should not be attributed to the Incidental Take Statement. NMFS would have the final authority in determining whether the take should count toward the Incidental Take Statement.
8. Any time that a take occurs, NASA would immediately contact NMFS to review the situation. At that time, NASA would inform NMFS of the amount of material dredged so far and the amount remaining to be dredged during that cycle. Also at that time, NASA and USACE would discuss with NMFS whether any new management measures could be implemented to prevent the total incidental take level from being exceeded.

Mitigation and Monitoring

9. NASA would submit a final report summarizing the results of dredging and any takes of listed species to NMFS within 30 working days of the completion of each dredging contract.
10. If the take estimate for any contract is exceeded, NASA and the USACE would work with NMFS to determine whether the additional take represents new information revealing effects of project activities that may not have been previously considered.

In addition to the above measures required by NMFS, NASA would employ the following:

1. As the NMFS-approved observer would be on board the dredge only from April 1 through November 30, a lookout/bridge watch would be present on the dredge at all times from December 1 through March 31 to alert the captain when a listed whale is spotted within 1 kilometer (km) (0.62 mi) of the dredge. The lookout will be knowledgeable in listed species identification. From April 1 through November 30, the NMFS-approved observer would assume this responsibility.
2. If a NMFS-approved observer or the lookout/bridge watch observes a whale within 1 km (0.62 mi) of the dredge, all pumps would be turned off (i.e., dredging will stop) until the whale leaves the area (i.e., is farther than 1 km [0.62 mi] from the dredge).
3. All dredge operators would be required to monitor the right whale sighting reports (i.e., sighting advisory system, dynamic management areas, seasonal management areas) to remain informed on the whereabouts of right whales in the vicinity of the action area.
4. All dredge operators would conform to the regulations prohibiting the approach of right whales closer than 500 yds (1,500 ft) (50 CFR 224.103 (c)). If a dredge vessel comes within the 500-yd (1,500-ft) buffer zone created by a surfacing whale, it would depart the area immediately at a safe, slow speed.
5. For dredging operations at night, the work area would be lit well enough to ensure that the observer/lookout can perform his/her work safely and effectively and that all mitigation measures can be performed to the extent practicable.
6. NASA would require its dredging contractor to provide information regarding whale sightings. This information would be reported to NMFS' Protected Resources Division Section 7 Coordinator.

In accordance with the ESA, NASA would reinitiate formal consultation with USFWS or NMFS when: 1) the amount of extent of incidental take is exceeded; 2) new information reveals that the agency action may affect listed species or critical habitat in a manner or to an extent not considered in the BO; 3) the action is subsequently modified in a manner that has an effect on the listed species or critical habitat not considered in the BO; or 4) a new species is listed or critical habitat designated that may be affected by the SRIPP. Additionally, in its 2010 BO, USFWS clearly states that any incidental take authorization is only applicable to the initial beach construction and seawall extension. As such, NASA would reinitiate consultation with USFWS for subsequent renourishment cycles. Although the NMFS BO addresses the SRIPP in its 50-year entirety, NASA would continue to coordinate with the agency prior to each renourishment cycle to ensure the BO's validity.

5.1.3 Essential Fish Habitat

Dredging at the proposed borrow sites would be conducted in a manner generally consistent with the recommendations made in two recent MMS publications examining the dredging of offshore shoals in the mid-Atlantic (CSA International, Inc. et al., 2009 and Dibajnia and Nairn, 2010). These recommendations include targeting depocenters for extraction, avoiding active erosional areas, shallow dredging over large areas rather than deep pits, dredging shoals in less than 30 m (98 ft) of water, and avoiding longitudinal dredging over the entire length of shoal.

More specifically, for initial fill:

- NASA would target Shoal A sub-area A-1 (an accretional area) for initial fill. Shoal A sub-area A-2 would only be used during off-nominal conditions;
- Dredging would be uniform over a large area and would not create deep pits;
- Cut depth would not be excessive at approximately 2-3 m (6.6-9.8 ft); and
- Dredging would not occur over the entire length of the shoal.

To stabilize the dune area and reduce borrow requirements (and potential effects on offshore shoals), NASA would plant the dunes with native vegetation and install sand fencing to trap windblown sand.

More detail on NASA's dredging plan is included in Appendix J. NASA would follow the same general dredging guidelines for planning renourishment fill cycles as for initial fill and would consider use of either Shoal A or Shoal B for offshore borrow material. Because specific details on the use of either offshore shoal would be developed in the future once actual renourishment volume requirements are known, NASA would continue to coordinate and consult with NMFS throughout the 50-year life of the SRIPP to avoid and minimize impacts on EFH.

5.1.4 Cultural Resources

It is unknown at this time what methods and exact locations a contractor may use to pump sand from dredge barges to Wallops Island. Because these methods may affect unidentified cultural resources, NASA would consult with VDHR prior to pump-out operations. NASA's contractor would supply NASA with a dredge plan prior to implementation, which NASA would review with VDHR and jointly decide whether further investigation is required and, if warranted, agree on a survey method. If underwater resources are discovered during the survey, they would be reported to VDHR along with a proposed avoidance buffer. VDHR's concurrence with the survey report would conclude the Section 106 process. In the event that previously unrecorded historic properties are discovered during project activities, NASA would stop work in the area and contact VDHR immediately.

If an unanticipated discovery of archaeological resources would occur at either of the offshore shoals within BOEMRE's jurisdiction, the dredge would immediately halt operations within 305 m (1,000 ft) of the area of the discovery. NASA would report the discovery to the Regional Supervisor, Leasing and Environment, Gulf of Mexico Region within 72 hours of discovery. The Regional Supervisor would then inform NASA as to how to proceed.

5.2 MONITORING

NASA would implement a monitoring program that focuses on three areas of the SRIPP; threatened and endangered species, the beach profile, and offshore shoals. The purpose of the monitoring program is to; (1) determine potential impacts to threatened and endangered species from the various components of the program, (2) evaluate the post-construction performance of the seawall extension and beach fill, (3) identify the need for beach renourishment and the quantity of material needed, and (4) assess the bathymetric changes to the sand shoal(s) after dredging.

NASA would ensure that the monitoring program is implemented by appropriately qualified, experienced personnel.

5.2.1 Threatened and Endangered Species

5.2.1.1 *Seawall Extension and Sand Placement*

In addition to complying with USFWS' required mitigation measures, NASA would employ a trained observer to monitor the area daily during when sand placement activities are within Piping Plover or sea turtle nesting season to ensure that impacts are avoided or minimized. When work on the beach overlaps sea turtle or Piping Plover nesting season, daily monitoring would be conducted within the first several hours of sunrise by an observer trained in accordance with NASA's Protected Species Monitoring Plan (NASA, 2010c). Monitoring would occur at least within a 300 m (984 ft) buffer of construction activities during Piping Plover and sea turtle nesting season to ensure Piping Plovers and sea turtles are not directly affected by construction activities. If any Piping Plover or sea turtle nests are detected within the proposed work area, NASA would avoid the area until it has coordinated with USFWS to employ site-specific measures to minimize potential effects.

Potential habitat areas for seabeach amaranth would be surveyed immediately prior to renourishment or sand removal activities at the north end of Wallops Island to ensure that the species is not present. In the event that the seabeach amaranth is encountered during project activities, NASA would work with USFWS to ensure appropriate measures are taken to protect the species and its habitat.

5.2.1.2 *Dredging Operations*

An NMFS-approved observer would be on board the dredging vessel for any dredging occurring between April 1 and November 30. This experienced endangered species observer would monitor dredging operations for evidence of sea turtle takes and would advise the vessel operator to slow the vessel or maneuver safely when sea turtles or marine mammals are spotted to further reduce the potential for interaction with vessels. A lookout/bridge watch would be present on the dredge at all times from December 1 through March 31 to alert the captain when a listed whale is spotted within 1 kilometer (km) (0.62 mi) of the dredge.

5.2.1.3 *North Wallops Island Excavation*

As there is currently a bald eagle nest on north Wallops Island, NASA would survey an area 200 m (660 ft) around the proposed work site to determine the presence of additional nests. If nests are identified, NASA would consult with USFWS and VDGIF to minimize effects.

Additionally, when more specific plans for excavation at the north end of Wallops Island are

known in the future (based on monitoring of the shoreline as described in Chapter 5 of this PEIS), NASA would conduct surveys for other protected species, consult with NMFS, USFWS, and VDGIF, and prepare the appropriate level of NEPA documentation prior to excavation.

5.2.2 Beach Profile

As funding allows, NASA would conduct pre- and semi-annual post-construction monitoring in the designated shoreline monitoring area following the initial beach fill. NASA would conduct combined subaerial (above water) and subaqueous (below water) monitoring surveys along the Wallops Island shoreline.

The objective of the annual beach profile post-construction monitoring program would be to evaluate the post-construction performance of the seawall extension and beach fill project. This evaluation would also be used to identify the need for beach renourishment.

The monitoring program would consist of data collection, including subaerial beach cross-section surveys, subaqueous beach profile surveys, aerial photographs, and storm data summaries. The monitoring program would also compare the post-construction data with the pre-construction data and evaluate the performance of the project.

The horizontal and vertical survey datums would adhere to Virginia State Plane Coordinate System, South Zone, North American Datum 1983/1993 (High Accuracy Reference Network) U.S. Survey Feet and North American Vertical Datum 1988, U.S. Survey Feet, respectively. The vertical accuracy for the survey would be International Hydrographic Organization Order 1 (standards of accuracy recommended for coastal areas with depths up to 100 m [330 ft] and sand or silt bottoms).

Consistent with the SRIPP adaptive management framework, beach profile monitoring protocol could be modified in the future based upon such factors as project performance or changes in technology. Additionally, more specific details regarding the monitoring protocol outlined in this section would be developed by the survey team prior to commencing work.

5.2.2.1 Pre-Construction

NASA would conduct a survey of the pre-construction profile baseline of the expanded project monitoring area. The expanded project monitoring area would be along the lengths of Wallops and Assawoman Islands, starting 0.8 km (0.5 mi) north of Chincoteague Inlet at the north to Gargathy Inlet at the south, a distance of approximately 29 km (18 mi). In the cross-shore direction, the survey elevation data would extend from behind the proposed dune line to seaward of the depth of closure (estimated to be at approximately -4.5 to -6 m (-15 to -20 ft) MLW). Near Chincoteague Inlet the ebb shoal complex creates a large shallow offshore area; therefore, surveys in this area would extend a maximum of 3.2 km (2 mi) offshore if the depth of closure is not reached.

Sufficient control points would be established to cover the entire expanded monitoring area and be able to support future long-term post-construction monitoring program needs. The control points would consist of 72 pipe benchmarks at intervals of 457 m (1,500 ft) along the monitoring baseline. The baseline would be located to maximize the survival of the pipe benchmarks during severe storm events. The benchmarks would be 3.8 cm (1.5 in) galvanized pipes driven into the beach to a depth of about 1.8 m (6 ft) and extending upward above the sand level approximately 0.6 m (2 ft) with a threaded cap on top. Vertical elevation of the tops of the pipes and horizontal

Mitigation and Monitoring

coordinates would be required for the pipe benchmarks. Control point number, elevation data, and horizontal coordinates would be engraved on the threaded cap.

NASA would perform beach cross-section surveys along new and/or previously established baselines on set stations every 152 m (500 ft) from Chincoteague Inlet to Assawoman Inlet and every 305 m (1,000 ft) from Assawoman Inlet to Gargathy Inlet and from Chincoteague Inlet to 0.8 km (0.5 mi) north of Chincoteague Inlet. The beach survey would extend from the baseline, offshore to a depth of -1.5 m (-5 ft) MLW, except in the seawall area where the beach survey would extend from the baseline to the seaward edge of the existing seawall crest. The profile surveys would locate the Mean High Water Level (MHWL) at each profile. Additional “spot shots” would be taken between profiles to locate the MHWL between profiles.

Beach survey data would be processed in Computer-Assisted Design (CAD), Beach Morphology Analysis Package (BMAP), and xyz formats.

To compare the accuracy of LiDAR data to that collected by the more traditional survey methods, NASA would obtain pre-construction LiDAR topographic survey data (subaerial only) provided by a qualified LiDAR survey contractor over the full extended monitoring area. The LiDAR topographic survey would be conducted concurrently with the pre-construction beach profile survey and would encompass the land area from the profile baseline and seaward to include the beach and the seawall. The vertical accuracy for the survey would be International Hydrographic Organization Order 1. The LiDAR survey data would be processed in CAD and xyz formats such that profiles and MHWL location could be established and compared with those established by the land-based survey. Decisions regarding the need for additional LiDAR surveys would be based on this evaluation.

NASA would obtain an initial set of digital geographically referenced color orthophotographs over the full extended monitoring area (29 km [18 mi] +/-). The intent of the orthophotographs would be to supplement the shoreline location between the beach profile survey points and to visually identify changes in the shoreline and beach area. The photographs would be taken at the same time of year that beach profile data would be collected. Aerial targets would be set by NASA at each baseline point prior to the aerial photography flight. The aerial photography flight and data collection would be conducted during mean lower low water as determined by the tidal gauge located at the Chincoteague USCG Station. The scale of the digital photographs would be 1:24,000. Rectified orthophotograph files would be combined with the beach profile files and the hydrographic survey files to create a single survey data file and shoreline change analysis of the entire area. Monitoring program shorelines and shoreline data available from other sources (e.g., NPS, NOAA, and USACE) would be directly imported into a shoreline change program (e.g., U.S. Geological Survey’s Digital Shoreline Analysis System, BMAP, and others) for analysis of patterns and trends.

Profile Comparisons

The USACE’s BMAP within Coastal Engineering and Design Analysis System (CEDAS) would be used for initial profile comparisons and analyses. Once the surveying data are compiled, the new survey profiles developed by combining the beach cross-sections, the offshore hydrographic survey, and the new profiles developed from the LiDAR survey would be overlaid on previous survey profiles, and the proposed authorized template profile to evaluate relative differences. Using BMAP, the following shoreline position and volumetric calculations would be performed:

- Shoreline change at mean high water;
- Shoreline change at the design berm elevation;
- Volume change between overlapping extents of new and previous survey profiles; and
- Volume surplus/deficit between the new survey profiles and the proposed authorized beach fill template.

5.2.2.2 *Post-Construction*

NASA would perform a combined subaerial and subaqueous monitoring survey in the project monitoring area along the lengths of Wallops and Assawoman Islands, starting 0.8 km (0.5 mi) north of Chincoteague Inlet at the north to Gargathy Inlet at the south, a distance of approximately 29 km (18 mi). In the cross-shore direction, the survey elevation data would extend from behind the dune line to seaward of the depth of closure, estimated to be at approximately -4.5 to -6 m (-15 to -20 ft) MLW. Near Chincoteague Inlet, the ebb shoal complex creates a large, shallow, offshore area; therefore, surveys in this area would extend a maximum of 3.2 km (2 mi) offshore if the depth of closure is not reached.

NASA would perform two beach cross-section surveys each year of the post-construction monitoring program. The first survey would likely be a Pre-Winter Survey (i.e., October) and would include beach cross-sections along the previously established baseline on set stations every 152 m (500 ft) from Chincoteague Inlet to Assawoman Inlet and every 305 m (1,000 ft) from Assawoman Inlet to Gargathy Inlet, and from Chincoteague Inlet to 0.8 km (0.5 mi) north of Chincoteague Inlet. This survey would be completed as soon as practicable following completion of the initial beach fill. The second survey would be a Post-Winter Survey (i.e., April) and would include beach cross-sections along the previously established baseline on set stations every 152 m (500 ft) from 0.8 km (0.5 mi) south of the south end of the beach fill placement to 0.8 km (0.5 mi) north of the north end of the beach fill placement. The profile surveys would locate the MHWL at each profile. Additional “spot shots” would be taken between profiles to locate the MHWL between profiles. The beach cross-section surveys would extend from the baseline and offshore to a depth of -1.5 m (-5 ft) MLW. Beach survey data would be processed in CAD, BMAP, and xyz formats.

NASA would perform two offshore hydrographic surveys each year of the monitoring program. The first survey would be a Pre-Winter Survey (i.e., October) and would include hydrographic survey profiles along the previously established baseline on set stations every 152 m (500 ft) from Chincoteague Inlet to Assawoman Inlet and every 305 m (1,000 ft) from Assawoman Inlet to Gargathy Inlet, and from Chincoteague Inlet to 0.8 km (0.5 mi) north of Chincoteague Inlet. The survey would be conducted as soon as practicable following completion of the initial beach fill. The second survey would be a Post-Winter Survey (i.e., April) and would include hydrographic survey profiles along the previously established baseline on set stations every 152 m (500 ft) from 0.8 km (0.5 mi) south of the south end of the beach fill placement to 0.8 km (0.5 mi) north of the north end of the beach fill placement. The hydrographic survey would be conducted using a single-beam echosounder collecting data along transect lines as described above. The offshore survey would extend from -1.2 m (-4 ft) MLW to the depth of closure -4.5 to -6 m (-15 to -20 ft) MLW. If possible (weather permitting), the hydrographic survey would be conducted within 2 weeks of the beach survey. Bathymetric survey data would be processed in CAD, BMAP, and xyz formats.

Mitigation and Monitoring

NASA would obtain two sets of geographically referenced digital color orthophotographs each year of the monitoring program. The first set of photographs would be Pre-Winter photographs (i.e., October) over the full extended monitoring area (0.8 km [0.5 mi] north of Chincoteague Inlet and south to Gargathy Inlet). The second set of photographs obtained would be Post-Winter photographs (i.e., April) over the full extended monitoring area. The photographs would be taken at the same time of year that beach profile data would be collected. Aerial targets would be set at selected baseline points prior to the aerial photography flight. The aerial photography flight and data collection would be conducted during MLW as determined by the tidal gauge located at the Chincoteague USCG Station. The scale of the digital photographs would be 1:24,000. The rectified orthophotograph files would be combined with the beach profile files and the hydrographic survey files to create a single survey data file and shoreline change analysis of the entire area. Monitoring program shorelines and shoreline data available from other sources (e.g., NPS, NOAA, and USACE) would be directly imported into a shoreline change program (e.g., U.S. Geological Survey's Digital Shoreline Analysis System, BMAP, and others) for analysis of patterns and trends.

Profile Comparisons

The BMAP tool of USACE's CEDAS would be used for initial profile comparisons and analyses. Once the surveying data are compiled, the new survey profiles would be overlaid on previous survey profiles and the authorized template profile to show relative differences. Using BMAP, the following shoreline position and volumetric calculations would be performed:

- Shoreline change at mean high water;
- Shoreline change at the design berm elevation;
- Volume change between overlapping extents of new and post-fill survey profiles; and
- Volume surplus/deficit between the new survey profile and the assumed authorized beach fill template.

Storm Data Collection

NASA would collect storm data for each moderate to severe storm event affecting the project. The data would include type of storm, date and duration, wind data from the National Climatic Data Center, tide and surge data, wave data, air temperature and pressure, wind speed and direction, wind gust, and sea surface temperature from the National Data Buoy Center. This data would be collected for all monitoring years and included in an annual summary report and related mapping. Field visits to the project area would also be conducted to evaluate the storm impacts on the project area. Formal subaerial and subaqueous post-storm surveys (comparable to those described above under pre-and post-construction monitoring) would be conducted as practicable.

Shoreline and Volumetric Change

In addition to relative profile comparisons, the shoreline and volumetric change based on three-dimensional surfaces of the study area within a GIS environment would be evaluated. These types of analyses expand on the two-dimensional profile comparisons and are recommended for identifying areas of concern along the shoreline and evaluating sediment transport trends. New

survey data would be incorporated into GIS to allow mapping and further analysis of shoreline and volumetric change. This includes developing a digital terrain model from the new survey data. Shoreline positions would be extracted from the digital terrain model and plotted in GIS for comparison with historical shoreline positions. Additionally, volume change grids would be calculated to plot the morphologic changes in relative survey periods. Color-shaded grids showing areas of erosion and accretion within the nearshore study area would be developed from the three-dimensional comparisons. The pre-construction LiDAR data would be processed and included as part of the analysis.

5.2.2.3 *Project Design Life Analysis*

Based on results of shoreline change and volume analyses, areas of concern in the study area would be identified. The results of the analyses would be used to evaluate performance of the beach nourishment project and to determine maintenance areas for future renourishment.

5.2.2.4 *Monitoring Summary and Mapping*

A report summarizing the data collection, coastal engineering analyses, observed trends from the shoreline change and volumetric change analyses, project design life estimates, identified areas of concern, statement of overall quantity needed to bring the entire beach up to the template, and recommended future work would be prepared semi-annually. The following items would also be included in the summary report:

- Profile comparison plots with summarized results (e.g., shoreline change, volume change)
- Large-scale map(s) showing relative shoreline positions and corresponding shoreline change rates for the reporting period
- Large-scale map(s) showing volumetric change over the study area extent

NASA would share all monitoring results and reporting with resource agencies and any other interested parties. This report would be used to assess the project performance with respect to storm damage protection and sand loss. Replenishment of the sand fill would be needed at intervals that would be determined by the monitoring measurements. When the trends in the volume changes indicate that a minimum fill volume is being approached it would be necessary to plan for such a renourishment operation.

It is expected that the sand placed on the beach would disperse over time to the south, to the north, and offshore. The relative rates of these losses would also be determined from interpretation of the monitoring data. These results would be reviewed in each of the monitoring reports to determine whether project modifications could be developed to reduce the rates of loss or to likewise lower maintenance costs. For example, it may be shown that the dominant net sand transport accounting for the overall fill volume loss is in a longshore direction. Based on the present understanding of the coastal system, once the fill is placed, this net direction could be to either the north or the south. It may be shown that a sand retention structure could be located adjacent to, or nearby, the placement area to help retain the sand or to capture the escaping sand so that it could be episodically returned with appropriate equipment. The monitoring would be used to determine whether such a structure would be effective to the north or south of the fill. If a comparison with the existing project maintenance practice shows that such a structure would be

Mitigation and Monitoring

cost-effective in reducing the need for renourishment sand from the offshore shoals then a modification to the preferred option may be considered. Such a development would require additional NEPA analysis, agency consultation, and permitting.

5.2.3 Offshore Shoals

NASA would provide NMFS pre- and post-borrow bathymetric maps of the dredged areas. The post-borrow survey would be performed soon after dredging was completed, likely not more than 2 weeks after completion of the initial fill phase of the project. NASA would follow standard USACE bathymetric survey procedures as stated in USACE survey manual publication number EM 1110-2-1003 (USACE, 2002). Survey data would be provided to interested resource agencies as soon as practicable thereafter. Future plans for dredging would be based on an assessment of bathymetric changes of the shoals between dredging cycles.

CHAPTER SIX: LIST OF PREPARERS

Name	Education and experience	Areas of Responsibility in EIS
URS		
Shari Silbert	Environmental Scientist, B.S. Chemistry, B.S. Biology, 16 years experience	Wallops Environmental Office Onsite Project Manager, Document Development and Review
Jeffrey Reidenauer	URS Principal Scientist, Ph.D. Biological Oceanography, PWS, CSE, 24 years experience	Project Management, Physical Oceanographic Processes, Bathymetry, Marine Life, EFH
Alan Niedoroda	URS Vice President, PhD. Coastal Processes, 41 years experience	ITR of Geography and Geomorphology, Oceanography and Coastal Processes
Suzanne Richert	URS Senior Scientist, M.S. Soil Science, 10 years experience	Project Management, NEPA Compliance, Social and Economic Environment Sections
Ida Namur	URS Senior Scientist, B.S. Environmental Science, 8 years experience	Biological Environment and Social and Economic Environment Sections
Ashley Kurzweil	URS Environmental Scientist, B.S. Biology, 3 years experience	Various Biological Sections
Sheyna Wisdom	URS Senior Noise Analyst/Biologist, B.S. Biology, M.S. Marine Science, 13 years experience	Marine Mammals
Stephen Robey	URS Senior Scientist, B.S. Resource and Environmental Management, 10 years experience.	Marine Mammals
Lisa Baraff	URS Marine Mammal Biologist, B.A. Human Ecology, M.S. Marine Biology, 28 years experience	Marine Mammals
Angela Chaisson	URS Senior Practice Leader for NEPA/Natural Resources, B.S. Wildlife Resources, CWB, 20 years experience	Independent Technical Reviewer, NEPA Compliance
Janet Frey	URS Senior Environmental Engineer, B.A. Geology, 23 years experience	Independent Technical Reviewer, NEPA Compliance
Jagadish Prakash	URS Senior Urban Planner, M.C.R.P (Masters in City and Regional Planning), 8 years experience	Social and Economic Environment Sections
Mike Kendall	URS Senior Air Program Manager Air Services Group, B.A. Geography, R.S., 26 years regulatory and consulting experience	Air Quality
Sally Atkins	URS Project Scientist, M.A. Environmental Management, 10 years experience	Air Quality
Christopher Ditton	URS Geographical Information Systems, B.S. Geography, 10 years experience	Figures

List of Preparers

Name	Education and experience	Areas of Responsibility in EIS
Ted Hogan	URS Senior Environmental Scientist, M.S. Water Resources Management, 38 years experience	Coastal Vegetation Communities Identification
Christopher Reed	URS Principal Engineer, Ph.D. Engineering Science and Mechanics, 29 years experience	Physical Oceanography, Coastal Engineering
Chris Polglase	URS Principal Archaeologist, M.A. Anthropology, RPA, 25 years experience	Independent Technical Reviewer
JB Pelletier	URS Principal Underwater Archaeologist, M.A. History-Nautical Archaeology, RPA, 23 years experience	Cultural Resources Sections and Remote Sensing Survey
Carrie Albee	URS Principal Architectural Historian, M.A. Architectural History, 12 years experience	Cultural Resources Sections
Valerie Speidel	EG&G Environmental Analyst/Specialist Wallops Environmental Office, M.S. Food Science and Technology, 7 years experience	Independent Technical Reviewer
Susan Patton	URS Principal Technical Editor, M.S. Geology, 22 years experience	Editorial Reviewer
Young Cho	URS Senior Document Control Word Processor, 10 years experience	Formatting
Rob Fernandez	URS Senior Technical Editor, B.S. Journalism/English, 15 years experience	Editorial Reviewer
Ivy Porpotage	URS Senior Technical Editor, BS Chemical Engineering, MFA, Creative Writing, 12 years experience	Editorial Reviewer
NASA		
Paul Bull	Civil Engineer, BS Civil Engineering, Master of Engineering (Civil), P.E., 16 years experience	SRIPP Project Manager, Development of Alternatives, Document review
Joshua Bundick	Environmental Protection Specialist, B.A. Environmental Sciences; 8 years experience	SRIPP PEIS Project Management, Alternatives Screening, Document Review, Biological Resources, Cumulative Impacts
Carolyn Turner	WFF Lead Environmental Engineer, B.S. Geology, MS Environmental Engineering; PG, CHMM, 20 years experience	Document Review
Joel Mitchell	Environmental Engineer, M.S. Environmental Management, 10 years experience	Document Review

List of Preparers

Name	Education and experience	Areas of Responsibility in EIS
BOEMRE		
Geoff Wikel	Oceanographer, M.S. Marine Science, M.P.P. Public Policy, 11 years experience	Document Review
Dirk Herkof	Meteorologist, M.S., B.S. Meteorology, 35 years experience	Air Quality Analysis for Dredging and Beach Fill
USACE		
George Mears	USACE Project Manager, BS Geology, ME, Environmental Engineering; MBA, Management, PMP, 13 years	Project Manager, Resource Scheduling, Planning, Outreach, and SRIPP study/EIS reviews
David King	Oceanographer , Ph.D. Oceanography, 22 years experience	Numerical Modeling and Development of Project Alternatives
Gregg Williams	Project Manager/Civil Engineer, Civil Engineering Technology, B.S., 17 years experience	SRIPP Alternatives Planning and Design
Mark Hudgins	Civil Engineer, B.S. Civil Engineering, M.E. Coastal Engineering, P.E., 23 years experience	Coastal Engineering, SRIPP Planning and Design
Robert Huntoon	Geotechnical Engineer, B.S. Civil Engineering, 5 years experience	Geotechnical Evaluation for Rock Revetment Extension and Potential North End Sand Renourishment Site

This page intentionally left blank.

CHAPTER SEVEN: AGENCIES, ORGANIZATIONS, AND PERSONS CONSULTED

7.1 INTRODUCTION

NEPA states that “There shall be an early and open process for determining the scope of issues to be addressed and for identifying the significant issues related to the proposed action.” Stakeholders and the general public have been engaged as the SRIPP and this EIS developed. Stakeholders include Federal, State and local governments, business interests, landowners, residents, and environmental organizations.

7.2 SCOPING PROCESS

During the SRIPP planning process, NASA provided several opportunities for public and stakeholder involvement, the first of which was a stakeholder and regulatory agency meeting held at WFF on November 20, 2008. On March 24, 2009 NASA announced its intent to prepare an EIS and conduct scoping in the *Federal Register*. NASA sent scoping letters to 71 targeted stakeholders and agencies in April 2009. NASA formally invited the two cooperating agencies (BOEMRE and USACE) to participate in the PEIS process via letters in April, 2009. The public, agencies, and NASA employees were also invited to provide comments on the SRIPP EIS Web site at http://sites.wff.nasa.gov/code250/shoreline_eis.html.

The first public scoping meeting was held on April 21, 2009 at the WFF Visitor’s Center. A public information meeting was also held at the WFF Visitor’s Center on December 8, 2009. The comments received during the initial public scoping were categorized into the topics shown in Table 62 below. A total of 146 comments were received. Multiple recommendations, discussions, or thoughts on the same theme from the same commenter were considered as one comment under that topic. NASA considered all scoping comments in preparing the Draft PEIS.

Table 62: Responses to Scoping by Comment Topic

Comment Topic	No. of Comments
Groin impacts on downdrift islands	26
Relocation of at-risk infrastructure/sea-level rise	19
Miscellaneous recommendation or comment	12
Alternatives	12
Funding	10
More explanation in EIS	10
Impacts on benthos and birds at borrow sites	9
Evaluate baseline conditions	8
Monitoring of effects	7
Impacts on shoreline north of WFF	6
Threshold criteria for project success and evaluation	6
Commercial and recreational fishing	4
Positive comment	4
Regional sediment budget modeling	4
Blackfish Bank shoal	3
Compensation for stakeholder losses	3
Recommended mitigation measures	2
Seawall	1
Total	146

7.3 FISHERIES SURVEY

In April and May 2009, NASA surveyed commercial and recreational fishermen primarily at the ports of Ocean City, MD, Chincoteague, VA, and Wachapreague, VA to assess potential impacts on the fishing industry from SRIPP activities. A total of 66 responses were received during the survey. Thirty-six of the respondents (55 percent) reported fishing within 8 km (5 mi) of one or more of these sites. Of those 36 respondents, 24 (67 percent) said they at least fished Blackfish Bank. Based on the results of the survey, NASA decided to look beyond Blackfish Bank for a source of borrow material.

7.4 WEB SITE

Throughout the duration of the SRIPP NEPA process, NASA has maintained a Web site that provides the public with the most up to date project information. The Web site may be accessed at http://sites.wff.nasa.gov/code250/shoreline_eis.html.

7.5 DRAFT PEIS

The public was notified of the opportunity to review and comment on this Draft SRIPP PEIS by announcements in the *Federal Register* and local newspapers. The Draft PEIS was also available for public review at the following locations:

NASA WFF Technical Library

Building E-105
Wallops Island, VA 23337
(757) 824-1065
Hours: Mon–Fri: 8 a.m. to 4:30 p.m.

NASA Headquarters Library

300 E Street SW, Suite 1J20
Washington, DC VA 20546
(202) 358-0168
Hours: Mon–Fri: 7:30 a.m. to 5:00 p.m.

Eastern Shore Main Public Library

23610 Front Street
P.O. Box 360
Accomac, VA 23301
Phone: (757) 787-3400
Monday, Tuesday, Wednesday, Friday:
9 a.m. to 6 p.m.
Thursday: 9 a.m. to 9 p.m.
Saturday: 9 a.m. to 1 p.m.

Island Library

4077 Main Street
Chincoteague, VA 23336
(757) 336-3460
Hours: Mon: 10 a.m. to 2 p.m.
Tues: 10 a.m. to 5 p.m.
Wed, Fri, Sat: 1 p.m. to 5 p.m.

Northampton Free Library

7745 Seaside Rd
Nassawadox, VA 23413
Phone: (757) 414-0010 (757) 442-2839
Monday, Tuesday, Wednesday, Friday:
9 am - 6 pm
Thursday: 9 am - 9 pm
Friday: 9 am - 6 pm
Saturday: 9 am - 1 pm

Copies of the Draft PEIS were sent directly to 125 stakeholders.

Additionally, NASA held a public comment meeting to discuss the Draft PEIS at the WFF Visitor's Center on March 16, 2010.

All comments received on the Draft PEIS were categorized into the topics shown in Table 63 below. A total of 315 comments were received.

Public comments on the Draft PEIS are included in Appendix L. NASA's responses to comments received on the Draft PEIS are included in Appendix M of this Final PEIS.

Agencies, Organizations, and Persons Consulted

Table 63: Comments by Category Received on Draft PEIS

Comment Topic	No. of Comments
Editorial	34
Alternatives	23
Project Support	21
North Wallops Island Borrow Site	18
Permitting	15
Project Impacts	16
Mitigation and Monitoring - Nesting season	12
Dredging	11
Sea-level Rise	11
Groin or Breakwater	13
Habitat	9
Project Impacts - Shoreline	9
Wildlife	9
Adaptive Management	8
Affected Environment	8
Cumulative Impacts	8
Mitigation and Monitoring - Shoreline	8
Birds	6
Environmental Impacts - Miscellaneous	6
Invertebrates	6
Munitions	6
Cost-Benefit Analysis	5
GENESIS model	5
Mitigation and Monitoring - General	5
Project Design	5
Solid and/or Hazardous Materials/Waste	5
Cultural Resources	4
Mitigation and Monitoring - Wildlife	4
Project Effectiveness	4
Bathymetry	3
Environmental Justice	3
Grain Size	3
Renourishment	3
Air Quality	2
Figures	2
Future NEPA Documentation and Agency Coordination	2
Dredging	1
Environmental Justice	1
Mitigation and Monitoring - Shoals	1
Total	315

7.6 FINAL PEIS

NASA considered all Draft PEIS comments in preparing the Final PEIS. A Notice of Availability will be published in the *Federal Register* and local newspapers to inform the public that the Final PEIS is available for review. A limited number of copies of the Final PEIS are available by contacting:

Joshua A. Bundick
NASA Wallops Flight Facility, Code 250.W
Wallops Island, VA 23337
Phone: (757) 824-2319
Fax: (757) 824-1819
Joshua.A.Bundick@nasa.gov

Copies of the Final PEIS may be reviewed at the locations listed in Section 7.4 above.

Additionally, copies of the Final PEIS have been sent directly to the 143 stakeholders identified in Table 64.

7.7 RECORD OF DECISION

NASA will not render a Record of Decision until at least 30 days following the publication of the U.S. EPA's Notice of Availability of the Final PEIS in the *Federal Register*. The Record of Decision will be available for public review on the project's Web site; copies will be provided upon request.

7.8 SUMMARY

In summary, NASA solicited public and agency review and comment on the environmental impacts of the SRIPP through:

1. Facilitating stakeholder meetings;
2. Surveying recreational and commercial fishermen;
3. Seeking input during the scoping process;
4. Publishing a Notice of Availability of the Draft PEIS in the *Federal Register* and local newspapers;
5. Publishing the Draft PEIS on the project Web site;
6. Directly mailing the Draft PEIS to interested parties;
7. Consulting with local, State, and Federal agencies;
8. Publishing a Notice of Availability of the Final PEIS in the *Federal Register* and local newspapers;
9. Publishing the Final PEIS on the project Web site; and
10. Directly mailing the Final PEIS to interested parties.

Table 64 shows which agencies/stakeholders: (1) received copies of the scoping letter, (2) provided responses to the scoping letters or Web site, (3) received copies of the Draft PEIS, (4) commented on the Draft PEIS, and (5) received copies of the Final PEIS.

This page intentionally left blank.

Table 64: Agencies, Organizations, and Individuals Consulted for the SRIPP PEIS

Name	Organization	Sent a Scoping Letter	Expressed Interest / Commented During Scoping	Sent a Copy of Draft PEIS	Expressed Interest/ Commented on Draft PEIS	Sent a Copy of Final PEIS
Federal Agencies						
Mr. Roger Amato	BOEMRE, Leasing Division	X		X		X
Mr. James Bennett	BOEMRE, Environmental Division	X		X		X
Mr. Dirk Herkhof	BOEMRE, Environmental Division	X		X		X
Mr. Horst Greczmiel	CEQ, Office of NEPA Oversight			X		X
Mr. Willie Taylor	DOI, Office of Environmental Policy and Compliance				X	X
Ms. Susan Bromm	EPA, Office of Federal Activities			X		X
Ms. Alaina DeGeorgio	EPA, Region III		X	X		X
Ms. Renee Searfoss	EPA, Region III	X		X		X
Mr. Jeffrey D. Lapp	EPA, Region III				X	X
Mr. Peter Colosi	NMFS, Protected Resources Division	X		X	X	X
Ms. Julie Crocker	NMFS, Protected Resources Division	X		X		X
Mr. John Nichols	NMFS, Habitat Conservation Division	X	X	X	X	X
Mr. David O'Brien	NMFS, Habitat Conservation Division	X		X		X
Ms Trish Kicklighter	NPS, Assateague Island National Seashore		X	X		X
Ms. Courtney Schupp	NPS, Assateague Island National Seashore	X		X	X	X
Mr. Doug Crawford	NOAA, Command and Data Acquisition Station	X		X		X
Mr. Robert Cole	USACE, Norfolk District	X	X	X		X
Dr. David King	USACE, ERDC Vicksburg	X	X	X		X
Mr. Nicholas Konchuba	USACE, Norfolk District	X		X		X
Mr. George Mears	USACE, Norfolk District	X		X		X
Mr. Christopher Spaur	USACE, Baltimore District					X

Agencies, Organizations, and Persons Consulted

Name	Organization	Sent a Scoping Letter	Expressed Interest / Commented During Scoping	Sent a Copy of Draft PEIS	Expressed Interest/ Commented on Draft PEIS	Sent a Copy of Final PEIS
Mr. John Walters	USCG, Waterways Management Section	X		X		X
LT Mark Merriman	USCG, Chincoteague Group	X		X		X
Mr. Gary LeCain	USGS, Environmental Affairs Program				X	X
Dr. Marilyn Ailes	U.S. Navy, SCSC	X	X	X		X
Mr. Rich Bitting	U.S. Navy, SCSC	X		X		X
CAPT James Boorujy	U.S. Navy, Fleet Forces Command	X		X		X
CDR John Keegan	U.S. Navy, SCSC	X		X		X
Ms. Joelle Buffa	USFWS, CNWR	X		X		X
Ms. Amanda Daisey	USFWS, CNWR	X		X		X
Mr. Louis Hinds, III	USFWS, CNWR	X	X	X		X
Mr. Tony Leger	USFWS, Northeast Regional Office	X		X		X
Mr. Tylan Dean	USFWS, Virginia Field Office	X		X	X	X
Mr. Mike Drummond	USFWS, Virginia Field Office	X		X		X
Ms. Cindy Schulz	USFWS, Virginia Field Office		X	X	X	X
State Agencies						
Ms. Catherine Harold	Chesapeake Bay Local Assistance Department	X		X		X
Mr. Richard Baldwin	MARS	X		X		X
Mr. Keith Tignor	VDACS					X
Ms. Kristal McKelvey	VDCR, Central Office			X		X
Ms. Rene Hypes	VDCR, Central Office			X		X
Mr. Tom Smith	VDCR, Central Office			X		X
Ms. Roberta Rhur	VDCR, Central Office			X		X
Ms. Dorothy Field	VDCR, Eastern Office			X		X
Mr. David Sacks	VDCR, Planning and Recreational Resources			X	X	X
Ms. Alli Baird	VDCR, Coastal Zone Locality Liaison				X	X

Agencies, Organizations, and Persons Consulted

Name	Organization	Sent a Scoping Letter	Expressed Interest / Commented During Scoping	Sent a Copy of Draft PEIS	Expressed Interest/ Commented on Draft PEIS	Sent a Copy of Final PEIS
Mr. Frank Daniel	VDEQ, Tidewater Regional Office	X		X		X
Ms. Cindy Keltner	VDEQ, Tidewater Regional Office			X	X	X
Ms. Ellie Irons	VDEQ, Office of Environmental Impact Review	X	X	X	X	X
Ms. Laura McKay	VDEQ, Coastal Zone Program		X	X		X
Mr. Paul Herman	VDEQ, Federal Facilities Restoration Program			X	X	X
Mr. Kotur Narasimhan	VDEQ, Division of Air Program Coordination			X	X	X
Ms. Cindy Keltner	VDEQ				X	X
Mr. Paul Kohler	VDEQ, Waste Division				X	X
Ms. Ruth Boettcher	VDGIF, Wildlife Diversity Division	X	X	X	X	X
Ms. Amy Ewing	VDGIF, Wildlife Diversity Division			X	X	X
Mr. David Whitehurst	VDGIF, Wildlife Diversity Division			X		X
Mr. Raymond Fernald	VDGIF, Nongame and Environmental Programs		X	X	X	X
Ms. Diedre Forsgren	VDH, Office of Drinking Water			X	X	X
Ms. Ethel Eaton	VDHR, Office of Review and Compliance	X		X		X
Mr. Ronald Grayson	VDHR, Office of Review and Compliance	X		X	X	X
Mr. Matt Heller	VDMME			X		X
Ms. Karen Duhring	VIMS, Center for Coastal Resources Management	X		X	X	X
Ms. Pamela Mason	VIMS, Center for Coastal Resources Management			X		X
Dr. Mark Luckenbach	VIMS, Eastern Shore Laboratory	X		X		X
Mr. Rob O'Reilly	VMRC, Fisheries Management Division			X	X	X
Mr. George Badger, III	VMRC, Habitat Division		X	X	X	X
Mr. Robert Grabb	VMRC, Habitat Division	X		X		X

Agencies, Organizations, and Persons Consulted

Name	Organization	Sent a Scoping Letter	Expressed Interest / Commented During Scoping	Sent a Copy of Draft PEIS	Expressed Interest/ Commented on Draft PEIS	Sent a Copy of Final PEIS
Mr. Mike Meier	VMRC, Habitat Division			X		X
Mr. Tony Watkinson	VMRC, Habitat Division	X		X		X
Local Government						
Mr. Steven Miner	Accomack County Administration	X		X		X
Mr. Grayson Chesser	Accomack County Board of Supervisors	X	X	X	X	X
Mr. Jack Gray	Accomack County Board of Supervisors	X		X		X
Ms. Laura Belle Gordy	Accomack County Board of Supervisors	X		X		X
Ms. Sandra Hart Mears	Accomack County Board of Supervisors	X		X		X
Mr. Donald Hart, Jr.	Accomack County Board of Supervisors	X		X		X
Mr. Stephen Mallette	Accomack County Board of Supervisors	X		X		X
Mr. E. Philip McCaleb	Accomack County Board of Supervisors	X		X		X
Ms. Wanda Thornton	Accomack County Board of Supervisors	X		X		X
Mr. Ronald Wolff	Accomack County Board of Supervisors	X		X		X
Mr. David Fluhart	Accomack County Building and Zoning	X		X	X	X
Ms. Elaine Meil	Accomack-Northampton Planning District Commission			X		X
Mr. Larry Trala	Accomack-Northampton Planning District Commission			X	X	X
Ms. Katherine Nunez	Northampton County Administration	X		X		X
Mayor Michael McDermott	Pocomoke City, Maryland		X	X		X
Mr. James Ring	Somerset County Board of Supervisors	X		X		X
Mr. Robert Ritter	Town of Chincoteague, Virginia	X		X		X
Mayor John Tarr	Town of Chincoteague, Virginia	X		X		X
Mayor William Sessoms, Jr.	City of Virginia Beach			X	X	X
Mayor Molly Joseph Ward	City of Hampton			X	X	X

Agencies, Organizations, and Persons Consulted

Name	Organization	Sent a Scoping Letter	Expressed Interest / Commented During Scoping	Sent a Copy of Draft PEIS	Expressed Interest/ Commented on Draft PEIS	Sent a Copy of Final PEIS
Mr. Richard Pollit	Wicomico County Administration	X		X		X
Ms. Louise Gulyas	Worcester County Board of Supervisors	X		X		X
Other Organizations & Individuals						
Dr. Arthur Schwartzchild	Anheuser Busch Coastal Research Center	X	X	X		X
Ms. Kathy Phillips	Assateague Coastal Trust		X	X	X	X
Mr. Nick Olmstead	BaySys Technologies, Inc.	X		X		X
Mr. Paul Mentz	BMT SYNTEK Technologies, Inc.		X	X		X
Mr. Mike Handforth	Chincoteague Charter Boat Association		X	X		X
Ms. Suzanne Taylor	Chincoteague, Virginia Chamber of Commerce	X		X		X
Mr. Denard Spady	Citizens for a Better Eastern Shore	X		X		X
Mr. Jim Rapp	Delmarva Low Impact Tourism Experiences		X	X		X
Mr. Jeff Davis	Eastern Shore Chamber of Commerce	X		X		X
Mr. Steven Habeger	Eastern Shore Defense Alliance		X	X		X
Ms. Donna Bozza	Eastern Shore of Virginia Tourism Commission	X		X		X
Mr. Billy Moore	Gerald M. Moore and Son, Inc.		X	X		X
Mr. Frank Roberts	Hampton Roads Military and Federal Facilities Alliance		X	X	X	X
Mr. Jack Miles	JH Miles and Company, Inc.			X		X
Ms. Amber Parker	Marine Science Consortium	X		X		X
Mr. Dave Wilson, Jr.	Maryland Coastal Bays Program		X	X		X
Dr. Paul Friesema	Northwestern University			X	X	X
Dr. Michael Fenster	Randolph-Macon College	X		X	X	X
Mr. Duane Gladding	Self			X		X
Mr. Steven Habeger	Self		X	X		X

Agencies, Organizations, and Persons Consulted

Name	Organization	Sent a Scoping Letter	Expressed Interest / Commented During Scoping	Sent a Copy of Draft PEIS	Expressed Interest/ Commented on Draft PEIS	Sent a Copy of Final PEIS
Ms. Cindy Kane	Self			X		X
Mr. Jack Kennedy, Jr.	Self		X	X		X
Mr. Vince Mascitti	Self		X	X		X
Mr. Fred McKee	Self		X	X		X
Mr. Robert Meyers	Self			X		X
Mr. Jim Rapp	Self		X	X		X
Mr. Calvert Seybolt	Self		X	X	X	X
Mr. Stephen Shuhayda	Self			X		X
Mr. Denard Spady	Self		X	X		X
Mr. Marcus Thomas	Self			X		X
Mr. Danhof Vandyke	Self			X		X
Ms. Carole Voss	Self		X	X		X
Mr. Ronald Walsh	Self			X		X
Mr. Jeff Watson	Self		X	X		X
Mr. Lawrence Whitlock	Self		X	X		X
Mr. Don Williams	Self		X	X		X
Ms. Jacqueline Thomas	Self			X	X	X
Mr. Joseph Robbins	Self			X	X	X
Ms. Gwynn Crichton	The Nature Conservancy			X		X
Mr. Joseph Fehrer	The Nature Conservancy					X
Mr. Bill Kittrell	The Nature Conservancy			X		X
Mr. David Phemister	The Nature Conservancy			X		X
Mr. Michael Lipford	The Nature Conservancy, Virginia State Office		X	X	X	X
Mr. Stephen Parker	The Nature Conservancy, Virginia Coast Reserve	X	X	X	X	X

Agencies, Organizations, and Persons Consulted

Name	Organization	Sent a Scoping Letter	Expressed Interest / Commented During Scoping	Sent a Copy of Draft PEIS	Expressed Interest/ Commented on Draft PEIS	Sent a Copy of Final PEIS
Mr. Barry Truitt	The Nature Conservancy, Virginia Coast Reserve	X		X		X
Mr. Randy Fox	Trails End Campground	X		X		X
Dr. Karen J. McGlathery	Virginia Coast Reserve Long-Term Ecological Research Project		X	X		X
Mr. David Burden	Virginia Eastern ShoreKeeper		X	X		X
Federal & State Elected Officials						
Honorable Mr. Glenn Nye	U.S. House of Representatives	X		X		X
Honorable Mr. Benjamin Cardin	U.S. Senate			X		X
Honorable Ms. Barbara Mikulski	U.S. Senate	X		X		X
Honorable Mr. Mark Warner	U.S. Senate	X		X		X
Honorable Mr. James Webb	U.S. Senate	X		X		X
Honorable Mr. Lynwood Lewis, Jr.	Virginia House of Delegates	X		X		X
Honorable Mr. Ralph Northam	Virginia Senate	X		X		X

Agencies, Organizations, and Persons Consulted

This page intentionally left blank.

CHAPTER EIGHT: REFERENCES

- Able, K.W. & M.O. Fahey. 1998. *The First Year in the Life of Estuarine Fishes in the Middle Atlantic Bight*. Rutgers University press, New Brunswick, NJ. 324 pp.
- Accomack County. 2001. Code of Regulations, County of Accomack, VA, Article II: Noise, Sec. 38-32 through 35. <http://www.municode.com/resources/gateway.asp?pid=13191&sid=46>. Site accessed March 9, 2009.
- Accomack County. 2008. Accomack County Comprehensive Plan. Adopted May 14, 2008. http://www.esva.net/~accomack/Planning/2008_comprehensive_plan_update.html. Site accessed January 9, 2010.
- Adams, C.E., T.J. Berger, W.C. Boicourt, J.H. Churchill, M.D. Earle, P. Hamilton, F.M. Vukovich, R.J. Wayland, and D.R. Watts. 1993. A Review of the Physical Oceanography of the Cape Hatteras, North Carolina Region. Volume I: Literature Synthesis. OCS Study MMS 93/0031. Bureau of Ocean Energy Management, Regulation, and Enforcement, Atlantic Outer Continental Shelf Region. 152 p.
- Alexander, R.R., R.J. Stanton, and J.R. Dodd. 1993. Influence of sediment grain size on the burrowing bivalves. *Palaios* 8: 289 – 303.
- Alpine Ocean Seismic Survey, Inc. 2008. Final Report, Vibracore Sampling, Wallops Flight Facility. Prepared for Norfolk USACE. Submitted by Alpine Ocean Seismic Survey, Inc., 70 Oak Street, Norwood, NJ 07648. January 17.
- Baird, R. W. 2001. Status of harbor seals, *Phoca vitulina*, in Canada. *Canadian Journal of Field-Naturalist*. 115: 663-675
- Barlow, P.M., 2003, Ground water in freshwater- saltwater environments of the Atlantic coast: U.S. Geological Survey Circular 1262
- Barco, S. G., W. A. McLellan, J. M. Allen, R. A. Asmutis-Silvia, R. Mallon-Day, E. M. Meagher, D. A. Pabst, J. Robbins, R. E. Seton, W. M. Swingle, M. T. Weinrich and P. J. Clapham. 2002. Population identity of humpback whales (*Megaptera novaeangliae*) in the waters of the U.S. mid-Atlantic states. *Journal of Cetacean Research and Management*. 4(2): 135-141.
- Barr, J. F., C. Eberl, and J. W. McIntyre. 2000. Red-throated Loon (*Gavia stellata*). In *The Birds of North America*, No. 513 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA
- Basco, D. 2006. Shore protection projects. *Coastal Engineering Manual*, Part V: Coastal Project Planning and Design, Chapter V-3, Engineer Manual 1110-2-1100. Washington, DC: U.S. Army Corps of Engineers, Washington, DC.
- Benfield, M.C. and T.J. Minello. 1996. Relative effects of turbidity and light intensity on reactive distance and feeding of an estuarine fish. *Environ. Biol. Fishes* 46:211-216.
- Bergstrom, P. W. 1991. Incubation temperatures of Wilson's plovers and killdeers. *Condor* 91 : 634-641.
- Bindoff, N.L., J. Willebrand, V. Artale, A. Cazenave, J. Gregory, S. Gulev, K.

References

- Hanawa, Le Quéré, S. Levitus, Y. Nojiri, C.K. Shum, L.D. Talley and A. Unnikrishnan, 2007, Observations; oceanic climate change and sea level, *in* Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Avery, M. Tignor and H.L. Miller, eds., *Climate Change 2007: The Physical Science Basis*, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate, Cambridge University Press, Cambridge, United Kingdom and New York, N.Y., USA.
- Boettcher, R., T. Penn, R. Cross and K. Terwilliger. 2007. An overview of the status and distribution of Piping Plovers (*Charadrius melodus*) in Virginia. *Waterbirds* 30 (Special Publication 1):138-151.
- Bordage, D., and J. L. Savard. 1995. Black Scoter (*Melanitta nigra*). In *The Birds of North America*, No. 177 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, D.C.
- Boulva, J. and I. A. McLaren 1979. Biology of the harbor seal, *Phoca vitulina*, in eastern Canadian *Bulletin of Fisheries Research* 200: 1-24.
- Bowman, M.L. and R. Dolan. 1985. The relationship of *Emerita talpoida* to beach characteristics. *Journal of Coastal Research*, 1(2): 151 – 163.
- Brooks, D. A. 1996. Physical Oceanography of the Shelf and Slope Seas from Cape Hatteras to Georges Bank: A Brief Overview. p. 47-74 In K. Sherman, N.A. Jaworski, T.J. Smayda (eds.), *The Northeast Shelf Ecosystem: Assessment, Sustainability, and Management*. Blackwell Science, Cambridge, MA. 564 pp.
- Bryant, Preston L., Jr. The Honorable. 2008. Governor's Commission on Climate Change, Final Report: A Climate Change Action Plan. December.
- Bruun, P. 1962. Sea level rise as cause of shore erosion. *Am. Soc. Civ. Eng. Proc.*, J. Waterways Harbors Div., 88: 117-130.
- Buckley, P. A., and F. G. Buckley. 2002. Royal Tern (*Sterna maxima*). In *The Birds of North America*, No. 700 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
- Buehler, D. A. 2000. Bald Eagle (*Haliaeetus leucocephalus*). In *The Birds of North America*, No. 564 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
- Burger, J. 1987. Physical and social determinations of nest-site selection in piping plover in New Jersey. *The Condor* 89:811-818.
- Burger, J. 1991. Foraging behavior and the effect of human disturbance on the piping plovers (*Charadrius melodus*). *Journal of Coastal Research* 7:39-52.
- Burlas, M., G. L. Ray, & D. Clarke. 2001. The New York District's Biological Monitoring Program for the Atlantic Coast of New Jersey, Asbury Park to Manasquan Section Beach Erosion Control Project. Final Report. U.S. Army Engineer District, New York and U.S. Army Engineer Research and Development Center, Waterways Experiment Station.

- Bustard, R. 1972. Sea Turtles. Natural History and Conservation. Collins London-Sydney 220 pp.
- Butman, C.A. 1987. Larval settlement of soft-sediment invertebrates: The spatial scales explained by active habitat selection and the emerging role of hydrodynamical processes. *Oceanogr. Mar. Biol. Ann. Rev.* 25: 113 – 165.
- Byles, R.A., and C.K. Dodd. 1989. Satellite biotelemetry of loggerhead sea turtles *Caretta caretta* from the east coast of Fla. Proceeding of the 9th Annual Workshop on Sea Turtle Conservation and Biology. National Oceanic and Atmospheric Administration Tech Mem NMFS-SEFC-232.
- Byrnes, M.R., 1988. Holocene Geology and Migration of a Low-Profile Barrier Island System, Metompkin Island, Virginia. PhD Dissertation, Oceanography Department, Old Dominion University, Norfolk, VA, 419 pp.
- Byrnes, M.R., R. M. Hammer, T.D. Thibaut, and D.B Synder. 2004. Effects of sand mining on physical processes and biological communities offshore New Jersey, U.S.A. *J. Coastal Res.*, 20(1): 25 – 43.
- Byrnes, M.R., R.M. Hammer, B.A. Vittor, S.W. Kelley, D.B. Snyder, J.M. Cote, J.S. Ramsey, T.D. Thibaut, N.W. Phillips, and J.D. Wood. 2003. Collection of Environmental Data Within Sand Resource Areas Offshore North Carolina and the Implications of Sand Removal for Coastal and Beach Restoration. U.S. Department of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, Leasing Division, Sand and Gravel Unit, Herndon, VA.
- OCS Report MMS 2000-056, Volume I and Volume II.
- Carr, A.F. 1986. Rips, FADS and little loggerheads. *Bioscience*,36, 92-100.
- CETAP (Cetacean and Turtle Assessment Program). 1982. Characterization of marine mammals and turtles in the Mid- and North Atlantic areas of the U.S. Outer Continental Shelf. Contract AA551-CT8-48 Prepared for U.S. Bureau of Land Management, Washington, D.C. by Cetacean and Turtle Assessment Program, University of Rhode Island, Graduate School of Oceanography, Kingston, Rhode Island.
- Churchill, J.H. 1989. The effect of commercial trawling on sediment resuspension and transport over the Middle Atlantic Bight continental shelf. *Continental Shelf Research*, 9: 841 – 864. Clapham, P.J. and J.G. Mead. 1999. *Megaptera novaeangliae*. *Mammalian Species* 604:1-9.
- Clarke D., C. Dickerson, and K. Reine. 2002. Characterization of Underwater Sounds Produced by Dredges. American Society of Conference Proceedings. 119, 64, DOI:10.1061/40680(2003)64
- Commonwealth of Virginia. 1975. Groundwater Conditions in the Eastern Shore of Virginia, Planning Bulletin 45, State Water Control Board, December 1.
- Conkwright, R.D. and R.A.G. Gast. 1994a. Potential Offshore Sand Resources in Northern Maryland Shoal Fields. Coastal and Estuary Geology File Report No. 94-8. Maryland Geological Survey. September 1994. 48 pp.

References

- Conkwright, R.D. and R.A.G. Gast. 1994b. Potential Offshore Sand Resources in Central Maryland Shoal Fields. Coastal and Estuary Geology File Report No. 94-9. Maryland Geological Survey. September 1994. 49 pp.
- Conkwright, R.D. and R.A.G. Gast. 1995. Potential Offshore Sand Resources in Southern Maryland Shoal Fields. Coastal and Estuary Geology File Report No. 95-4. Maryland Geological Survey. October 1995. 43 pp.
- Conkwright, R.D. and C.P. Williams. 1996. Potential Offshore Sand Resources in Central Maryland Shoal Fields. Coastal and Estuary Geology File Report No. 96-3. Maryland Geological Survey. October 1996. 58 pp.
- Corkeron, P.J. and R.C. Connor. 1999. Why do baleen whales migrate? *Marine Mammal Science*. 15(4):1228-1245.
- Cowardin, L. M., V. Carter, F. C. Golet, E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U. S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. Jamestown, ND: Northern Prairie Wildlife Research Center Home Page. <http://www.npwrc.usgs.gov/resource/1998/classwet/classwet.htm> (Version 04DEC98).
- Crain, D. A., A. B. Bolten, and K. A. Bjorndal. 1995. Effects of beach nourishment on sea turtles: review and research initiatives. *Restoration Ecology* 3(2): 95-104.
- CSA International, Inc., Applied Coastal Research and Engineering, Inc., Barry A. Vittor & Associates, Inc., C.F. Bean, L.L.C., and Florida Institute of Technology. 2009. Analysis of Potential Biological and Physical Impacts of Dredging on Offshore Ridge and Shoal Features. Prepared by CSA International, Inc. in cooperation with Applied Coastal Research and Engineering, Inc., Barry A. Vittor & Associates, Inc., C.F. Bean, L.L.C., and the Florida Institute of Technology for the U.S. Department of the Interior, Minerals Management Service, Leasing Division, Marine Minerals Branch, Herndon, VA. OCS Study MMS 2010-010. 160 pp. + apps.
- Cuthbert, F. J., and L. R. Wires. 1999. Caspian Tern (*Sterna caspia*). In *The Birds of North America*, No. 403 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
- Cutter, G.R., Jr. and R.J. Diaz. 2000. Benthic Resource Mapping and Resource Evaluation of Potential Sand Mining Areas, 1998-1999. In: *Environmental Survey of Potential Sand Resource Sites Offshore Delaware and Maryland* (Virginia Institute of Marine Science, ed.), Part 1. Final Report to the U.S. Department of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, International Activities and Marine Minerals Division, Herndon, VA. Contract No. 1435-01-97-CT-30853. 514 pp.
- Desfosse, J. C., J. A. Musick, A. D. Estes, and P. Lyons. 1990. Stock identification of summer flounder (*Paralichthys dentatus*) in the southern mid-Atlantic Bight. Final Report to Virginia Marine Resources Commission, WB-86-01-02.
- Davis, R., & Dolan, R. 1993. Nor'easters. *American Scientist*, 81(5), 428. Retrieved from Academic Search Premier database.
- Dean, R.G. 2002. Beach Nourishment – Theory and Practice. Advanced Series

- on Ocean Engineering – Volume 18. World Scientific, New Jersey. 399pp.
- Diaz, H. 1980. The mole crab *Emerita talpoida*: A Case of Changing Life History Pattern. *Ecological Monographs*, 50, 437-456.
- Diaz, R.J., G.R. Cutter, Jr. and C.H. Hobbs, III. 2004. Potential impacts of sand mining offshore Maryland and Delaware: Part 2 – Biological considerations. *J. Coastal Res.* 20(1): 61 – 69.
- Diaz, R.J., C.O. Tallent and J.A. Nestlerode. 2006. Benthic Resources and Habitats at the Sandbridge Borrow Area: A Test of Monitoring Protocols. In: MMS OCS Study 2005-056. Field Testing of a Physical/Biological Monitoring Methodology for Offshore Dredging and Mining Operations. Pgs 1 – 49.
- Dibajnia, M. and R.B. Nairn. (*in press*). Investigations of Dredging Guidelines to Maintain and Protect the Geomorphic Integrity of Offshore Ridge and Shoal Regimes. U.S. Department of the Interior, Minerals Management Service. XXX OCS Region. OCS Study MMS 2010-XXX. 150 pp. + appendices.
- Dolan, R., Hayden, B., Jones, C. 1979. Barrier Island Configuration. *Science*. 401-403. DOI: 10.1126. April.
- Dolan, R., H. Lins, and B. Hayden. 1988. Mid-Atlantic coastal storms. *J. Coastal Res.* 4(3): 417 – 433.
- Dolan, R., Sasha Dofflemeyer, Cynthia Donoghue and Jodi Jones Smith. 2004. Analysis of Changes in the Beach Sediment and Beach-face Organisms Associated with Sand Bypassing from Oregon Inlet to Pea Island, North Carolina, 1990 to 2002. Coastal Research Associates, Charlottesville, Virginia.
- Donnelly, C., N. Kraus and M. Larson. 2006. State of knowledge on measurement and modeling of coastal overwash. *Journal of Coastal Research* 22(4): 965-991.
- Eastern Shore Chamber of Commerce. 2007. *Community Economic Development for the Eastern Shore: Summit Report - June 2007*. Prepared by: Virginia Tech Office of Economic Development. <http://www.esvachamber.org/ecoprofile.html>. Site accessed February 3, 2009.
- Eckman, J.E. 1983. Hydrodynamic processes affecting benthic recruitment. *Limnol. Oceanogr.* 28: 241 – 257.
- Edwards, G.A. and L. Irving. 1943. The influence of temperature and season on the oxygen consumption of the sandcrab *Emerita talpoida*. *J. Cellular Comp. Physiol.* 21:169-182.
- Environment Canada. 2006. *Greenhouse Gas Sources and Sinks in Canada*. National Inventory Report. 1990-2004. http://www.ec.gc.ca/pdb/GHG/inventory_report/2004_report/ann13_e.cfm. Site accessed January 13, 2010.
- Environmental Protection Agency (EPA). 1974. *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety*. Prepared by the EPA Office of Noise Abatement and Control. March.
- EPA. 2004. *Aerial Photographic Analysis of NASA Wallops Flight Facility Site, Wallops Island, Virginia*.
- EPA. 2009a. Coastal Sensitivity to Sea-Level Rise: A Focus on the Mid-Atlantic Region. U.S. Climate Change Science Program, Synthesis and Assessment Product 4.1. Lead Agency: U.S. EPA.

References

- Other Key Participating Agencies: U.S. Geological Survey, National Oceanic and Atmospheric Administration.
Contributing Agencies: Department of Transportation. CCSP 4.1 January 15. Final Report.
- EPA. 2009b. Technology Transfer Network Clearinghouse for Inventories & Emissions Factors: Emissions Factors and AP-42.
<http://www.epa.gov/ttnchie1/ap42/>. Site accessed January 13, 2010.
<http://www.epa.gov/ispd/sectorinfo/sectorprofiles/ports/ports-emission-inv-april09.pdf>
- EPA. 2009c. Current Methodologies in Preparing Mobile Source Port-Related Emission Inventories. Final Report. April.
- EPA. 2010. Air and Radiation Web site. National Ambient Air Quality Standards (NAAQS)
<http://www.epa.gov/air/criteria.html>. Site accessed August 24, 2010.
- Erwin, R.M., G.M. Sanders, D.J. Prosser, and D.R. Cahoon. 2006. High tides and rising seas: potential effects on estuarine waterbirds. In: *Terrestrial Vertebrates in Tidal Marshes: Evolution, Ecology, and Conservation* [Greenberg, R. (ed.)]. Studies in avian biology no. 32. Cooper Ornithological Society, Camarillo, CA, pp. 214-228.
- Fauchald, K. and P.A. Jumars. 1979. The diet of worms: a study of polychaete feeding guilds. *Oceanogr. Mar. Biol. Ann. Rev.* 17: 193 – 284.
- Federal Emergency Management Agency (FEMA). 1991. Projected Impact of Relative Sea Level Rise on the National Flood Insurance Program.
http://www.epa.gov/climatechange/effects/downloads/flood_insurance.pdf. October.
- Fenster, M.S., R. Dolan, and R.A. Morton. 2001. Coastal storms and shoreline change: signal or noise? *Journal of Coastal Research*, 12(1): 294 – 310.
- Fenster, M.S., Dolan, R., and Jones-Smith, J., 2008. What grain size distributions reveal about sediment sources and sinks for the Virginia barrier islands. Geological Society of America, Southeastern Section – 57th Annual Meeting.
- Field, M.E., 1979. Sand bodies on Coastal Plain shelves: Holocene record of the U.S. Atlantic inner shelf off Maryland. *Journal of Sedimentary Petrology*, v. 50, no. 2, 505-528.
- Finkelstein, K., 1983, Cape formation as a cause of erosion on adjacent shorelines; Proceedings Coastal Zone '83, American Society of Civil Engineers, 620-640.
- Filadelfo, R.J. 2001. Navy vs. Commercial Ship Traffic- Unclassified Version, Memorandum. Prepared by the Center for Naval Analyses, Alexandria, VA.
- Flemming, S.P., R.D. Chiasson, P.C. Smith, P.J. Austin-Smith, and R.P. Bancroft. 1988. Piping plover status in Nova Scotia related to its reproductive and behavioral responses to human disturbance. *Journal of Field Ornithology* 59(4):321-330.
- Forsell, D. 2003. Special Report on the distribution and abundance of wintering seaducks and waterbirds in Mid-Atlantic Coastal waters emphasizing the mouth of the Chesapeake Bay. U.S. Fish and

- Wildlife Service, Chesapeake Bay Field Office, Annapolis, MD. 10 pp.
- Forsell, D. and C. Watson. 2006. Waterbird Use of Offshore Shoals and Possible Species-specific Impacts of How Shoals are Removed. In: Summary of First Regional Workshop on Dredging, Beach Nourishment, and Birds on the South Atlantic Coast. M. P. Guilfoyle, R. A. Fischer, D. N. Pashley, and C. A. Lott, Eds. USACE ERDC/EL TR-06-10. September.
- Garrison, L.P., P.E. Rosel, A.A. Hohn, R. Baird, and W. Hoggard. 2003. Abundance of the coastal morphotype of bottlenose dolphin *Tursiops truncatus*, in U.S. continental shelf waters between New Jersey and Florida during winter and summer 2002. NMFS/SEFSC report prepared and reviewed for the Bottlenose Dolphin Take Reduction Team. Available from: Southeast Fisheries Science Center, 75 Virginia Beach Dr., Miami, FL 33149.
- Gerstein, E. 2002. Manatees, bioacoustics and boats: Hearing tests, environmental measurements and acoustic phenomena may together explain why boats and animals collide. Feature Article. *American Scientist*. March-April 2002 Volume 90, Number 2. pg 154.
- Gilbert, J. R. and N. Guldager 1998. Status of harbor and gray seal populations in northern New England, NMFS, Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA. NMFS/NER Cooperative Agreement 14-16-009-1557.
- Gochfeld, M. and J. Burger. 1994. Black Skimmer (*Rynchops niger*). In *The Birds of North America*, No. 108 (A. Poole and F. Gill, Eds.). Philadelphia: The Academy of Natural Sciences; Washington, D.C.: The American Ornithologists' Union.
- Gochfeld, M., and J. Burger. 1996. Family Sternidae (Terns). Pp. 624-667 in del Hoyo, J., Elliott, A., & Sargatal, J., eds. *Handbook of the Birds of the World*. Vol. 3. Lynx Edicions, Barcelona.
- Gochfeld, M., J. Burger, and I. C. T. Nisbet. 1998. Roseate Tern (*Sterna dougallii*). In *The Birds of North America*, No. 370 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
- Gordon, R. B., D. C. Rhoads, and K. K. Turekian, 1972. *The Environmental Consequence of Dredge Spoil Disposal in Central Long Island Sound: 1. the New Haven Spoil Ground and New Haven Harbor*. Department of Geology and Geophysics, Yale University. 39 pp.
- Gravens, M. B., Ebersole, B.A., Walton. T.L., and Wise, R.A. 2006. Beach-fill design. *Coastal Engineering Manual, Part V, Coastal Project Planning and Design, Chapter V-4, Engineer Manual 1110-2-1100*. Washington, DC: U.S. Army Corps of Engineers. <http://chl.erdcl.usace.army.mil/chl.aspx?p=s&a=ARTICLES;104>.
- Grippio, M.A., Cooper, S., and Massey, G.M. 2007. Effect of beach renourishment projects on waterbird and shorebird communities. *Journal of Coastal Research*, 23(5), 1088-1096. West Palm Beach (Florida), ISSN 0749-0208.
- Grosslein, M. D., and T. Azarovitz (eds.), 1982. *Ecology of the middle Atlantic Bight fish and shellfish Monograph*

References

15. Fish Distribution. *MESA New York Bight Atlas*. New York Sea Grant Inst., Albany, N.Y.
- Hain, J.H.W., M.J. Ratnaswamy, R.D. Kenney, and H.E. Winn. 1992. The fin whale, *Balaenoptera physalus*, in waters of the northeastern United States continental shelf. Reports of the International Whaling Commission 42:653-669.
- Hansen, J., Sato, M., Kharecha, P., Russell, G., Lea, D.W., and Siddall, M., 2007. Climate change and trace gases: Philosophical Transactions of the Royal Society A, v. 365, p. 1925-1954.
- Hackney, C.T., M.H. Posey, S.W. Ross, and A.R. Norris, eds. 1996. A Review and Synthesis of Data: Surf Zone Fishes and Invertebrates in the South Atlantic Bight and the Potential Impacts from Beach Nourishment. Prepared for U.S. Army Corps of Engineers, Wilmington District, Wilmington, NC.
- Hall, S.J. 1994. Physical disturbance and marine benthic communities: life in unconsolidated sediments. *Oceanogr. Mar. Biol. Ann. Rev.* 32: 179 – 239.
- Halsey, S. D. 1979. New model of barrier island development. In: LEATHERMAN, S.P. (ed.), *Barrier Islands from the Gulf of St. Lawrence to the Gulf of Mexico*, Academic Press, New York. 185–210.
- Hardaway, C.S., Jr., D.A. Milligan, G.R. Thomas, and C.H. Hobbs, III. 1998. Preliminary shoreline adjustments to Dam Neck Beach Nourishment Project, southeast Virginia coast. In: Environmental studies relative to potential sand mining in the vicinity of the City of Virginia Beach, Virginia: Final Report. Virginia Institute of Marine Science, Gloucester Point, VA.
- Harrington, B. A. 2001. Red Knot (*Calidris canutus*). In *The Birds of North America*, No. 563 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
- Harris, M.S. 1992. The Geomorphology of Hog Island, Virginia: A Mid-Atlantic Coast Barrier. MS Thesis. University of Virginia, Charlottesville, Va.
- Hatch, J. J., and D. V. Weseloh. 1999. Double-crested Cormorant (*Phalacrocorax auritus*). In: *The Birds of North America*, No. 441 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
- Hayes, M. O. 1979. Barrier island morphology as a function of wave and tide regime, in Leatherman, S. P. ed., *Barrier islands from the Gulf of St. Lawrence to the Gulf of Mexico*: Academic Press, New York, NY, pp 1-29.
- Hayes, M.O. and R.B. Nairn. 2004. Natural maintenance of sand ridges and linear shoals on the U.S. Gulf and Atlantic continental shelves and the potential impacts of dredging. *Journal of Coastal Research*, 20(1): 138 – 148.
- Herbich, J.B. (ed.). 2000. *Handbook of Dredging Engineering*. The McGraw-Hill Companies. 2nd Edition.
- Hirth, H.F. 1971. Synopsis of biological data on the Green Turtle *Chelonia mydas* (Linnaeus) 1758. *F.A.O. Fish Synop.*, No. 84. Hobbs, C.H. III, Krantz, D.E., Wikel, G.L (unknown) *Coastal Processes and Offshore Geology*. Submitted as a chapter for *The Geology of Virginia*, Chuck Bailey ed.
- Hitchcock, D.R., R.C. Newell, and L.J. Seiderer. 1999. Investigation of benthic and surface plumes associated with marine aggregate mining in the

- United Kingdom, Final Report. U.S. Department of the Interior, Minerals Management Service. MMS OCS Study No. 99-0029. Contract No. 14-35-0001-30763. 163 pp.
- Hobbs III, C.H., C.B. Landry, and J.E. Perry III. 2008. Assessing anthropogenic and natural impacts on ghost crabs (*Ocyropsis quadrata*) at Cape Hatteras National Seashore, North Carolina. *Journal Coastal Research* 24(6): 1450 – 1458.
- Hoebel, A. R., C.W. Potter and P.B. Best. 1998. Genetic differentiation between parapatric ‘nearshore’ and ‘offshore’ populations of the bottlenose dolphin. *Proceedings of the Royal Society of London* 265: 1177-1183.
- Hollister, C.D. 1973. Atlantic continental shelf and slope of the United States - texture of surface sediments from New Jersey to southern Florida: USGS Prof. Pap. 23 p.
- Hopkins, S. R. and J. I. Richardson (eds.). 1984. Recovery plan for marine turtles. Natl. Marine Fish. Serv., Washington, D.C. 355 p.
- Intergovernmental Panel on Climate Change (IPCC). 2001. *Climate change 2001; The scientific basis, contribution of Working Group I to the third assessment report of the Intergovernmental Panel on Climate Change*: Cambridge, England, Cambridge University Press, 944 p. <http://www.ipcc.ch/ipccreports/ar4-wg1.htm>
- IPCC. 2007. *Climate Change 2007; The physical science basis, Contribution of Working Group I to the fourth assessment report of the Intergovernmental Panel on Climate Change*: Cambridge University Press, Cambridge, United Kingdom and New York, N.Y., USA.
- IPCC. 2009. *Climate Change Science Compendium*. United Nations Environment Programme. September.
- IWC (International Whaling Commission). 2001. Report of the Workshop on the Comprehensive Assessment of Right Whales: A worldwide comparison. *Journal of Cetacean Research and Management (Special Issue 2)*:1-60.
- Jefferson, T.A., S. Leatherwood, and M.A. Webber. 1993. *FAO species identification guide. Marine mammals of the world*. Rome, Italy: Food and Agriculture Organization of the United Nations.
- Jehl, J. R., Jr., J. Klima, and R. E. Harris. Short-billed Dowitcher (*Limnodromus griseus*). In *The Birds of North America*, No. 564 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
- Jones & Stokes. 2007. *Addressing Climate Change in NEPA and CEQA Documents*. Updated in August. www.climatechangeofocusgroup.com.
- Kastler, J.A. and P.L. Wiberg. 1996. Sedimentation and boundary changes of Virginia salt marshes. *Estuarine, Coastal, and Shelf Science*, 42(6), 683-700.
- Katona, S. K., V. Rough and D. T. Richardson 1993. *A field guide to whales, porpoises, and seals from Cape Cod to Newfoundland*. Washington, DC, Smithsonian Institution Press. 316 pp.
- Kenney, R.D., M.A.M. Hyman, and H.E. Winn. 1985. Calculation of standing stocks and energetic requirements of the cetaceans of the northeast United States outer continental shelf. NOAA Technical Memorandum NMFS-F/NEC-41:1-99.
- Kenney, R. D. 1990. Bottlenose dolphins off the northeastern United States. Pages

References

- 369-386. In: S. Leatherwood and R. R. Reeves (editors), *The bottlenose dolphin* Academic Press, San Diego, 653 pp.
- Kennett, J.P. 1982. *Marine Geology*. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. 752 p.
- Kikukawa, A., N. Namezaki, K. Hirate, and H. Ota. 1998. Factors affecting nest beach selection by sea turtles: A multivariate approach. In: S. P. Epperly and J. Braun (compilers). *Proceedings of the 17th annual symposium on sea turtles biology and conservation*, 65-66. NOAA Technical Memorandum NMFS-SEFSC-415.
- Kikukawa, A., N. Namezaki, K. Hirate, and H. Ota. 1999. Factors affecting nesting beach selection by loggerhead turtles (*Caretta caretta*): A multivariate approach. *Journal of Zoology* 249: 447-454.
- Knowlton, A.R., J.B. Ring, and B. Russell. 2002. Right whale sightings and survey effort in the mid Atlantic region: migratory corridor, time frame, and proximity to port entrances. Final Rep. to National Marine Fisheries Ship Strike Working Group. 25 p. Available at: <http://www.nero.noaa.gov/shipstrike/midatlanticreportFINAL.pdf>
- Kochel, R.C., Kahn, J., Dolan, R., Hayden, B.P., and May, P. 1985. Mid-Atlantic barrier island geomorphology: *Journal of Coastal Research*, v. 1, p. 1-9.
- Komar, P.D. and Allan, J.C., 2008. Increasing Hurricane-Generated Wave Heights along the U.S. East Coast and their climate controls. *Journal of Coastal Research*, 24(2), 479-488. West Palm Beach (Florida), ISSN 0749-0208.
- Layman, C.A. 2000. Fish assemblage structure of the shallow ocean surf-zone on the eastern shore of Virginia barrier islands. *Estuarine, Coastal and Shelf Science*, 51: 201 – 213.
- Leatherman, S. P. 1982. *Barrier Island Handbook*. University of Maryland, 109 pp.
- Leatherwood, S. and R. R. Reeves 1983. *The Sierra Club handbook of whales and dolphins*. Sierra Club Books, San Francisco. 302 pp.
- Leber, K.M., 1982. Seasonality of macroinvertebrates on a temperate, high wave energy sandy beach. *Bulletin of Marine Science* 32: 86–98.
- Lutcavage, M. and J.A. Musick. 1985. Aspects of the biology of sea turtles in Virginia. *Copeia* 1985; 440-456.
- Lutcavage, M. 1981. The status of marine turtles in Chesapeake Bay and Virginia coastal waters. Masters thesis. Virginia Institute of Marine Science, College of William and Mary at Gloucester Point, Virginia.
- MacWhirter, B., P. Austin-Smith, Jr., and D. Kroodsma. 2002. Sanderling (*Calidris alba*). In *The Birds of North America*, No. 653 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
- Marine Aggregate Levy Sustainability Fund (MALSF). 2009. A generic investigation into noise profiles of marine dredging in relation to the acoustic sensitivity of the marine fauna in UK waters with particular emphasis on aggregate dredging: Phase I Scoping and review of key issues. MEPF Ref No: MEPF 08/P21.

- McIntyre, J. W., and J. F. Barr. 1997. Common Loon (*Gavia immer*). In *The Birds of North America*, No. 313 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists' Union, Washington, D.C.
- McNicholl, M. K., P. E. Lowther, and J. A. Hall. 2001. Forster's Tern (*Sterna forsteri*). In *The Birds of North America*, No. 595 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
- Meylan, A. 1982. Sea turtle migration - evidence from tag returns. In: Bjorndal, K.A. (Ed.). *Biology and Conservation of Sea Turtles*. Washington, DC: Smithsonian Inst. Press, pp. 91-100.
- Mid-Atlantic Regional Spaceport (MARS). 2008. MARS Web site. <http://www.marsspaceport.com/>. Site accessed January 29, 2009.
- McBride, R.A. and Moslow, T.F., 1991. Origin, evolution, and distribution of shoreface sand ridges, Atlantic inner shelf, U.S.A. *Marine Geology*, 97: 57-85.
- McLachlan, A. 1990. Dissipative beaches and macrofaunal communities on exposed intertidal sands. *Journal of Coastal Research* 6: 57 - 71.
- McNicholl, M. K., P. E. Lowther, and J. A. Hall. 2001. Forster's Tern (*Sterna forsteri*). In *The Birds of North America*, No. 595 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
- Melvin, S.M., L.H. MacIvor, and C.R. Griffin. 1992. Predator exclosures: a technique to reduce predation of piping plover nests. *Wildlife Society Bulletin*. 20: 143-148.
- Minerals Management Service (MMS). 1999. Environmental Report, Use of Federal Offshore Sand Resources for Beach and Coastal Restoration in New Jersey, Maryland, Delaware, and Virginia. Prepared by The Louis Berger Group, Inc. November.
- MMS. 2001. Numerical Modeling Evaluation of the Cumulative Physical Effects of Offshore Sand Dredging for Beach Nourishment. Applied Coastal Research and Engineering, Inc. Prepared by Sean W. Kelley, John S. Ramsey, and Mark R. Byrnes. Prepared for U.S. Department of the Interior Bureau of Ocean Energy Management, Regulation, and Enforcement, International Activities and Marine Minerals Division (INTERMAR), Herndon, VA. OCS Report MMS 2001-098, 95 pp. + 106 pp. appendices.
- MMS. 2004. Review of Existing and Emerging Environmentally Friendly Offshore Dredging Technologies. OCS Report MMS 2004-076. Prepared by W.F. Baird & Associates Ltd. and Research Planning, Inc. 441 pp.
- MMS. 2005. Notice to Lessees (NTL) 2005-G07, *Archaeological Resource Surveys and Reports*, and with the Secretary of the Interior's *Standards and Guidelines for Archaeology and Historic Preservation* (Federal Register 48, No 190, 1983).
- Moffatt & Nichol, 1986. Wallops Island Shore Protection Study. NASA/Goddard Space Flight Facility, Wallops Island, Virginia. 72 pp.
- Moffatt & Nichol. 1987. Shore Protection Alternatives, Goddard Space Flight Center, Wallops Island Virginia. Phase

References

- A Report. Final Submittal. Prepared by Moffatt and Nichol, Engineers, 3717 National Drive, Suite 107, Raleigh, North Carolina 27612.
- Moffatt & Nichol. 1989. Study of Wallops Island Seawall Repair Alternatives Phase B. Final Submittal. Presented to National Aeronautics and Space Administration, Goddard Space Flight Center, Wallops Flight Facility, Wallops Island, Virginia. May 3.
- Moffatt & Nichol. 1992. Wallops Island Shoreline Evolution Modeling Study. Prepared for NASA/Goddard Space Flight Center, Wallops Flight Facility, Wallops Island, Virginia. Prepared by Moffatt & Nichol Engineers, 3717 National Drive, Suite 107, Raleigh, North Carolina 27612. May 8.
- Moffatt & Nichol. 1998. Wallops Island Seawall Study, National Aeronautics and Space Administration, Goddard Space Flight Center, Wallops Flight Facility. Purchase Order Number S-80448-Z. Prepared by Moffatt & Nichol Engineers, 2209 Century Drive, Suite 500, Raleigh, North Carolina 27612. August 28.
- Molina, K. C., J. F. Parnell and R. M. Erwin. 2009. Gull-billed Tern (*Sterna nilotica*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: <http://bna.birds.cornell.edu/bna/species/140doi:10.2173/bna.140>
- Moulding, J. and D. Nelson. 1988. Beach nourishment issues related to sea turtle nesting. In: W. Lyke and T. Hoban (compilers). Proceedings of the symposium of coastal water resources. Technical Publication Series TPS-88-1.
- American Water Resources, Bethesda, Maryland, pp. 87-93.
- Mowbray, T. B. 2002. Northern Gannet (*Morus bassanus*). In The Birds of North America, No. 693 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA. In The Birds of North America
- Mullin, K. D. and G. L. Fulling. 2003. Abundance and distribution of cetaceans in the southern U.S. North Atlantic Ocean during summer 1998. Fishery Bulletin, U.S. 101:603-613.
- Musick, J. A. 1974. Seasonal distribution of the sibling hakes, *Urophycis chuss* and *U. tenuis* (Pisces, Gadidae) in New England. Nat. Mar. Fish. Ser. Fish. Bull. 72: 481-495.
- Musick, J. A., J. A. Colvocoresses, E. J. Foell. 1986. Seasonality and distribution, availability and composition of fish assemblages in Chesapeake Bight. Chapter 21, In: A. Yanez y. Arancibia (ed.), Fish Community Ecology in Estuaries and Coastal Lagoons: Towards an Ecosystem Integration. Univ. Mexico Press., Mexico City.
- Nammack, M.F., J.A. Musick, and J.A. Colvocoresses. 1985. Life history of spiny dogfish off the northeastern United States. Transactions of the AFS 114:367-76.
- NASA. 1996. *Environmental Justice Implementation Plan*.
- NASA. 2003a. *EA for AQM-37 Operations at the NASA GSFC WFF, Wallops Island, Virginia*. Prepared by EG&G Technical Services.

- NASA. 2003b. *Cultural Resources Assessment of Wallops Flight Facility, Accomack County, Virginia*. Prepared by URS Group, Inc. and EG&G Technical Services. <http://climate.nasa.gov/uncertainties/>. Site accessed January 7, 2010.
- NASA. 2004. *Historic Resources Survey and Eligibility Report for NASA/WFF*. Prepared by URS Group, Inc. and EG&G Technical Services.
- NASA. 2005. *Final Site-Wide Environmental Assessment, Wallops Flight Facility, Virginia*. Prepared for NASA Goddard Space Flight Center. Prepared by URS-EG&G. January.
- NASA. 2008a. *Environmental Resources Document, Wallops Flight Facility*. July.
- NASA. 2008b. *Environmental Assessment for Wallops Research Park*. August.
- NASA. 2009a. *Final MARS Environmental Assessment, Wallops Flight Facility, Virginia*. Prepared for NASA Goddard Space Flight Center. Prepared by URS-EG&G. August.
- NASA. 2009b. Benthic Video Survey of SRIPP Proposed Borrow Sites Technical Memorandum. Prepared for WFF by URS Corp, Inc. November.
- NASA. 2009c. SRIPP Cultural Resources Study of Proposed Borrow Sites. Prepared for WFF by URS Corp, Inc. November.
- NASA. 2009d. Commercial and Recreational Fisheries Study, Shoreline Restoration and Infrastructure Protection Program at NASA Wallops Flight Facility, Wallops Island, VA. Prepared by URS. May.
- NASA. 2010b. NASA Climate Change: NASA's Eyes on the Earth Web site.
- NASA. 2010c. Wallops Island Protected Species Monitoring Plan. Prepared by URS, Inc. Wallops Environmental Office, Wallops Island, Virginia. April.
- NASA. 2010d. Biological Assessment, Wallops Flight Facility Shoreline Restoration and Infrastructure Protection Program. February.
- NASA. 2010f. Seabeach Amaranth Survey of Wallops Island Shoreline. Conducted by WFF Code 250 Environmental Office.
- Audubon Society. 2010. Important Bird Areas Program Web site. <http://web4.audubon.org/bird/iba/>. Site accessed October 18, 2010.
- National Park Service (NPS). 2003. *Shoreline Restoration at Assateague Island National Seashore*. Betsie Blumberg. http://www.nature.nps.gov/yearinreview/yir2003/06_D.html. Site accessed November 3, 2009.
- National Marine Fisheries Service (NMFS) 1991. Recovery plan for the humpback whale (*Megaptera novaeangliae*). National Marine Fisheries Service, Silver Spring, Maryland 105 pp. http://www.nmfs.noaa.gov/pr/pdfs/recovery/whale_humpback.pdf.
- NMFS. 2004. Endangered Species Act Section 7 Consultation on Dredging of Gulf of Mexico Navigation Channels and Sand Mining ("Borrow") Areas Using Hopper Dredges by COE Galveston, New Orleans, Mobile, and Jacksonville Districts (Consultation Number F/SER/2000/01287), 119 pp.

References

- NMFS. 2005. Endangered Fish and Wildlife; Notice of Intent to Prepare and Environmental Impact Statement. January 11. 70 FR 1871. Web site: Spring Condition by Shelf Subregions. <http://www.nefsc.noaa.gov/omes/OMES/fall2007/adv3.html>. Site accessed September 24, 2009.
- NMFS. 2006a. Draft recovery plan for the fin whale (*Balaenoptera physalus*). Silver Spring, Maryland: National Marine Fisheries Service.
- NMFS. 2006b. Draft recovery plan for the sperm whale (*Physeter macrocephalus*). National Marine Fisheries Service, Silver Spring, MD. http://www.nmfs.noaa.gov/pr/pdfs/recovery/draft_spermwhale.pdf. Site accessed January 9, 2010.
- NMFS. 2007. Endangered Species Act Section 7 Consultation, Biological Opinion. Wallops Island Shoreline Restoration and Infrastructure Protection Program (F/NER/2007/03720). September 25.
- NMFS. 2009. Total Commercial Fishery Landings At Major U. S. Ports Summarized By Year And Ranked By Poundage. http://www.st.nmfs.noaa.gov/pls/webpls/MF_LPORT_YEARP.RESULTS. Site accessed January 9, 2010.
- NMFS. 2010. Incidental Take Authorizations Web site. www.nmfs.noaa.gov/pr/permits/incidental.htm. NOAA Fisheries Office of Protected Resources. Accessed June 15, 2010.
- National Oceanic and Atmospheric Administration (NOAA). 2004. Variations in Sea Level. <http://www.ngs.noaa.gov/GRD/GPS/Projects/CB/SEALEVEL/sealevel.html#record>. Accessed April 15, 2010.
- NOAA Northeast Fisheries Science Center (NEFSC). 2007. Ecosystem Advisory Web site: Spring Condition by Shelf Subregions. <http://www.nefsc.noaa.gov/omes/OMES/fall2007/adv3.html>. Site accessed September 24, 2009.
- NOAA/NMFS. 2008. *FEIS to Implement Vessel Operational Measures to Reduce Ship Strikes to North Atlantic Wright Whales*.
- NOAA, 2009a. *Cetaceans: Whales, Dolphins, and Porpoises*. NOAA Fisheries, Office of Protected Resources. <http://www.nmfs.noaa.gov/pr/species/mammals/cetaceans/>. Site accessed August 5, 2009.
- NOAA, 2009b. *Marine Turtles* NOAA Fisheries, Office of Protected Resources. <http://www.nmfs.noaa.gov/pr/species/turtles/>. Site accessed August 17, 2009.
- NOAA. 2009c. November 11-13 Nor'easter. www.erh.noaa.gov. Site accessed December 28, 2009.
- NOAA Office of Protected Resources. 2009. Shortnose Sturgeon (*Acipenser brevirostrum*) obtained from: <http://www.nmfs.noaa.gov/pr/species/fish/shortnosesturgeon.htm>. Site accessed January 9, 2010.
- NOAA Coastal Services Center. 2010. Beach Nourishment: A Guide for Local Government Officials - Cross-shore and Longshore Transport Models for Large Scale Geological Processes. NOAA Web site. Site accessed June 29, 2010.
- National Research Council (NRC), 1987. Responding to Changes in Sea Level: Engineering Implications. Committee on Engineering Implications of Changes in Relative Mean Sea Level,

- Marine Board, National Research Council. ISBN: 0-309-59575-4, 160 pg.
- NRC. 1995. Environmental issues associated with beach nourishment. In: Beach nourishment and protection. National Academy Press, Washington, D. C., pp. 107-126.
- NRC. 1990. Committee on Sea Turtle Conservation. Decline of seaturtles: causes and prevention. National Academy Press. Washington, D.C. 259 pp.
- NRC. 2003. Ocean Noise and Marine Mammals. The National Academies Press, Washington, D.C. 192 pp.
- Nedwell, J.R., and B. Edwards. 2004. A review of measurements of underwater man-made noise carried out by Subacoustech Ltd, 1993 – 2003. Subacoustic Report Reference: 534R0109. 131 pp.
- Nelson, D.A. and D.D. Dickerson. 1987. Correlation of loggerhead turtle nest digging times with beach sand consistency. Abstract of the 7th Annual Workshop on Sea Turtle Conservation and Biology.
- Nelson, D. A. and D. D. Dickerson. 1988. Effects on beach nourishment on sea turtles. In: Tait, L.S. (compiler) Proceedings of the Fifth Annual National Conservation on Beach Preservation Technology: new directions in beach management, St. Petersburg, Florida. Florida Shore and Beach Preservation Assessment, Tallahassee, Florida.
- Nelson. D.A. 1988. Life history and environmental requirements of loggerhead turtles. US Fish and Wildlife Service, Biological Report 88(23), Washington, DC.
- Nelson, D.A., K. Mauck, and J. Fletemeyer. 1987. Physical effects of beach nourishment on sea turtle nesting, Delray Beach, Florida. Technical Report EL-87-15. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.
- Nelson, W.G. 1985. Physical and Biological Guidelines for Beach Restoration Projects. Part I. Biological Guidelines. Report No. 76. Florida Sea Grant College, Gainesville.
- Nelson, W.G. 1993. Beach restoration in the southeastern US: environmental effects and biological monitoring. *Ocean Coastal Management*, 19:157-182.
- Newell, R.C., L.J. Seiderer, and D.R. Hitchcock, 1998. The impact of dredging works in coastal waters: A review of the sensitivity to disturbance and subsequent recovery of biological resources on the seabed. *Oceanography and Marine Biology Annual Review*, 36: 127-178.
- Nicholls, R.J., P.P. Wong, V.R. Burkett, J.O. Codignotto, J.E. Hay, R.F. McLean, S. Ragoonaden and C.D. Woodroffe, 2007: Coastal systems and low-lying areas. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 315-356.
- Niedoroda, A.W., D.J.P. Swift and J.A. Thorne. 1989. Modeling shelf storm beds: controls of bed thickness and bedding sequence. In: *Shelf*

References

- sedimentation, shelf sequences and related hydrocarbon accumulation, R.A. Mortin & D. Nummedal (eds.) GCSSEPM Foundation, Seventh Annual Research Conference, pp. 15 – 39.
- Nisbet, I. C. T. 2002. Common Tern (*Sterna hirundo*). The Birds of North America, No. 618 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
- Nol, Erica and Robert C. Humphrey. 1994. American Oystercatcher (*Haematopus palliatus*), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Birds of North America Online.
<http://bna.birds.cornell.edu/bna/species/082doi:10.2173/bna.82>.
- Nol, E., and M. S. Blanken. 1999. Semipalmated Plover (*Charadrius semipalmatus*). In The Birds of North America, No. 444 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
- North Atlantic Right Whale Consortium (NARWC) 2009. *Whale Facts*.
<http://www.rightwhaleweb.org/>. Site accessed August 5, 2009.
- Olney, J. and D.M. Bilkovic. 1998. Part 3. Literature Survey of Reproductive Finfish and Ichthyoplankton Present in Proposed Sand Mining Locations within the Middle Atlantic Bight In: Environmental Survey of Potential Sand Resource Sites Offshore Delaware and Maryland (Virginia Institute of Marine Science, ed.), 2000, Final Report to the U.S. Department of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, International Activities and Marine Minerals Division, Herndon, VA. Contract No. 1435-01-97-CT-30853. 514 pp.
- Oertel, G.F. and Kraft, J.C., 1994. New Jersey and Delmarva barrier islands. In: R.A. Davis, Jr. (Editor), Geology of Holocene barrier island systems. Springer-Verlag, Berlin, Federal Republic of Germany, pp. 207-232.
- Oreskes, Naomi. 2004. Beyond The Ivory Tower: The Scientific Consensus on Climate Change. *Science* 306 (5702), 1686. [DOI: 10.1126/science.1103618]. December.
- Palka, D., A. Read and C. Potter 1997. Summary of knowledge of white-sided dolphins (*Lagenorhynchus acutus*) from U.S. and Canadian Atlantic waters. Report of the International Whaling Commission 47: 729-734.
- Palmer, M.A. 1988. Dispersal of marine meiofauna: a review and conceptual model explaining passive transport and active emergence with implications for recruitment. *Mar. Ecol. Prog. Ser.* 48: 81 – 91.
- Parnell, J. F., R. M. Erwin, and K. C. Molina. 1995. Gull-billed Tern (*Sterna nilotica*). In The Birds of North America, No. 140 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia and The American Ornithologists Union, Washington, D.C.
- Payne, P. M. and L. A. Selzer 1989. The distribution, abundance and selected prey of the harbor seal, *Phoca vitulina concolor*, in southern New England. *Marine Mammal Science* 5(2): 173-192.

- Payne, P.M., L.A. Selzer, and A.R. Knowlton. 1984. Distribution and density of cetaceans, marine turtles, and seabirds in the shelf waters of the northeastern United States, June 1980-December 1983, based on shipboard observations. NOAA/NMFS Contract No. NA-81-FA-C-00023. 245 pp.
- Pekala, J.M., 1996, Stratigraphy and geologic history of Anna Maria Island, Manatee County, Florida, unpublished M.S. Thesis: Department of Geology, University of South Florida, 144 p.
- Perry, S.L., D.P. DeMaster, and G.K. Silber. 1999. The great whales: History and status of six species listed as endangered under the U.S. Endangered Species Act of 1973. *Marine Fisheries Review* 61(1):1-74.
- Peterson, C.H., D.H.M. Hickerson, and G.G. Johnson. 2000. Short-term consequences of nourishment and bulldozing on the dominant large invertebrates of a sandy beach. *J. Coastal Res.* 16(2): 368 – 378.
- Peterson, C.H., M.J. Bishop, G.A. Johnson, L.M. D’Anna, and L.M. Manning. 2006. Exploiting beach filling as an unaffordable experiment: benthic intertidal impacts propagating upwards to shorebirds. *J. Exp. Mar. Biol. Ecol.* 338(2006): 205 – 221.
- Phoel, W. C. 1985. Community structure of demersal fishes on the inshore U.S. Atlantic continental shelf: Cape Anna, Massachusetts to Cape Fear, North Carolina. Ph.D. dissertation presented to the School of Marine Science, Virginia Institute of Marine Science, College of William & Mary, 95 pp.
- Posey, M, W Lindberg, T. Alphin and F. Vose. 1996. Influence of storm disturbance on an offshore benthic community. *Bulletin of Marine Science* 59: 523-529.
- Posey, M.H. and T.D. Alphin. 2002. Resilience and stability in an offshore benthic community: responses to sediment borrow activities and hurricane disturbance. *J. Coastal Res.*, 18(4): 685 – 697.
- Rahmstorf, S., 2007, A semi-empirical approach to projecting future sea-level rise: *Science*, v. 315, p. 368-370.
- Rahmstorf, S., Cazenave, A., Church, J.A., Hansen, J.E., Keeling, R. F., Parker, D.E., and Somerville, R.C.J., 2007, Recent climate observations compared to projections: *Science Express*, 10.1126/science.1136843.
- Reeves, R. R., P. J. Clapham, R. L. Brownell, Jr. and G. K. Silber. 1998. Recovery Plan for the blue whale (*Balaenoptera musculus*). Office of Protected Resources, National Marine Fisheries Service, Silver Spring, MD 20910. 39 pp. http://www.nmfs.noaa.gov/pr/pdfs/recovery/whale_blue.pdf
- Reine, K. and D. Clarke. 1998. “Entrainment by hydraulic dredges-A review of potential impacts.” Technical Note DOER-E1. U.S. Army Engineer Research and Development Center, Vicksburg, MS.
- Reilly, F., Jr. and F.J. Bellis. 1983. The ecological impact of beach nourishment with dredged materials on the intertidal zone at Bogue Banks, North Carolina. U.S. Army Corps of Engineers, CERC Misc. Rep. 83-3, 1-74.

References

- Responsive Management. 2000. Boating and Boaters Survey Web site. <http://www.responsivemanagement.com/boating.php>
- Rhoads, D.C. 1974. Organism-sediment relations on the muddy sea floor. *Oceanography and Marine Biology Annual Rev.* 12:263-300.
- Rice, D.W. 1998. Marine mammals of the world: Systematics and distribution. Lawrence, Kansas: Society for Marine Mammalogy.
- Richardson, D. T. 1976. Assessment of harbor and gray seal populations in Maine 1974-1975. Final report to Marine Mammal Commission. Contract No. MM4AC009
- Richardson, W.J., C.R. Greene, Jr., C.I. Malme, and D.H. Thomson. 1995. Marine Mammals and Noise. Academic Press, Inc., San Diego, CA.
- Richardson, T.M. and McBride, R.A. 2007. Historical Shoreline Changes and Morphodynamics of Parramore Island, Virginia (1852-2006). Proceedings, Coastal Sediments '07, American Society of Civil Engineers, New Orleans, Louisiana.
- Rooth, J.E., Stevenson, J.C., Cornwell, J.C., 2003. Increased sediment accretion rates following invasion by *Phragmites australis*: the role of litter. *Estuaries* 26, 475-483.
- Rumbold, D. G., P. W. Davis, and C. Perretta. 2001. Estimating the effect of beach nourishment on *Caretta caretta* (loggerhead sea turtle) nesting. *Restoration Ecology* 9(3): 304-310.
- Ryder, C. E. 1993. The effect of beach renourishment on sea turtle nesting and hatching success at Sebastian Inlet State Recreation Area East-Central, Florida. M. S. thesis, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, pp. 103.
- Scharle, B. 2009. Personal communication regarding USDA Wildlife Service Piping Plover Surveys on Wallops Island. July 23. Cited in NASA (2009) Final Biological Assessment for Proposed and Ongoing Orbital Launch Operations at Wallops Flight Facility. August.
- Schwartz, M. 2005. Encyclopedia of Coastal Science (Encyclopedia of Earth Sciences Series). M. Schwartz Editor. Springer Netherlands. pp. 352.
- Schneider, D. C. and P. M. Payne 1983. Factors affecting haul-out of harbor seals at a site in southeastern Massachusetts. *Journal of Mammalogy* 64(3): 518-520.
- Shepard, F. P. and Wanless, H.R. 1971. Our Changing Coastlines. McGraw-Hill, N.Y., 579 pps.
- Sherman, K., M. Grosslein, D. Mountain, D. Busch, J. O'Reilly, and R. Theroux. 1996. The Northeast shelf ecosystem: an initial perspective. pp. 103 – 126 in: K. Sherman, N.A. Jaworski, and T.J. Smayda, (eds.). *The Northeast Shelf Ecosystem: Assessment, Sustainability, and Management*. Blackwell Science, Cambridge, MA.
- Shields, M. 2002. Brown Pelican (*Pelecanus occidentalis*). In *The Birds of North America*, No. 609 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.
- Shoop, C.R. and R.D. Kenney. 1992. Swason distributions and abundance of loggerhead and leatherback sea turtles in waters of the northeastern United States. *Herp. Mongraphs* 6:43-67.
- Shortal, J. A. 1978. A new dimension: Wallops Island flight test range—the first

- fifteen years *NASA Reference Publication 1028*.
- Slacum, Jr., H.W., W.H. Burton, E.T. Methratta, E.D. Weber, R.J. Lanso, & J. Dew-Baxter. (*in press*). Assemblage Structure in Shoal and Flat-bottom Habitats on the Inner Continental Shelf of the Middle Atlantic Bight, U.S.A. Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science.
- Slacum, H.W. Jr., W.H. Burton, J.H. Vølstad, J. Dew, E. Weber, R. Llansó, and D. Wong. 2006. Comparisons Between Marine Communities Residing on Sand Shoals and Uniform-bottom Substrate in the Mid-Atlantic Bight. Final Report to the U.S. Department of the Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, International Activities and Marine Minerals Division, Herndon, VA. OCS Report MMS 2005-042, 149 pp. + app.
- Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene, Jr., D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas, and P.L. Tyack. 2007. Marine mammal noise exposure criteria: Initial scientific recommendations. *Aquatic Mammals*, Special Issue 33.
- Steinitz, M. J., M. Salmon, and J. Wyneken. 1998. Beach renourishment and loggerhead turtle reproduction: a seven year study at Jupiter Island, Florida. *Journal of Coastal Research* 14(3): 1000-1013.
- Stern, S.J. 2002. Migration and movement patterns. Pages 742-748 in Perrin, W.F., B. Würsig, and J.G.M. Thewissen, eds. *Encyclopedia of marine mammals*. San Diego, California: Academic Press.
- Stevick, P.T., J. Allen, P.J. Clapham, N. Friday, S.K. Katona, F. Larsen, J. Lien, D.K. Mattila, P.J. Palsbøll, J. Sigurjónsson, T.D. Smith, N. Øien, and P.S. Hammond. 2003. North Atlantic humpback whale abundance and rate of increase four decades after protection from whaling. *Marine Ecology Progress Series* 258: 263 - 273.
- Strange, E.M. 2008d. The Atlantic side of the Virginia eastern shore. Section 3.9 in: *Background Documents Supporting Climate Change Science Program Synthesis and Assessment Product 4.1: Coastal Elevations and Sensitivity to Sea Level Rise* [Titus, J.G. and E.M. Strange (eds.)]. EPA 430R07004. U.S. Environmental Protection Agency, Washington, DC, pp. 258-261. <http://epa.gov/climatechange/effects/coastal/background.html>
- Swift, D.J.P. and M.E. Field. 1981. Evolution of a classic sand ridge field: Maryland sector, North American inner shelf. *Sedimentology* 28: 461 – 482.
- Tedesco, Kathy, Richard A. Feely, Christopher L. Sabine and Catherine E. Cosca. 2005. *Impacts of Anthropogenic CO₂ on Ocean Chemistry and Biology*. National Oceanographic and Atmospheric Administration Research. Archive of Spotlight Feature Articles. October 3. http://www.research.noaa.gov/spotlite/spot_gcc.html. Site accessed August 22, 2010.
- The Local Fisherman. 2009. Fishing Chincoteague Inlet. <http://www.thelocalfisherman.com/fishing-chincoteague-inlet/>. Site accessed 12/28/2009.

References

- The Nature Conservancy. 1995. USGS-NPS Vegetation Mapping Program. Vegetation Classification of Assateague Island National Seashore. November 14.
- Theroux, R.B. and R.L. Wigley. 1998. Quantitative composition and distribution of the macrobenthic invertebrate fauna of the continental shelf ecosystems of the northeastern United States. NOAA Technical Report NMFS 140.
- Thompson, B. C., J. A. Jackson, J. Burger, L. A. Hill, E. M. Kirsch, and J. L. Atwood. 1997. Least Tern (*Sterna antillarum*). In *The Birds of North America*, No. 290 (A. Poole and F. Gill, eds.). The Academy of Natural Sciences, Philadelphia, PA, and The American Ornithologists™ Union, Washington, D.C.
- Torres, L. G., P. E. Rosel, C. D'Agrosa and A. J. Read. 2003. Improving management of overlapping bottlenose dolphin ecotypes through spatial analysis and genetics. *Marine Mammal Science* 19:502-514.
- Town of Chincoteague. 2009. Town of Chincoteague Comprehensive Plan. April.
- U.S. Army Corps of Engineers (USACE). 1992. Final Feasibility Report and Environmental Assessment Sandbridge, Virginia Beach, Virginia. USACE, Norfolk District.
- USACE. 1994. Beach Erosion Control and Hurricane Protection Study, Virginia Beach, Virginia - General Reevaluation Report, Main Report, Environmental Assessment, and Appendices. Norfolk District.
- USACE. 1998. Ocean City, Maryland and vicinity water resources study. Final feasibility and environmental impact statement with appendices. USACE, Baltimore District, Baltimore, MD. xx pp.
- USACE. 2002. Coastal Engineering Manual. Engineer Manual 1110-2-1100, U.S. Army Corps of Engineers, Washington, D.C. (in 6 volumes). <http://140.194.76.129/publications/eng-manuals/>.
- USACE. 2004. Regional Sediment Management (RSM) Demonstration Program. ERDC/RSM-TN-14, September 2004. Coastal Overwash Part 1: Overview of Processes. U.S. Army Corps of Engineers Engineer Research and Development Center.
- USACE. 2006. Beach Erosion Mitigation and Sediment Management Alternatives at Wallops Island, VA. Prepared by Andrew Morang, Gregory G. Williams, and Jerry W. Swean. September. Coastal and Hydraulics Laboratory ERDC/CHL TR-06-21.
- USACE. 2007. Focused Archive Search Report, Ordnance and Explosives Impact areas and Chemical Warfare Materials Ocean Dump Sites off Wallops Island, Accomack County, Virginia. USACE St Louis District. January.
- USACE. 2008. Atlantic Coast of Maryland Shoreline Protection Project Final Supplemental Environmental Impact Statement General Reevaluation Study: Borrow Sources for 2010-2044. August.
- USACE. 2009a. North End Sand Borrow Site, NASA Wallops Flight Facility,

- Wallops Island, Virginia. Report of Subsurface Exploration and Laboratory Testing. Prepared by USACE Norfolk District, Geo Environmental Section, Fort Norfolk, 803 Front Street, Norfolk, VA 23510. November.
- USACE. 2009b. Environmental Assessment, Sandbridge Beach Erosion Control and hurricane protection project, Virginia Beach, Virginia.
- USACE. 2009c. Sea Turtle Data Warehouse 2009.
<http://el.erdc.usace.army.mil/seaturtles/>. Site accessed November 11, 2009.
- USACE. 2009d. Water Resource Policies and Authorities Incorporating Sea-Level Change Considerations in Civil Works Programs. EC 1165-2-211. Circular No. 1165-2-211. July.
- USACE. 2010a. Storm Damage Reduction Project Design for Wallops Island. USACE, Engineer Research and Development Center. Prepared by D.B. King, Jr., D.L. Ward, M.H. Hudgins & G.G. Williams. ERDC/LAB TR-0X-X. November.
- USACE. 2010b. Coastal and Hydraulics Laboratory Wave Information Studies Web site.
<http://chl.erdc.usace.army.mil/wis>. Site accessed January 9, 2010.
- U.S. Census Bureau. 2000. Chincoteague Zip Code.
<http://factfinder.census.gov/servlet/> Accessed January 29, 2009.
- U.S. Census Bureau. 2008a. State & County QuickFacts. Accomack County.
<http://quickfacts.census.gov/qfd/states/51000.html>. Site accessed August 3, 2009.
- U.S. Census Bureau. 2008b. Populations Estimate Program. Virginia Population Estimate.
<http://factfinder.census.gov/servlet/>. Accessed August 3, 2009.
- U.S. Census Bureau. 2010. State and County QuickFacts. Web site last Revised: Monday, 16-Aug-2010.
<http://quickfacts.census.gov/qfd/states/51/51001.html>. Site accessed August 24, 2010.
- U.S. Coast Guard (USCG). 2009a. Navigation Rules Online Web site.
http://www.navcen.uscg.gov/mwv/navrules/rotr_online.htm. Site accessed December 17, 2009.
- USCG. 2009b. Private Aids to Navigation.
<http://www.uscg.mil/D11/DP/PatonOnline.asp>. Site accessed December 30, 2009.
- U.S. Department of Agriculture (USDA). 1994. *Accomack County Soils Description and Preliminary Soils Map, Accomack County, Virginia*. Accomack County Soil Conservation Service. November.
- U.S. Department of the Navy. 2009. VACAPES Range Complex Final Environmental Impact Statement/Overseas EIS. March.
- U.S. Fish and Wildlife Service (USFWS). 2007. Designated National Wild and Scenic Rivers.
<http://www.rivers.gov/wildriverslist.html>. Site accessed August 14, 2009.
- USFWS. 2008. Federally Endangered, Threatened, Proposed and Candidate Species, Accomack county, Virginia. Virginia Field Office. September 24.

References

- USFWS. 2009a. Questions and Answers: Double Crested Cormorant Management. <http://www.fws.gov/migratorybirds/CurrentBirdIssues/Management/cormorant/FinalRule/Q&As2003.htm>. Site accessed September 11, 2009.
- USFWS. 2009b. Other Critters of Chincoteague National Wildlife Refuge. <http://www.fws.gov/northeast/chinco/othercritters.html>. Site accessed August 14, 2009
- USFWS. 2010a. Chincoteague National Wildlife Refuge Endangered Species, Federally Listed Species Web site. <http://www.fws.gov/northeast/chinco/endangeredspecies.html>. Site accessed October 18, 2010.
- Vasslides, J.M. and K.W. Able. 2008. Importance of shoreface sand ridges as habitat for fishes off the northeast coast of the United States. *Fish. Bull.* 106: 98 – 107.
- VDEQ. 2008a. Coastal Zone Management Program. <http://www.deq.virginia.gov/coastal/laws/pols.html>. Site accessed August 7, 2009.
- VDEQ. 2008b. Air Regulations Web site. Ambient Air Quality Standards, Chapter 30. <http://www.deq.state.va.us/air/regulations/air30.html>. Site accessed March 12, 2009.
- VDEQ. 2009. State Water Control Board. 9 VAC 25-260 Virginia Water Quality Standards. Statutory Authority: § 62.1-44.15 3a of the Code of Virginia. With Amendments Effective August 20, 2009. <http://www.deq.state.va.us/wqs/download.html>. Site accessed December 13, 2009.
- Virginia Department of Game and Inland Fisheries (VDGIF). No Date. Sea Turtles in Virginia. http://www.dgif.virginia.gov/habitat/landowners/infosheets/sea_turtles.pdf. Site accessed November 17, 2009.
- VDGIF. 2005. Virginia's Comprehensive Wildlife Conservation Strategy. <http://bewildvirginia.org/wildlife-action-plan/front-matter.pdf>. Site accessed October 18, 2010.
- VDGIF. 2009. Threatened, Endangered, and Special Concern Species. <http://www.dgif.virginia.gov/wildlife/virginiatescspecies.pdf>. Site accessed September 16, 2009.
- VDGIF. 2010. Species of Greatest Conservation Need. <http://bewildvirginia.org/species/>. Site Accessed September 30, 2010.
- Virginia Employment Commission (VEC). 2009a. VEC Web Site. Virginia Statewide Workforce Connection Labor Market Information. Released September 2009. <http://www.vawc.virginia.gov/lmi/area/areaprofiledata.asp?session=areadetail&geo=5101000000>. Site accessed October 28, 2009.
- VEC. 2009b. VEC Web Site. Accomack County, Virginia Workforce Connection Labor Market Information. Released September 2009. <http://www.vawc.virginia.gov/lmi/area/areaprofiledata.asp?session=areadetail&geo=5104000001>. Site accessed October 28, 2009.

- Virginia Institute of Marine Science (VIMS). 2006. Field testing of a physical/biological monitoring methodology for offshore dredging and mining operations. Prepared for MMS. OCS Study MMS 2006-056. 429 pp.
- VIMS. No Date. Submerged Aquatic Vegetation (SAV) in Chesapeake Bay. <http://web.vims.edu/bio/sav/AboutSAV.html>. Site accessed 8/14/2009.
- Viscido, S.V., D.E. Stearns, and K.W. Able. 1997. Seasonal and spatial pattern of an epibenthic decapod crustacean assemblage in north-west Atlantic continental shelf waters. *Estuarine, Coastal and Shelf Science* 45: 377 - 392.
- Waring, G. T., C. P. Fairfield, C. M. Ruhsam and M. Sano 1992. Cetaceans associated with Gulf Stream Features off the Northeastern USA Shelf. ICES [Int. Counc. Explor. Sea] C.M. 1992/N:12.
- Waring G.T., E. Josephson, C.P. Fairfield, and K. Maze-Foley (eds). 2007. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments — 2007. NOAA Tech Memo NMFS NE 205. 415 p. <http://www.nefsc.noaa.gov/nefsc/publications/tm/tm205/>
- Waring G.T., E. Josephson, C.P. Fairfield, and K. Maze-Foley (eds). 2009. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments — 2008. NOAA Tech Memo NMFS NE 210. 440 p. <http://www.nefsc.noaa.gov/publications/tm/tm210/>
- Waring, G.T., J. M. Quintal, and C.P. Fairfield (eds). 2002. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments — 2002. NOAA Tech Memo NMFS NE 169. 328 p. <http://www.nmfs.noaa.gov/pr/pdfs/sars/ao2002.pdf>.
- Watts, B. D. and B. R. Truitt. 2000. Abundance of shorebirds along the Virginia Barrier Islands during spring migration. *Raven* 71:33–39.
- Welty, J.C. 1982. The life of birds. Saunders College Publishing, Philadelphia, Pennsylvania. 754pp.
- Weston, D.P. 1988. Macrobenthos-sediment relationships on the continental shelf off Cape Hatteras, North Carolina. *Cont. Shelf Res.* 8(3): 267 – 286.
- W.F. Baird and Associates, Ltd. 2004. Development of the MMS Dredge Plume Model. Prepared for Leasing Division, Sand and Gravel Unit, Bureau of Ocean Energy Management, Regulation, and Enforcement, 114 pp.
- White, C. M., N. J. Clum, T. J. Cade, and W. G. Hunt. 2002. Peregrine Falcon (*Falco peregrinus*). In *The Birds of North America* No. 660 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA. Accessed on August 18, 2009 from http://www.allaboutbirds.org/guide/Peregrine_Falcon/lifehistory
- Whitman, A. A. and P. M. Payne 1990. Age of harbour seals, *Phoca vitulina concolor*, wintering in southern New England. *Can. Field-Nat.* 104(4): 579-582.
- Wigley, R.L. and R.B. Theroux, 1981. Atlantic Continental Shelf and Slope of the United States—Macrobenthic Invertebrate Fauna of the Middle Atlantic Bight Region—Faunal Composition and Quantitative Distribution. U.S. Geological Survey Professional Paper 529-N. 198 pp.

References

- Wikel, G.L. 2008. Variability in Geologic Framework and Shoreline Change: Assateague and Wallops Islands, Eastern Shore of Virginia. M.S. Thesis. The College of William and Mary in Virginia. 210 pp.
- Wilber, P. and M. Stern. 1992. A re-examination of infaunal studies that accompany beach renourishment studies. pp. 242-257 in *New Directions in Beach Management. Proceedings of the 5th Annual National Conference on Beach Preservation Technology*. The Florida Shore and Beach Preservation Association, Tallahassee, FL.
- Wilber, D.H., D.G. Clarke, G.L. Ray, and M. Burlas. 2003. Response of surf zone fish to beach nourishment operations on the northern coast of New Jersey, U.S.A. *Marine Ecology Progress Series*, 250: 231 – 246.
- Wilke, A.L., D.F. Brinker, B.D. Watts, A.H. Traut, R. Boettcher, J.M. McCann, B.R. Truitt and P. Denmon. 2007. American Oystercatchers in Maryland and Virginia: status and distribution. *Waterbirds* 30 (Special publication 1):152-162.
- Wilke, A.L., R. Boettcher and C. Smith. 2009. 2008 Piping Plover, Wilson's Plover and American Oystercatcher Breeding Status in Virginia. Final Report submitted to the Virginia Department of Conservation and Recreation Division of Natural Heritage, Nassawadox, VA. 23 Pp.
- Winn, H.E., C.A. Price, and P.W. Sorensen. 1986. The distributional biology of the right whale (*Eubalaena glacialis*) in the western North Atlantic. Reports of the International Whaling Commission (Special Issue 10):129-138.
- Witherington, B. E. 1992. Behavioral response of nesting turtles to artificial lighting. *Herpetologica* 48: 31-39.
- Witherington, B.E., and R. Erik Martin, 1996. Understanding, Assessing and Resolving Light Pollution Problems on Sea Turtle Nesting Beaches. Florida Marine Research Institute Technical Report. St. Petersburg, Fla.: Florida Marine Research Institute.
- Wood, D. W. and K. A. Bjorndal. 2000. Relation of temperature, moisture, salinity, and slope to nest site selection in loggerhead sea turtles. *Copeia* 1: 119-128.
- Wynne, K and Schwartz, M. 1999. *Guide to Marine Mammals & Turtles of the U.S. Atlantic & Gulf of Mexico*. Rhode Island Seagrant.
- Zajac, R.N., R.B. Whitlatch, and S.F. Thrush. 1998. Recolonization and succession in soft-sediment infaunal communities: the spatial scale of controlling factors. *Hydrobiologia* 375/376: 227 – 240.
- Zarillo, G., J. Reidenauer, K. Zarillo, T. Shinsky, E. Reyier, M. Barkaszi, J. Shenker, M. Verdugo, and N. Hodges. 2008. Biological Characterization/Numerical Wave Model Analysis within Borrow Sites Offshore West Florida Coast. U.S. Department of Interior, Bureau of Ocean Energy Management, Regulation, and Enforcement, MMS 2008-005. Volume 1: Main Text 224 pp & Volume II: Appendices 300 pp.
- Zervas, C. 2001. Sea Level Variations of the United States 1854-1999: NOAA Technical Report NOS CO-OPS 36, 201 p.

- <http://tidesandcurrents.noaa.gov/publications/techrpt36doc.pdf>.
- Zervas, C. 2004. North Carolina Bathymetry/Topography Sea Level Rise Project; Determination of Sea Level Trends: NOAA Technical Report NOS CO-OPS 41, 31 p.
<http://tidesandcurrents.noaa.gov/publications/techrpt41.pdf>.
- Zhang, Keqi, Bruce C. Douglas, Stephen P. Leatherman. 2000. Twentieth-Century Storm Activity along the U.S. East Coast. *American Meteorological Society Journal of Climate*: 1748, Vol. 13. May 15.
- Personal Communication*
- Ballou, Thomas (VDEQ). 2010. Email to Sally Atkins (URS Corporation) regarding State Implementation Plan question and air quality emissions data for Accomack County, VA. August 23, 2010, 3:21 p.m.
- Herkhof, Dirk. 2009. Email to Joshua A. Bundick. December 15, 2009, 4:13 p.m.
- Mitchell, Joel. 2009. Email regarding coordinates for Piping Plover nesting sites on Wallops Island.
- Pittman, Thomas. 2010. Email to Josh Bundick regarding costs associated with various WFF activities. May 26, 10:25 a.m.
- Reed, Billie. 2009. E-mail with Joshua Bundick regarding development of economic numbers for the Mid-Atlantic Regional Spaceport Expansion project. Email dated Monday, July 13, 2009 2:45 p.m. Numbers developed by Old Dominion University and Chincoteague Chamber of Commerce for the TacSat 3 launches.
- Stamper, Douglas. 2009. USACE Norfolk Area Office Project Manager for Navigation Maintenance Dredging of the Waterway on the Coast of Virginia (also known as the Virginia Inside Passage). Email correspondence with George Mears of USACE on October 19, 2009.
- Travelstead, Jack. 2010. Chief, Fisheries Management Division, Virginia Marine Resources Commission. Email from Mr. Travelstead to Joshua Bundick. July 19.
- Wikel, Geoff (BOEMRE). 2009. Included in comments on Preliminary DEIS dated December 15, 2009.
- Williams, Gregory. 2009. Email dated November 4, 2009 to SRIPP USACE Team members describing anticipated dredge cut depth from a hopper dredge.

References

This page intentionally left blank.

CHAPTER NINE: INDEX

A

- Accomack County, iv, v, vii, 2, 9, 110, 125, 133, 140, 195, 197, 198, 199, 200, 205, 208, 209, 210, 211, 305, 306, 312, 343, 347, 348, 361, 392, 397, 409, 416, 417, 418, 421
- Accretion, ES-VI, 54, 75, 84, 111, 113, 117, 219, 224, 228, 230, 233, 235, 237, 239, 264, 267, 321, 343, 371, 377, 414
- Affected Environment, ii, 2, 93, 314, 365, 386
- Air Quality, ES-VII, ES-XI, ii, iii, 85, 89, 133, 135, 136, 249, 252, 253, 255, 256, 257, 259, 260, 334, 347, 348, 350, 379, 381, 386, 418, 421
- Alternatives
 Comparison of, i, ii, 19, 79
 No Action, iii, ES-IV, 33, 79, 215, 217, 218, 219, 220, 221, 222, 224, 228, 231, 232, 233, 234, 237, 239, 241, 242, 243, 244, 247, 248, 249, 253, 257, 260, 261, 262, 263, 264, 266, 267, 272, 273, 278, 279, 281, 284, 290, 302, 303, 305, 306, 307, 308, 311, 312, 315
 Proposed Action, iii, ES-II, ES-V, i, ii, vii, 18, 19, 38, 58, 59, 60, 67, 79, 80, 81, 83, 91, 221, 232, 248, 249, 347, 365
- Assateague, ES-VI, v, 52, 53, 73, 84, 97, 98, 101, 103, 109, 111, 113, 114, 115, 117, 121, 122, 125, 126, 132, 133, 151, 152, 156, 158, 159, 181, 187, 188, 195, 196, 197, 209, 213, 214, 224, 225, 227, 234, 236, 241, 314, 328, 331, 335, 338, 351, 352, 353, 354, 357, 358, 360, 389, 393, 409, 416, 420
- Assawoman
 Inlet, vii, 5, 93, 122, 209, 217, 220, 319, 321, 374, 375
 Island, ES-III, ES-V, ES-VI, 9, 29, 60, 69, 83, 84, 93, 111, 113, 119, 122, 125, 126, 132, 133, 151, 152, 187, 195, 222, 223, 228, 230, 234, 337, 338, 354, 357, 358, 360, 373, 375
- Atmosphere, 22, 95, 131, 137, 333

- At-Risk Infrastructure, i, 21, 35, 36, 217, 263, 278, 279, 302, 384

B

- Bathymetry, ES-V, ES-IX, ii, iii, v, 83, 87, 93, 97, 98, 99, 101, 103, 105, 107, 115, 117, 118, 215, 216, 217, 225, 232, 270, 334, 335, 366, 379, 386, 421
- Beach Fill, ES-II, ES-III, ES-IV, ES-V, ES-VI, ES-VII, ES-VIII, ES-X, i, v, viii, 10, 18, 19, 21, 26, 29, 34, 35, 36, 37, 38, 44, 45, 46, 54, 58, 59, 60, 61, 67, 68, 69, 73, 79, 80, 82, 83, 84, 85, 86, 88, 115, 159, 216, 217, 219, 220, 221, 222, 223, 224, 228, 230, 231, 232, 233, 234, 235, 236, 237, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 271, 272, 273, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 289, 290, 291, 294, 296, 299, 301, 302, 303, 304, 305, 306, 307, 308, 310, 311, 312, 313, 314, 322, 334, 335, 337, 348, 358, 366, 372, 373, 375, 376, 381, 413
- Benthos, ES-X, ii, iii, 88, 160, 161, 163, 164, 270, 273, 274, 276, 277, 278, 281, 283, 284, 293, 304, 334, 347, 350, 351, 352, 363, 384
- Biological Assessment, iv, ix, 147, 184, 293, 300, 409, 414
- Birds
 Migratory, ES-VIII, 86, 152, 155, 267, 268, 354, 356, 360
 Seabirds, ES-VIII, 86, 267, 268, 270, 271, 355, 413
 Shorebirds, ES-VIII, 86, 152, 155, 156, 157, 161, 187, 267, 268, 269, 270, 276, 297, 342, 355, 356, 367, 413, 419
- Blackfish Bank Shoal, 46, 52, 53, 196, 207, 210, 213, 242, 304, 336
- Borrow Sites, ES-III, ES-VII, ES-VIII, 1, 20, 26, 45, 46, 52, 53, 54, 58, 67, 68, 70, 79, 80, 85, 86, 115, 131, 142, 162, 171, 196, 206,

Index

- 213, 216, 225, 227, 228, 231, 232, 236,
245, 246, 247, 251, 253, 254, 257, 258,
261, 264, 265, 267, 268, 270, 276, 280,
282, 285, 291, 293, 294, 297, 303, 304,
309, 310, 311, 312, 313, 315, 334, 352,
365, 366, 371, 384
- Breakwater, ES-II, ES-III, ES-IV, ES-V, ES-VI,
ES-VIII, ES-IX, i, iv, v, viii, 19, 30, 31,
37, 41, 69, 70, 71, 79, 80, 83, 84, 86, 87,
207, 208, 217, 230, 232, 233, 234, 239,
240, 242, 243, 244, 247, 248, 258, 259,
262, 263, 264, 265, 266, 267, 271, 272,
273, 277, 278, 279, 281, 283, 290, 299,
300, 302, 303, 305, 306, 307, 308, 311,
312, 314, 365, 366, 386
- C**
- Carbon Dioxide, ix, 95, 136, 137, 138, 250, 252,
253, 254, 255, 256, 257, 258, 259, 260,
261, 333, 350, 415
- Carbon Monoxide, ix, 22, 133, 134, 135, 250,
252, 253, 254, 255, 256, 257, 258, 259,
260, 261, 347, 348, 349, 420, 421
- Chincoteague
Inlet, v, 5, 9, 44, 45, 54, 93, 111, 113, 114,
115, 116, 117, 122, 125, 144, 159, 210,
213, 214, 224, 228, 305, 321, 373, 374,
375, 376, 415
National Wildlife Refuge, ix, 93, 151, 158,
182, 188, 190, 195, 209, 390, 418
- Clean Air Act, ix, 133, 136, 137
- Clean Water Act, ix, 1, 17, 59, 125, 245, 342,
364
- Climate Change, ES-V, ES-VII, 14, 83, 85, 95,
96, 137, 219, 242, 254, 316, 333, 334,
338, 341, 343, 344, 346, 349, 350, 352,
353, 354, 357, 360, 361, 398, 404, 405
- Coastal Plain, 110, 115, 402
- Coastal Zone Management, ii, iii, ix, 132, 248,
249, 418
- Commercial Fishing, 9, 196, 197, 304, 305, 316,
333, 351, 352, 353, 355
- Consultations with Agencies and Individuals,
ES-XI, iv, 76, 89, 181, 205, 206, 231,
281, 284, 286, 300, 308, 309, 310, 311,
354, 360, 364, 370, 378, 409, 410
- Continental Shelf, ES-XI, v, xi, 1, 89, 93, 94, 97,
115, 117, 131, 160, 161, 172, 175, 176,
177, 178, 179, 192, 241, 274, 275, 278,
280, 283, 328, 334, 335, 337, 341, 350,
351, 352, 353, 354, 358, 361, 397, 399,
403, 404, 405, 413, 415, 416, 419
- Contingency Plan
Integrated, x, 141, 242, 243, 244, 245, 246,
247, 262, 281, 282, 366
- Council on Environmental Quality, ES-I, ix, 1, 18,
33, 316, 365, 389
- Critical Habitat, 188, 291, 370
- Cultural Resources, ES-XI, ii, iii, iv, ix, 6, 73,
88, 98, 199, 200, 205, 206, 207, 208, 307,
308, 309, 310, 311, 371, 380, 386, 409
- Cumulative Impacts, ES-XI, 89, 254, 316, 333,
334, 337, 338, 341, 342, 347, 348, 350,
351, 352, 353, 354, 357, 358, 360, 361,
380, 386
- Currents, 14, 29, 73, 114, 116, 117, 121, 131,
159, 161, 164, 170, 207, 224, 233, 234,
239, 242, 246, 280, 285, 334, 342
- D**
- Delmarva Peninsula, 2, 93, 111, 147, 152, 182,
183, 187, 199, 209, 210, 304
- Dissolved Oxygen, 125, 245, 246
- Dredging, ES-V, ES-VI, ES-VII, ES-VIII, ES-
IX, ES-X, ES-XI, ii, v, vii, viii, 1, 18, 20,
44, 45, 46, 51, 53, 54, 58, 70, 73, 74, 75,
76, 77, 79, 80, 82, 83, 84, 85, 86, 87, 88,
89, 91, 113, 114, 121, 125, 141, 190, 210,
216, 217, 224, 225, 227, 228, 231, 232,
233, 234, 236, 237, 239, 241, 242, 245,
246, 247, 249, 251, 252, 255, 256, 257,
259, 260, 263, 270, 271, 272, 273, 274,
275, 277, 278, 279, 280, 281, 282, 284,
285, 288, 289, 290, 291, 292, 293, 294,
295, 297, 299, 300, 301, 304, 306, 308,
309, 310, 311, 312, 313, 314, 315, 316,
317, 328, 331, 332, 333, 334, 335, 337,
338, 341, 347, 348, 349, 350, 351, 352,
353, 354, 355, 357, 358, 360, 363, 365,
366, 367, 368, 369, 370, 371, 372, 378,

381, 386, 400, 401, 403, 404, 406, 407,
409, 411, 419, 421

Dunes, Sand, v, 14, 26, 36, 63, 110, 132, 147,
187, 217, 249, 355, 359, 371

E

Emissions, ES-VII, vii, viii, 85, 133, 135, 136,
137, 138, 249, 250, 251, 252, 253, 254,
255, 256, 257, 258, 259, 260, 261, 307,
347, 348, 349, 350, 402, 421

Employment and Income, 197

Endangered Species, ES-X, x, 88, 174, 175, 181,
289, 290, 300, 358, 372, 409, 410, 413,
418

Environment
Biological, ii, iii, 93, 147, 215, 264, 347, 350,
379
Physical, ii, iii, 93, 215, 334, 365
Socioeconomic, iii, 361

Environmental Justice, ii, iii, vii, ix, 208, 209,
307, 386, 408

Erosion, Shoreline, ES-I, ES-V, ES-VII, i, vi, 9,
18, 29, 45, 83, 85, 148, 217, 218, 232,
263, 264, 283, 290, 338, 366

Essential Fish Habitat, ES-IX, ii, iii, iv, ix, 76,
172, 281, 351, 371

F

Facilities, ES-I, ES-IV, i, iii, v, 2, 5, 6, 7, 9, 14,
17, 19, 20, 21, 25, 33, 35, 36, 37, 81, 133,
136, 137, 140, 141, 142, 143, 147, 195,
199, 200, 205, 206, 208, 210, 217, 247,
261, 262, 263, 302, 303, 307, 316, 317,
318, 320, 321, 322, 327, 328, 331, 332,
350, 369, 391, 393, 407

Fill, Beach, ES-II, ES-III, ES-IV, ES-V, ES-VI,
ES-VII, ES-VIII, ES-X, i, v, viii, 10, 18,
19, 21, 26, 29, 34, 35, 36, 37, 38, 44, 45,
46, 54, 58, 59, 60, 61, 67, 68, 69, 73, 79,
80, 82, 83, 84, 85, 86, 88, 115, 159, 216,
217, 219, 220, 221, 222, 223, 224, 228,
230, 231, 232, 233, 234, 235, 236, 237,
239, 240, 241, 242, 243, 244, 245, 246,
247, 248, 250, 251, 252, 253, 254, 255,
256, 257, 258, 259, 260, 261, 262, 263,
264, 265, 266, 267, 268, 269, 271, 272,

273, 275, 276, 277, 278, 279, 280, 281,
282, 283, 284, 289, 290, 291, 294, 296,
299, 301, 302, 303, 304, 305, 306, 307,
308, 310, 311, 312, 313, 314, 322, 334,
335, 337, 348, 358, 366, 372, 373, 375,
376, 381, 413

Fishing

Commercial, 9, 196, 197, 304, 305, 316, 333,
351, 352, 353, 355
Recreational, ES-X, 52, 53, 88, 196, 207,
214, 248, 304, 314, 361, 363, 384

Floodplains, 26, 125, 131, 247

G

Geology, ES-V, ii, iii, 83, 109, 217, 223, 231,
232, 379, 380, 381, 399, 400, 403, 404,
406, 407, 412, 413

Geotextile Tubes, ES-I, ES-IV, v, 10, 13, 15, 17,
26, 33, 60, 205, 207, 208, 215, 217, 219,
321, 337

Global Warming, x, 95, 136

Greenhouse Gases, vii, viii, x, 95, 136, 137, 138,
349, 401

Groin, ES-II, ES-III, ES-IV, ES-V, ES-VI, ES-
VIII, ES-IX, i, iv, v, vi, viii, 15, 19, 29,
30, 37, 41, 69, 70, 71, 79, 80, 83, 84, 86,
87, 120, 121, 207, 208, 216, 228, 229,
232, 233, 234, 237, 240, 242, 243, 244,
246, 248, 255, 257, 260, 262, 263, 264,
265, 267, 271, 272, 273, 277, 279, 281,
283, 289, 299, 302, 303, 305, 306, 307,
308, 310, 312, 314, 318, 365, 366, 384,
386

H

Hazardous

Materials, ES-VII, ii, iii, 9, 22, 85, 141, 199,
245, 262, 263, 366, 386
Waste, ii, iii, 141, 142, 262, 263

Health and Safety, ii, iii, 199, 306, 307

Hopper Dredge, vi, 70, 73, 74, 141, 245, 251,
270, 275, 278, 280, 282, 283, 285, 288,
292, 313, 354, 368, 409, 421

Hurricanes, 13, 94, 95, 125, 331, 332, 333, 338,
406, 413, 416, 417

Index

Hydrodynamics, 159, 161, 216, 334, 401

I

Implementation Schedule, ii, vii, 79, 80, 220

Infrastructure

Existing, 218, 262, 327

Initial Nourishment, ES-III, v, 29, 65, 68, 69, 331

Intergovernmental Panel on Climate Change, 14, 95, 96, 97, 405, 411

Invertebrates, ES-XI, ii, iii, 89, 156, 170, 278, 279, 282, 284, 304, 351, 357, 416, 419

L

Land Use, ES-V, ii, iii, vii, 6, 83, 95, 139, 140, 195, 302

Launch Range Activities, 348, 349

Longshore Sediment Transport, ES-II, ES-VI, 14, 30, 34, 53, 69, 84, 111, 113, 117, 121, 222, 223, 224, 225, 227, 228, 232, 234, 236, 237, 240, 315, 337, 366

M

Mammals

Marine, ES-VII, ES-X, ES-XI, ii, iii, vii, viii, 85, 88, 89, 141, 174, 175, 180, 192, 194, 261, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 299, 334, 353, 354, 358, 361, 372, 379, 399, 405, 411, 414, 415, 420

Terrestrial, 182

Meteorology, ii, 94, 381

Mid-Atlantic Bight (MAB), x, 93, 97, 117, 159, 160, 162, 170, 171, 179, 193, 278, 353, 415

Mid-Atlantic Regional Spaceport (MARS), iii, ES-I, ES-IV, x, 2, 5, 6, 9, 14, 17, 33, 93, 198, 327, 390, 407, 409, 421

Minerals Management Service (MMS), x, 1, 74, 170, 206, 225, 227, 231, 246, 282, 285, 354, 371, 397, 399, 400, 401, 405, 407, 415, 419, 420

Mitigation Measures, ES-XI, ii, vii, 2, 20, 89, 91, 215, 229, 243, 246, 247, 262, 263, 283, 297, 298, 312, 314, 315, 346, 352, 365, 367, 370, 372, 384

Modeling

GENESIS, 67, 117, 217, 220, 221, 386

STeady-state spectral WAVE model (STWAVE), 225

Monitoring, ES-II, iii, 10, 18, 20, 44, 59, 68, 76, 80, 136, 137, 140, 171, 188, 190, 199, 207, 208, 269, 273, 274, 279, 283, 297, 300, 334, 347, 360, 361, 365, 367, 372, 373, 374, 375, 376, 377, 384, 386, 398, 401, 409, 411, 419

Munitions and Explosives of Concern (MEC), ES-VII, ii, v, vii, x, 45, 85, 142, 143, 144, 145, 147, 263, 264, 366

N

National Ambient Air Quality Standards

(NAAQS), vii, x, 133, 134, 250, 251, 253, 255, 258, 347, 350, 402

National Environmental Policy Act (NEPA), iii, ES-I, ES-II, x, 1, 2, 18, 59, 73, 215, 254, 314, 315, 316, 332, 333, 349, 373, 378, 379, 383, 385, 386, 389, 405

National Marine Fisheries Service (NMFS), ES-XI, iv, vii, x, 76, 89, 91, 147, 173, 174, 176, 177, 181, 183, 184, 188, 190, 191, 192, 193, 197, 213, 231, 281, 284, 285, 286, 288, 289, 291, 292, 293, 294, 295, 300, 301, 304, 354, 358, 360, 364, 368, 369, 370, 371, 372, 373, 378, 389, 399, 403, 405, 406, 409, 410, 413, 416, 419

National Park Service (NPS), xi, 113, 151, 331, 374, 376, 389, 409, 416

Nitrogen Dioxide (NO₂), xi, 134

Nitrogen Oxides (NOX), xi, 95, 135, 347

Nitrous Oxides (N₂O), xi, 95, 136, 137, 138, 250, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261

Nodal Zone, 119, 223, 234, 337, 366

Noise

Construction, 261, 356

- Underwater, 138, 141, 261, 279, 286, 288, 289, 292, 301, 334, 353, 399
- North Wallops Island, ES-V, v, vii, viii, 6, 37, 54, 55, 57, 58, 79, 83, 91, 151, 153, 228, 246, 253, 257, 260, 309, 310, 311, 318, 366, 372, 386
- ## O
- Oceanography, ii, iii, 116, 232, 379, 380, 381, 397, 398, 399, 411, 414
- Offshore Environment, 190, 215, 333
- Overwash, ES-V, 13, 83, 111, 151, 187, 218, 219, 243, 244, 264, 337, 342, 343, 344, 352, 353, 357, 401, 416
- Ozone (O₃), xi, 95, 133, 134
- ## P
- Permits, Licenses, and Approvals, iii, 364
- Plankton, ii, iii, 159, 272, 273, 280, 304
- Pump-Out Buoy, 73, 76, 82, 285, 294, 308, 309, 313, 314, 338
- ## R
- Range Safety, 2, 25, 264
- Renourishment, ES-II, ES-III, ES-IV, ES-V, ES-VI, ES-VIII, v, viii, 2, 10, 18, 20, 29, 34, 37, 38, 39, 41, 45, 54, 58, 59, 65, 67, 68, 69, 70, 76, 79, 80, 81, 82, 83, 84, 86, 91, 110, 216, 219, 222, 224, 225, 228, 229, 230, 231, 232, 234, 235, 237, 239, 249, 252, 253, 254, 256, 257, 258, 259, 260, 261, 265, 266, 267, 268, 269, 271, 273, 276, 277, 278, 284, 291, 293, 294, 295, 296, 297, 298, 300, 304, 305, 312, 313, 315, 316, 331, 332, 334, 335, 336, 337, 347, 350, 356, 357, 358, 362, 367, 370, 371, 372, 373, 377, 378, 381, 386, 403, 414, 415, 420
- Reptiles, 190
- ## S
- Sand
Dunes, i, 21, 26, 35, 36, 132, 144, 147
- Grain Size, vii, 44, 45, 46, 51, 52, 54, 57, 58, 67, 68, 110, 115, 160, 162, 172, 207, 219, 232, 245, 246, 274, 276, 285, 295, 366, 386, 397, 402
- Placement, ii, 73, 76, 91, 219, 234, 244, 251, 272, 293, 366, 372
- Retention Structures, ES-III, i, 18, 19, 21, 29, 34, 35, 36, 37, 38, 68
- Sources, 54, 58, 81, 228, 328, 332
- Scoping, iv, viii, 53, 333, 383, 384, 387, 389, 406
- Screening
Criteria, i, 33, 38
Results, i, 34
Secondary, ES-II, i, 19, 37, 38, 81
- Seafloor, 10, 46, 97, 131, 157, 171, 246, 279, 332, 333, 335, 341, 351, 362
- Sea-Level Rise, ES-I, ES-III, ES-V, 1, 14, 17, 60, 67, 83, 96, 97, 118, 218, 224, 228, 230, 242, 316, 333, 338, 343, 344, 354, 357, 360, 384, 401, 413
- Seawall, ES-I, ES-II, ES-III, ES-IV, ES-V, ES-VI, ES-VII, ES-VIII, i, v, vi, vii, viii, 1, 10, 13, 17, 19, 20, 21, 26, 29, 33, 34, 35, 36, 37, 38, 41, 44, 59, 60, 61, 63, 67, 68, 69, 70, 71, 79, 80, 83, 84, 85, 86, 91, 93, 110, 111, 115, 118, 119, 126, 129, 140, 148, 160, 161, 162, 188, 190, 215, 216, 217, 218, 219, 220, 221, 222, 223, 228, 229, 230, 231, 232, 233, 234, 237, 239, 241, 242, 243, 244, 246, 247, 248, 249, 250, 253, 254, 255, 257, 258, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 271, 272, 273, 275, 276, 277, 278, 279, 281, 282, 283, 284, 289, 290, 291, 293, 297, 299, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 317, 318, 319, 320, 321, 332, 337, 338, 348, 350, 352, 365, 366, 367, 370, 372, 373, 374, 384, 408
- Sediment
Budget, v, 13, 117, 120, 384
Plume, 245, 294
Removal, 58, 228, 261, 366
Transport, ES-V, ES-XI, v, vi, vii, 19, 53, 58, 83, 89, 93, 110, 111, 113, 117, 118, 119, 120, 121, 122, 217, 218, 220, 223, 224, 225, 227, 228, 229, 234, 235, 236, 237,

Index

- 238, 239, 240, 241, 266, 267, 310, 337, 366, 376
- Shoreline
- Change, ES-I, ES-VI, v, vii, 17, 20, 53, 84, 109, 110, 112, 113, 220, 227, 233, 334, 338, 374, 375, 376, 377, 402, 414, 420
 - Erosion, ES-I, ES-V, ES-VII, i, vi, 9, 18, 29, 45, 83, 85, 148, 217, 218, 232, 263, 264, 283, 290, 338, 366
- Socioeconomic Environment, iii, 361
- State Historic Preservation Office (SHPO), 199, 309
- Submerged Aquatic Vegetation (SAV), ii, iii, xi, 158, 159, 272, 419
- Surface Water, v, 117, 122, 123, 125, 131, 242, 243, 244, 246, 270, 338, 341, 342, 343
- Surveys, iv, 44, 45, 46, 52, 54, 58, 75, 91, 98, 111, 113, 115, 117, 140, 151, 159, 164, 171, 176, 177, 181, 192, 193, 195, 196, 205, 206, 207, 208, 213, 225, 264, 272, 291, 297, 304, 307, 308, 309, 310, 311, 336, 356, 366, 367, 371, 372, 373, 374, 375, 376, 377, 378, 380, 384, 397, 399, 400, 402, 406, 409, 412, 414, 419
- T**
- Tenants, i, 2, 5, 20, 125, 210, 261
- Threatened and Endangered (T&E) Species, ii, iii, viii, 175, 181, 290, 334, 357, 358, 361, 367, 372
- Turbidity, ES-VII, ES-IX, ES-X, 85, 87, 88, 158, 162, 244, 245, 246, 247, 248, 270, 272, 273, 274, 277, 280, 281, 282, 283, 284, 285, 293, 295, 301, 304, 305, 338, 341, 342, 352, 363, 366, 397
- Turtles, ES-X, viii, 58, 88, 91, 152, 183, 184, 188, 189, 190, 191, 270, 293, 294, 295, 296, 297, 301, 315, 356, 358, 359, 360, 361, 367, 368, 369, 372, 399, 404, 407, 408, 411, 414, 415, 417, 420
- U**
- U.S. Army Corps of Engineers (USACE), i, iii, ES-I, ES-VI, viii, xi, 1, 13, 17, 19, 20, 26, 29, 30, 31, 34, 37, 44, 45, 46, 51, 52, 53, 54, 57, 58, 59, 67, 70, 73, 74, 75, 80, 81, 84, 91, 93, 95, 110, 111, 113, 114, 115, 116, 117, 118, 119, 125, 126, 142, 143, 144, 190, 213, 217, 218, 219, 220, 222, 223, 224, 225, 226, 227, 228, 229, 230, 234, 235, 236, 237, 238, 239, 240, 241, 243, 245, 247, 263, 276, 284, 300, 313, 317, 321, 331, 332, 334, 335, 336, 343, 351, 352, 358, 359, 362, 363, 364, 369, 370, 374, 376, 378, 381, 383, 389, 397, 403, 404, 413, 416, 417, 421
- U.S. Coast Guard (USCG), xi, 2, 210, 213, 245, 313, 316, 317, 363, 366, 374, 376, 390, 417
- U.S. Fish and Wildlife Service (USFWS), ES-XI, iv, xi, 89, 91, 93, 125, 147, 151, 156, 181, 182, 183, 184, 187, 188, 190, 195, 269, 270, 293, 296, 297, 298, 300, 301, 321, 343, 356, 360, 361, 364, 367, 368, 370, 372, 390, 403, 417, 418
- V**
- Vegetation, X, ii, iii, v, 54, 58, 88, 91, 126, 133, 147, 148, 149, 151, 152, 153, 157, 158, 159, 180, 181, 187, 191, 264, 265, 266, 272, 291, 298, 299, 338, 344, 356, 360, 371, 380, 416
- Vibracore Sampling, v, 49, 397
- Video Surveys, iv, v, 131, 164, 165, 246, 274, 409
- Virginia Capes Operating Area (VACAPES OPAREA), xii, 328, 341, 353
- Virginia Inside Passage, 45, 122, 317, 421
- W**
- Wallops Flight Facility, i, iii, ES-I, ES-II, ES-VII, X, ES-XI, i, v, vi, viii, xii, 1, 2, 5, 6, 9, 17, 18, 20, 21, 23, 25, 27, 33, 35, 36, 60, 69, 70, 79, 81, 85, 88, 89, 93, 94, 125, 136, 138, 140, 141, 147, 155, 188, 195, 197, 198, 199, 200, 205, 206, 207, 208, 209, 210, 213, 233, 242, 243, 244, 245, 246, 247, 249, 250, 254, 261, 264, 268, 269, 281, 282, 302, 305, 306, 307, 308, 316, 317, 322, 327, 328, 331, 338, 339, 341, 342, 343, 344, 347, 348, 349, 350,

352, 354, 355, 356, 357, 359, 360, 361,
362, 363, 366, 380, 383, 384, 385, 387,
397, 401, 408, 409, 414, 416, 421

Water

Quality, 91, 122, 125, 242, 244, 245, 246,
247, 272, 273, 278, 282, 285, 307, 334,
338, 341, 351, 352, 353, 364, 366, 418
Resources, ES-VII, ES-XI, ii, iii, 85, 89, 122,
242, 244, 333, 338, 342, 380, 408, 416,
417

Waves, iii, ES-I, ES-III, ES-IV, ES-VI, 10, 13,
14, 17, 20, 26, 29, 30, 36, 53, 60, 68, 75,
84, 95, 96, 97, 109, 110, 111, 115, 116,
117, 119, 131, 148, 160, 162, 207, 215,
217, 219, 220, 221, 225, 227, 233, 236,
246, 247, 262, 265, 266, 272, 279, 286,
295, 298, 341, 342, 355, 376, 404, 406,
417, 420

Wetlands, vi, viii, 22, 25, 29, 125, 126, 151,
215, 243, 247, 321, 322, 342, 343, 344,
345, 346, 352, 355